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Evolution of physician resources in China (2003–2021): quantity, quality, structure, and geographic distribution

Yu Xiao[1*†], Zhou Zhang[2*†], Chun-mei Xu[2], Jian-ying Yu[3], Ting-ting Chen[3], Shu-wan Jia[2], Na Du[1], Shao-yi Zhu[4] and Jing-hui Wang[2]

Abstract

Introduction Physicians are an indispensable part of the healthcare system, crucial for maintaining public health. Since the issues in market-oriented healthcare reform emerged in 2003, China has implemented a series of healthcare system reforms to improve the equitable distribution of medical resources. The impact of these reform measures on the physician workforce has yet to be systematically assessed.

Methods Data were sourced from the China Health Statistics Yearbook from 2003 to 2021. We conducted a detailed descriptive statistical analysis of physicians' quantity, quality, and structure. The Gini coefficient was calculated to evaluate national physician distribution equity, and the Theil index was further used to analyze interprovincial and intraprovincial inequality trends in the physician workforce. Global Moran's *I* and hotspot analysis were employed to examine the spatial heterogeneity and clustering of physician labor.

Results The number of physicians increased from 1.87 million in 2003 to 4.29 million in 2021, with an average annual growth rate of 4.72%. The male-to-female ratio changed from 1:0.69 to 1:0.92. The main educational level of physicians elevated to a bachelor's degree (45.9%). However, the proportion of young doctors (< 35 years) declined from 41.1 to 26.0%. The Gini coefficient decreased from 0.140 in 2003 to 0.071 in 2021, and the Theil index dropped from 0.091 to 0.057. Decomposition of the Theil index revealed that overall differences in physician distribution primarily stemmed from intraprovincial inequality rather than interprovincial inequality. Global Moran's I decreased from 0.304 in 2003 to 0.109 in 2015 and then increased to 0.444 in 2021. Hotspot analysis showed uneven physician distribution, with high-value clusters in northern regions and low-value clusters in southern regions.

Conclusions Over the past 19 years, despite improvements in the quantity and quality of physicians, the decline in young physicians and worsening regional disparities pose challenges.

Keywords China, Health workforce, Health equity, Physician staff, Spatial correlation, Moran's *I*

†Yu Xiao and Zhou Zhang have contributed equally to this work.

*Correspondence:
Yu Xiao
xiaoy3@outlook.com
Zhou Zhang
zhanghuangawu@gmail.com
Full list of author information is available at the end of the article

Introduction

Physicians, as core providers of healthcare services, constitute a vital and scarce resource within the healthcare system. Their quantity, quality, structure, and geographic distribution profoundly influence healthcare sector development and the quality and fairness of medical services [1, 2]. In the late 1950s, the Chinese government instituted a primary healthcare system endorsed by the World Health Organization [3]. However, starting in 1978, the gradual reduction of substantial funding for this system led Mainland China to initiate market-oriented reforms in healthcare [4]. Public hospitals shifted toward financial self-sustainability to counterbalance inadequate national funding. Nevertheless, the market-oriented approach eroded the altruistic essence of the healthcare sector, resulting in a decline in service fairness and a notable surge in healthcare costs [5, 6]. The 2003 Severe Acute Respiratory Syndrome epidemic exposed flaws in the market-oriented healthcare reform [7], prompting the government's attention to issues of "difficulty in accessing healthcare" and "high medical costs". According to the 2021 Global Health Security Index report from Johns Hopkins University, China ranked 36th globally in the "a robust and sufficient healthcare system" category, scoring 51.8 out of 100 [8]. This suggests that, on a global scale, China boasts relatively abundant healthcare resources.

Nevertheless, China's healthcare system contends with regional development imbalances [9, 10]. Developed areas boast more and better healthcare human resources, while underdeveloped or remote rural regions face shortages [11, 12]. Unequal distribution stems from geographical, population, regional GDP, and government policy factors. Past studies employed economic metrics like Gini coefficients, Theil indices, and Global Moran's *I* to gauge inequality [13–15]. Some used Theil coefficient decomposition and Hotspot analysis to identify concentrated resources [16]. However, existing research on China's physician distribution has two shortcomings. Firstly, it predominantly examines equity based on per capita GDP or geographical size, overlooking diverse regional features and substantial economic disparities [17–19]. For instance, the GDP gap between Beijing and Gansu can be fourfold, while Shanghai's population density can surpass Tibet's by a hundredfold [20, 21]. Thus, assessing fairness solely based on GDP and geographical size has limitations. Secondly, existing data predate 2018 [9, 10, 16]. Amid the Thirteenth Five-Year Plan (2016–2020) and the COVID-19 impact, physician distribution fairness and changes in China lack a clear conclusion.

This study utilized data from the China Health Statistics Yearbook for a population-based statistical analysis spanning 2003 to 2021. Our comprehensive analysis delved into physician resources, covering quantity, quality, structure, and distribution. The primary objective is to offer empirical data for optimizing healthcare human resource allocation and promoting regional equity in China. To the best of our knowledge, this study represents the most current and comprehensive analysis of physician resources in China.

Methods

Definition of physicians

Per the Physician Law of the People's Republic of China, physicians are qualified medical professionals registered to practice in medical, preventive, and healthcare institutions. In China, physicians fall into two categories: licensed practicing physicians with the capability for independent medical practice and assistant physicians who operate under the guidance of licensed practicing physicians.

Regional classification

China's administrative divisions consist of 34 provincial-level regions, comprising 23 provinces, 5 autonomous regions, 4 directly-administered municipalities, the Hong Kong and Macao Special Administrative Regions. Rural areas include county-level administrative units and the townships or villages under them, while urban areas pertain to city-level administrative units and their corresponding urban districts.

Data sources

The physician and urban–rural resident data were extracted from the China Health Statistics Yearbook covering all 31 provinces, autonomous regions, and direct-controlled municipalities in China (excluding Hong Kong, Macao, and Taiwan). National and provincial year-end population data were obtained from the China Statistical Yearbook. Since the China Health Statistics Yearbook began separately recording urban and rural physician numbers starting in 2003, and complete data for 2022 are not yet available, this study analyzed data from 2003 to 2021.

Indicators

Quantity: Examining total numbers and density (per 1000 population).

Quality: Evaluating education, experience, and professional titles.

Structure: Analyzing gender and age distribution.

Distribution: Using indicators like Gini coefficient, Theil index, and Hotspot analysis for geographic spread.

Data analysis

We collected data from the yearbooks spanning 2004 to 2022, covering physician resources and population from

2003 to 2021. Excel software facilitated data consolidation, organization, and analysis. Count and proportion were utilized to assess physician quantity, quality, and composition from 2003 to 2021.

The Gini coefficient, commonly employed to gauge income distribution inequality, was adapted to evaluate fairness in healthcare resource allocation. The formula is as follows:

$$G = 1 - \sum_{i=1}^{n} (x_i - x_{i-1})(y_i + y_{i-1}).$$

In this equation, G stands for the Gini coefficient, i denotes the province identifier, x_i represents the cumulative percentage of the population, and y_i represents the cumulative percentage of healthcare human resources. Generally, a Gini coefficient below 0.2 is categorized as highly even, while the range of 0.2–0.3 signifies relative evenness, 0.3–0.4 indicates relative inequality, and values exceeding 0.4 are regarded as very unequal.

For a thorough analysis of inequality, the Theil index acts as a valuable decomposition indicator, breaking down overall inequality into two components: inter-provincial differences (T1L) and intra-provincial differences within the same region (T2L). The formula for the Theil index is as follows:

$$\text{TheilL} = T_{1L} + T_{2L} = \sum_{i=1}^{I} C_i \log \frac{C_i}{B_i} + \sum_{i=1}^{I} C_i \sum_{j=1}^{J} C_{ij} \log \frac{C_{ij}}{B_{ij}}.$$

For inter-provincial differences, we used B_i to represent the total number of physicians in province i and C_i to represent the total population in province i. j represents urban or rural areas. For intra-provincial differences, we used B_{ij} to represent the proportion of urban or rural physicians in province i among the total physicians and C_{ij} to represent the proportion of urban or rural population in province i among the total population.

Moreover, we calculated the ratio of the provincial Theil index to the total Theil index to clarify the impact of intra-provincial differences on overall inequality. The Theil index values range from 0 to 1, where lower values indicate a more equitable distribution of physicians. Recognizing that traditional economic analysis methods may not fully capture the specific distribution of physicians, we introduced spatial analysis methods. Concretely, we will quantitatively analyze the spatial heterogeneity and clustering of human resources using Global Moran's I. Additionally, through Hotspot analysis, we will visualize the spatial pattern of physician distribution to more clearly identify imbalances in physician allocation. Global Moran's I was employed to evaluate the spatial autocorrelation of physician distribution, determining whether there is spatial clustering or dispersion in the dataset. The formula for its calculation is as follows:

$$I = \frac{n}{S_0} \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} w_{ij}(x_i - \overline{x})(x_j - \overline{x})}{\sum_{i=1}^{n} (x_i - \overline{x})^2}.$$

In the formula, n represents the total number of provinces, S_0 represents the sum of all spatial weights, x_i and x_j represent the physician density of the ith and jth provinces, $\overline{x}$ represents the mean value of all data points, and w_{ij} represents the spatial weight between data points i and j. If the calculated p-value is less than 0.05, it indicates significant spatial autocorrelation in the data's geographical space. The Moran's I value ranges from + 1 to − 1, with values close to + 1 indicating a significant clustering trend of physicians on the map, and values close to -1 indicating a significant dispersion trend of physicians on the map. If the calculated p-value is greater than 0.05, it cannot be concluded that there is significant spatial autocorrelation in the data's geographical space.

Upon confirming the presence of spatial autocorrelation in the overall data distribution, Hotspot analysis was conducted to pinpoint regions with significantly higher (Hotspot) and lower (Cold spot) values than the mean. The formula for calculating the Getis–Ord Gi* statistic is as follows:

$$Gi* = \frac{\sum_{j=1}^{n} w_{ij}x_j - \overline{x}\sum_{j=1}^{n} w_{ij}}{s\sqrt{\frac{\sum_{j=1}^{n} w_{ij}^2 - \left(\sum_{j=1}^{n} w_{ij}\right)^2 / n}{n-1}}}.$$

The outcomes are presented in Z-scores, where high or low values aid in identifying clustered areas. High Z-scores indicate values significantly above the surrounding area's average, while low Z-scores signify values notably lower than the surrounding average. For improved visualization, ArcGIS 10.8 was utilized for mapping. In these maps, higher positive Z-scores are depicted in red, indicating more pronounced Hotspot clustering, while lower negative Z-scores tend towards blue, indicating a more significant dispersion trend. This color scheme facilitates an intuitive understanding of regional clustering and dispersion patterns.

Software tool

A descriptive analysis of the quantity, quality, and structure of physicians was conducted using Microsoft Excel 2017 (Microsoft Corporation, Redmond, WA, USA). The calculations for Theil index and Global Moran's I were performed using Stata 17 (StataCorp LLC, College Station, TX, USA). Geographic description and analysis of spatial autocorrelation for physicians were performed with ArcGIS 10.8 software (ESRI, Redlands, CA, USA). Statistically significant results were defined as having a $P<0.05$ for all tests.

Results

Physician quantity

As shown in Fig. 1, from 2003 to 2021, the total number of physicians in Mainland China increased from 1.87 million to 4.29 million, with an annual average growth rate of 4.72%. The number of urban physicians increased from 1.22 million to 2.48 million, while rural physician numbers increased from 650,000 to 1.81 million. Physician density per thousand population increased from 1.54 in 2003 to 3.04 in 2021. Specifically, urban physician density increased from 2.13 to 3.73 per thousand population, while rural physician density increased from 1.04 to 2.42 per thousand population. Notably, the significant drop in urban physician numbers and the rapid increase in rural physicians in 2010 resulted primarily from changes in the Chinese government's urban–rural classification standards. In 2021, the rural areas saw a substantial rise in the number of physicians, whereas urban areas experienced a noticeable decline. This shift was a result of changes in population counting methods, specifically transitioning from the registered population to the count of permanent residents. From 2010 to 2020, the annual average growth rate of rural physicians was 4.25%, which was 2.3 percentage points lower than that of urban physicians.

Physician structure

As shown in Table 1, in 2003, male physicians accounted for 59% of the total, while female physicians accounted for 41%. By 2021, the proportion of female physicians had

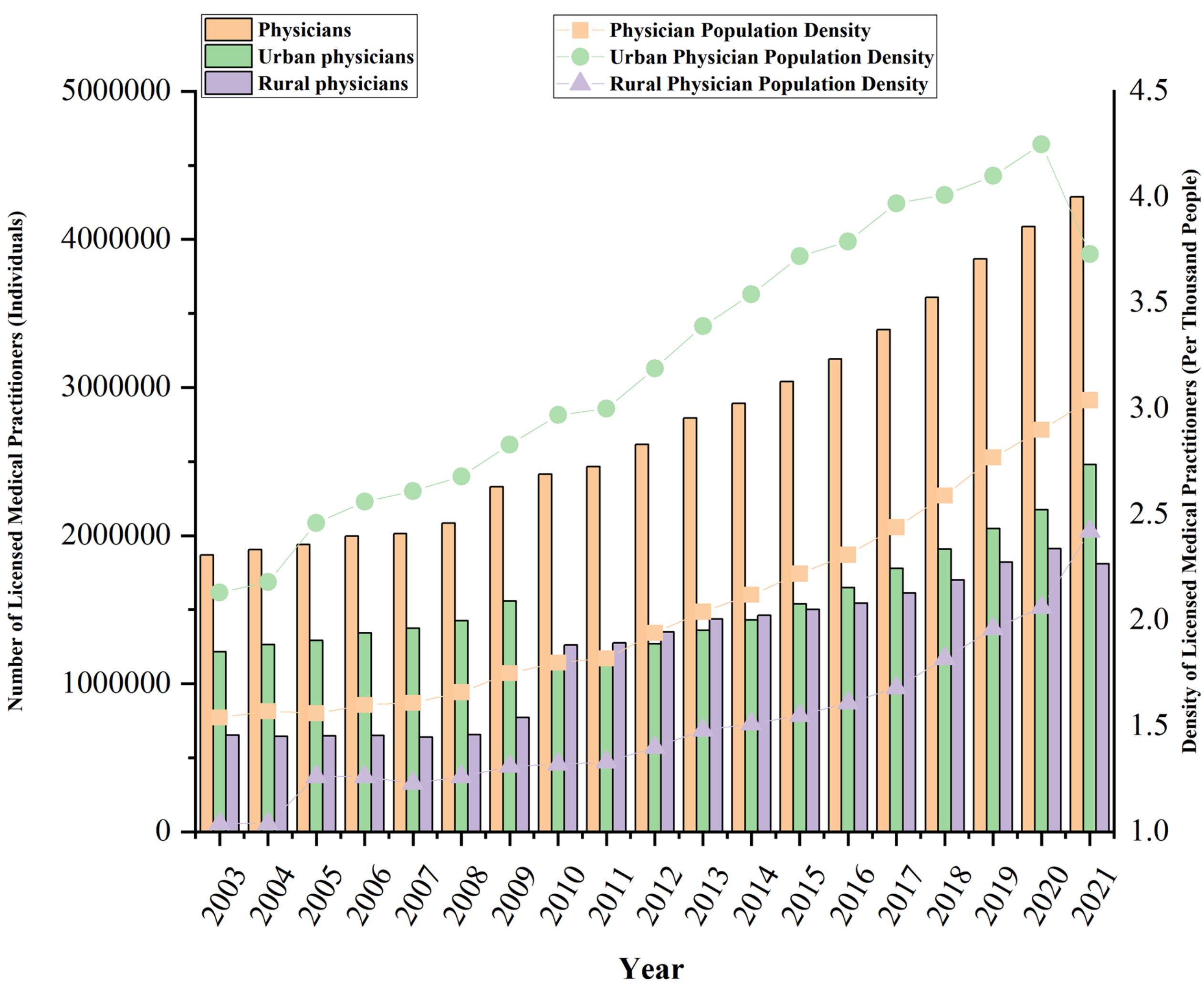

Fig. 1 Trends in the number of physicians in Mainland China from 2003 to 2021

Table 1 Gender and age distribution of physicians in 2003 and 2021

Variables	Physicians	
	2003 (%)	2021 (%)
Gender		
Male	59.0	52.5
Female	41.0	47.5
Age		
< 25 years	4.7	0.8
25–34 years	37.1	25.2
35–44 years	29.4	31.3
45–54 years	23.0	23.6
55–59 years	4.9	7.9
≥ 60 years	1.0	11.2

Table 2 Work experience, education, and title distribution of physicians in 2003 and 2021

Variables	Physicians	
	2003 (%)	2021 (%)
Work experiences		
< 5 years	12.5	16.9
5–9 years	18.5	17.6
10–19 years	30.1	24.5
20–29 years	22.6	20.9
≥ 30 years	16.2	20.1
Education levels		
Master or above	2.8	14.9
Baccalaureate	30.7	45.9
Associate degree or below	66.5	39.2
Professional titles		
Advanced title	16.0	20.4
Intermediate titles	38.9	29.7
Preliminary titles	42.5	46.7
Others	2.6	3.1

risen to 47.5%, indicating a more equitable gender distribution among physicians in Mainland China. Regarding the age structure of physicians in Mainland China, in 2021, the proportion of physicians aged 25 and below and those aged 25–34 had decreased compared to 2003 (0.8 vs. 4.7% and 25.2 vs. 37.1%, respectively), while the proportion of physicians aged 60 and above had significantly increased (11.2% vs. 1.0%).

Physician quality

As shown in Table 2, in 2021, the proportions of physicians with less than 10 years of work experience, 10 to 29 years of work experience, and over 30 years of work experience were 34.5, 45.4, and 20.1%, respectively. In 2003, these proportions were 31.0, 52.7, and 16.2%, respectively. In terms of educational attainment, physicians' educational levels have significantly improved over the past decade. In 2003, only 2.8% of physicians held master's degrees or higher, while the highest proportion held associate degrees or lower, at 66.5%. By 2021, the proportion of physicians with bachelor's degrees had increased to the highest (45.9%), and the proportion with master's degrees or higher had risen to 14.9%, while the proportion with associate degrees or lower had decreased to 39.2%. In terms of professional titles, in 2021, the proportions of physicians with primary, intermediate, and senior professional titles were 46.7, 29.7, and 20.4%, respectively. In 2003, these proportions were 42.5, 38.9, and 16.0%, respectively.

Physician distribution

As shown in Fig. 2, from 2003 to 2021, the Gini coefficient of physician human resources in Mainland China, based on population distribution, exhibited an overall decreasing trend. From 2003 to 2015, the Gini coefficient decreased steadily from 0.14 to 0.078. From 2016 to 2018, it fluctuated between 0.078 and 0.080. From 2019 to 2021, the Gini coefficient continued to decrease to 0.071. These changes indicated a gradual improvement in the fairness of physician resource allocation nationwide.

Due to significant changes in the statistical criteria for rural and urban populations in China in 2021, the analysis of the Theil index was conducted using data from 2003 to 2020. As shown in Fig. 3 and Table 3, the total Theil index decreased significantly from 0.091 in 2003 to 0.057 in 2020, reflecting notable improvements in the equity of physician distribution over time. Similarly, the inter-provincial Theil index declined from 0.014 to 0.010, while the intra-provincial (urban–rural) Theil index decreased from 0.077 to 0.047 during the same period. These trends indicate that both inter-provincial and intra-provincial (urban–rural) disparities in the distribution of physicians were reduced.

As highlighted in Table 3, the contribution rates to inequality reveal distinct patterns. The proportion of inequality attributable to inter-provincial differences fluctuated between 13.92 and 17.54%. Conversely, intra-provincial (urban–rural) differences consistently accounted for the majority of inequality, ranging from 82.46 to 86.08%. These findings underscore that intra-provincial disparities remain the primary driver of overall inequities in physician distribution across Mainland China.

As shown in Fig. 4, the trend in physician spatial distribution can be divided into three stages. The first stage,

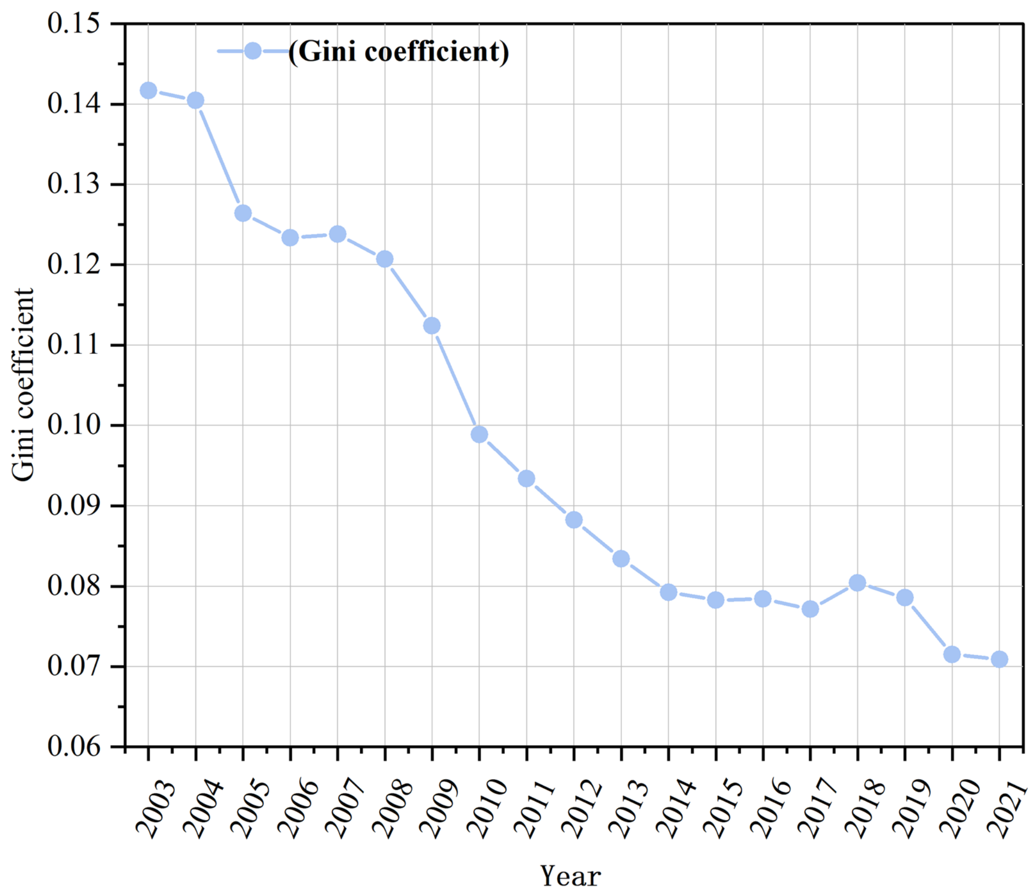

Fig. 2 Trends in the Gini coefficient of physicians in Mainland China from 2003 to 2021

from 2003 to 2012, showed positive spatial correlation in physician density ($Z > 1.96$, $p < 0.05$), with the Global Moran's I decreasing from 0.304 to 0.194. This indicated an increase in the fairness of physician spatial distribution during this stage. The second stage, from 2013 to 2016, exhibited no spatial correlation in physician density ($Z < 1.96$, $p > 0.05$), suggesting a more random distribution of physicians. In the third stage, spanning from 2017 to 2021, there was once again a positive spatial correlation in physician density ($Z > 1.96$, $p < 0.05$). The Moran's I increased from 0.145 to 0.444 during this period, signifying an escalation in regional physician clustering and a reduction in the spatial.

Figure 5 displays the results of physician density Hotspot analysis for the years 2003, 2006, 2009, 2012, 2017, and 2021. Red areas represent high-value clusters of physician distribution, while blue areas represent low-value clusters. The results showed that there were high-value Hotspot in the northern regions, mainly concentrated in Beijing and its surrounding areas. This feature was particularly pronounced in 2021, indicating a higher level of physician supply in Beijing and its surrounding areas. In the southern regions, there were low-value Hotspot, primarily in Guangxi, Guizhou, and Chongqing, suggesting lower levels of physician supply in these regions.

Discussion

Our aim is to comprehensively assess the physician workforce across four crucial aspects: quantity, quality, structure, and distribution. This systematic approach enhances our understanding of labor supply dynamics, particularly in addressing urban–rural and regional disparities. The insights gained support precise healthcare professional allocation, contributing to the progress of Healthy China [22].

From 2003 to 2021, the number of physicians in Mainland China increased from 1.87 million to 4.29 million, reflecting an average annual growth rate of approximately 4.72%, indicating significant improvements in physician quantity. Challenges persist as, in 2021, the number of practicing physicians per thousand population (3.04) falls short of the 2025 goal (3.20) [22]. In the WHO classification, Mainland China's 2.73 physicians per thousand is higher than South Korea's 2.6 but lags behind Russia's

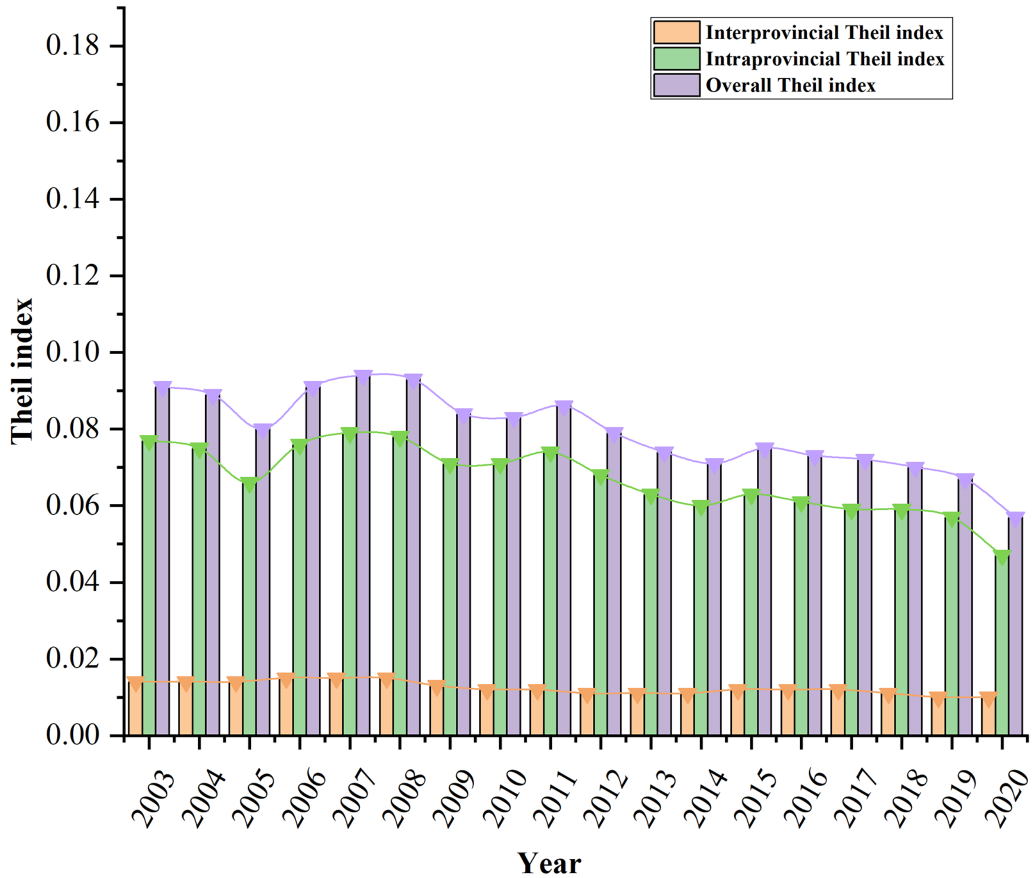

Fig. 3 Trends in Theil index of physicians in Mainland China from 2003 to 2020

[23, 24]. Considering 16.3% are assistant physicians, the ratio still trails developed countries.

Gender dynamics among Mainland China's physicians have evolved, with female physicians constituting a nearly equal share. Indeed, there has been a shift in the gender composition of physicians in many countries worldwide [25–27]. For example, since 2017, female enrollment in medical schools across the United States has surpassed that of males [28]. In China, expanding compulsory education has contributed to narrowing gender gaps at the educational level, affording women more opportunities for higher education [29]. Socially ingrained gender stereotypes steer women toward medical careers, a preference influenced by traditional role perceptions [30, 31]. Additionally, women typically possess greater empathy and excellent communication skills, which are particularly important in the field of medicine [32].

The absolute number of young physicians in Mainland China has increased from 752,000 to 1.115 million, representing a growth of approximately 48.3%. However, during the same period, the total number of physicians increased by 134.4%. As a result, the proportion of young physicians has decreased from 41.1% in 2003 to 26.0% in 2021. Therefore, the main reason for the decline in the proportion of young physicians is that the growth rate of the total physician workforce significantly outpaced the growth rate of the young physician population. This phenomenon reflects an overall expansion of the physician workforce, while the addition of young physicians has lagged behind. Consequently, the proportion of young physicians has declined despite their absolute numbers rising.

The age distribution of physicians in Mainland China reveals a decline in the proportion of young practitioners influenced by multifaceted factors. Widespread violence against medical personnel and prolonged doctor–patient conflicts have created an unfavorable practice environment, impacting young physicians' job satisfaction and career choices [33, 34]. Additionally, despite shouldering substantial workloads, young physicians face relatively low incomes. Chinese physicians aged 26 to 35 work an average of 52.43 h per week but earn an annual income of only 63,278.59 yuan [35]. In contrast, the average annual income for physicians in the United States is significantly

Table 3 Changes in the contribution rate of Theil index differences of physicians in Mainland China from 2003 to 2020. (Note: T*1L* = inter-provincial Theil index, T*2L* = intra-provincial Theil index, TL = total Theil index.)

Year	T1L	T1L/TL (%)	T2L	T2L/TL (%)	Theil L
2003	0.014	15.38	0.077	84.62	0.091
2004	0.014	15.73	0.075	84.27	0.089
2005	0.014	17.50	0.066	82.50	0.080
2006	0.015	16.48	0.076	83.52	0.091
2007	0.015	15.96	0.079	84.04	0.094
2008	0.015	16.13	0.078	83.87	0.093
2009	0.013	15.48	0.071	84.52	0.084
2010	0.012	14.46	0.071	85.54	0.083
2011	0.012	13.95	0.074	86.05	0.086
2012	0.011	13.92	0.068	86.08	0.079
2013	0.011	14.86	0.063	85.14	0.074
2014	0.011	15.49	0.060	84.51	0.071
2015	0.012	16.00	0.063	84.00	0.075
2016	0.012	16.44	0.061	83.56	0.073
2017	0.012	16.67	0.059	81.94	0.072
2018	0.011	15.71	0.059	84.29	0.070
2019	0.010	14.93	0.057	85.07	0.067
2020	0.010	17.54	0.047	82.46	0.057

higher, with specialists earning $316,000 (2.303 million yuan) and family physicians earning $217,000 (1.581 million yuan) [36]. The actual value of Chinese physicians' labor was not fully reflected in their earnings [37, 38]. As economic opportunities diversify, some medical graduates explore non-medical positions in the evolving job market [39].

In terms of physician quality, there is a notable increase in the proportion of physicians with undergraduate and higher education levels in Mainland China. However, challenges persist in the physician training and evaluation system. Public hospitals tie technical titles to remuneration, often requiring physicians to publish numerous papers for promotion [40]. This emphasis on research may overshadow the importance of healthcare service quality and clinical skills. Acknowledging this, the Chinese government introduced the Guiding Opinions on Deepening the Title System for Health Professionals in 2021, shifting the evaluation criterion to prioritize clinical proficiency over research publications [41].

Additionally, despite the significant improvement in the educational backgrounds of mainland Chinese physicians, it is essential to note the heterogeneity within the physician workforce. A recent study has indicated substantial disparities among physicians in different levels of hospitals concerning standardized patient management [42]. The accuracy of management by physicians in county-level hospitals is 90%, while in township health centers and rural physicians, it is 38% and 28%, respectively. In a vast and densely populated country like China, there is a delicate balance between medical quality (medical elitism) and accessibility (equity in healthcare resource distribution). China places a stronger emphasis on the latter. In 2020, China implemented nationwide standardized residency training to enhance the homogeneity of physician quality [43].

Regarding the equitable distribution of physicians in Mainland China, our study conducted a comprehensive trend analysis of the Gini coefficient of physicians since 2003. Consistently below the 0.2 threshold, this coefficient demonstrates a continual decline, suggesting an overall more equitable physician distribution in the country, aligning with prior research [44]. To explore regional equity further, we calculated the Theil index. While improvements were observed between provinces and urban–rural areas, disparities between urban and rural regions persist. Despite various measures post the 2009 healthcare reform to promote equity [45], our study indicates the need for more effective strategies. Narrative reviews of physicians staying in rural areas highlight the significance of a sense of belonging shaped by community support, familial integration, rural upbringing, and positive workplace interactions [46, 47].

The spatial distribution of physicians in Mainland China reveals regional disparities between the North and South. A consistent trend of high-density physician clustering in northern regions is observed, attributed to a robust economic foundation, rapid urbanization, and abundant medical education institutions, particularly around Beijing. Conversely, southern regions exhibit sparser physician distribution, possibly due to complex geography in the southwest, an agriculture-based economy, and slower infrastructure development. Moreover, the spatial distribution of physicians in Mainland China has shown a pattern of initially decreasing and then increasing clustering tendencies. The healthcare reform introduced in 2009 led to a rapid reduction in spatial distribution disparities, resulting in a trend toward greater balance. However, since 2019, the Global Moran's I has sharply increased, reflecting a more pronounced clustering of physicians, especially in northern regions. This surge in clustering can be attributed to several factors, including slowed population growth, increased mortality rates in northern regions, and a reduction in interprovincial mobility, particularly due to the COVID-19 pandemic [48, 49]. The higher mortality rates in northern regions could have further exacerbated the physician density in these areas, as physicians may have concentrated in regions with higher healthcare demands. The pandemic also restricted the movement of physicians

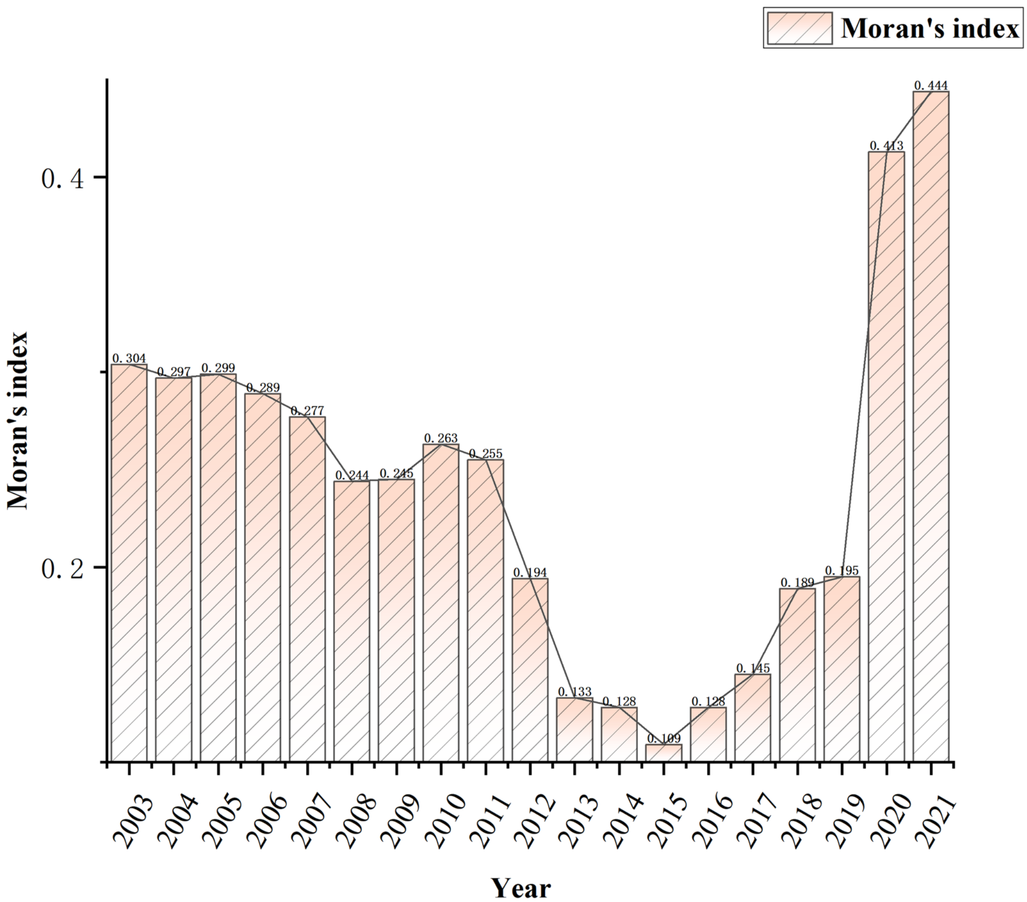

Fig. 4 Trends in the Global Moran's *I* of physicians in Mainland China from 2003 to 2021

between provinces, further amplifying these regional disparities [50].

This study presents several limitations. Firstly, our examination of clinical physicians' distribution is confined to the provincial level, necessitating future research to encompass municipal and county levels for a more comprehensive analysis. Secondly, the study does not distinguish between practicing and assistant physicians, potentially leading to an overestimation of physician supply in regions that are relatively underserved. Moreover, ongoing modifications to national health statistics data collection methods may impact our analysis. Lastly, the study only includes data up to 2022, preventing an assessment of physician quantity, quality, structure, and distribution post-pandemic. Future research should explore changes pre- and post-outbreak for a more holistic perspective. Additionally, the data used in this study do not include detailed information on the educational backgrounds of physicians by urban and rural areas, which is closely linked to healthcare quality.

Conclusion

Mainland China has witnessed notable advancements in healthcare, encompassing physician quantity, gender balance, and overall healthcare quality, driven by successive reform policies. However, a troubling decline in the proportion of young physicians and persistent geographical imbalances in physician distribution present new challenges. Addressing strained doctor–patient relationships, adjusting physician income levels, and enhancing the precise and equitable distribution of medical resources are urgent imperatives for the healthcare system.

What is already known on this topic?

In an effort to address concerns in market-oriented healthcare reform, China has been implementing a range of reforms since 2003 to improve the fair distribution of medical resources.

No article was found to systematically study physician resources in terms of quantity, quality, structure, and geographical distribution.

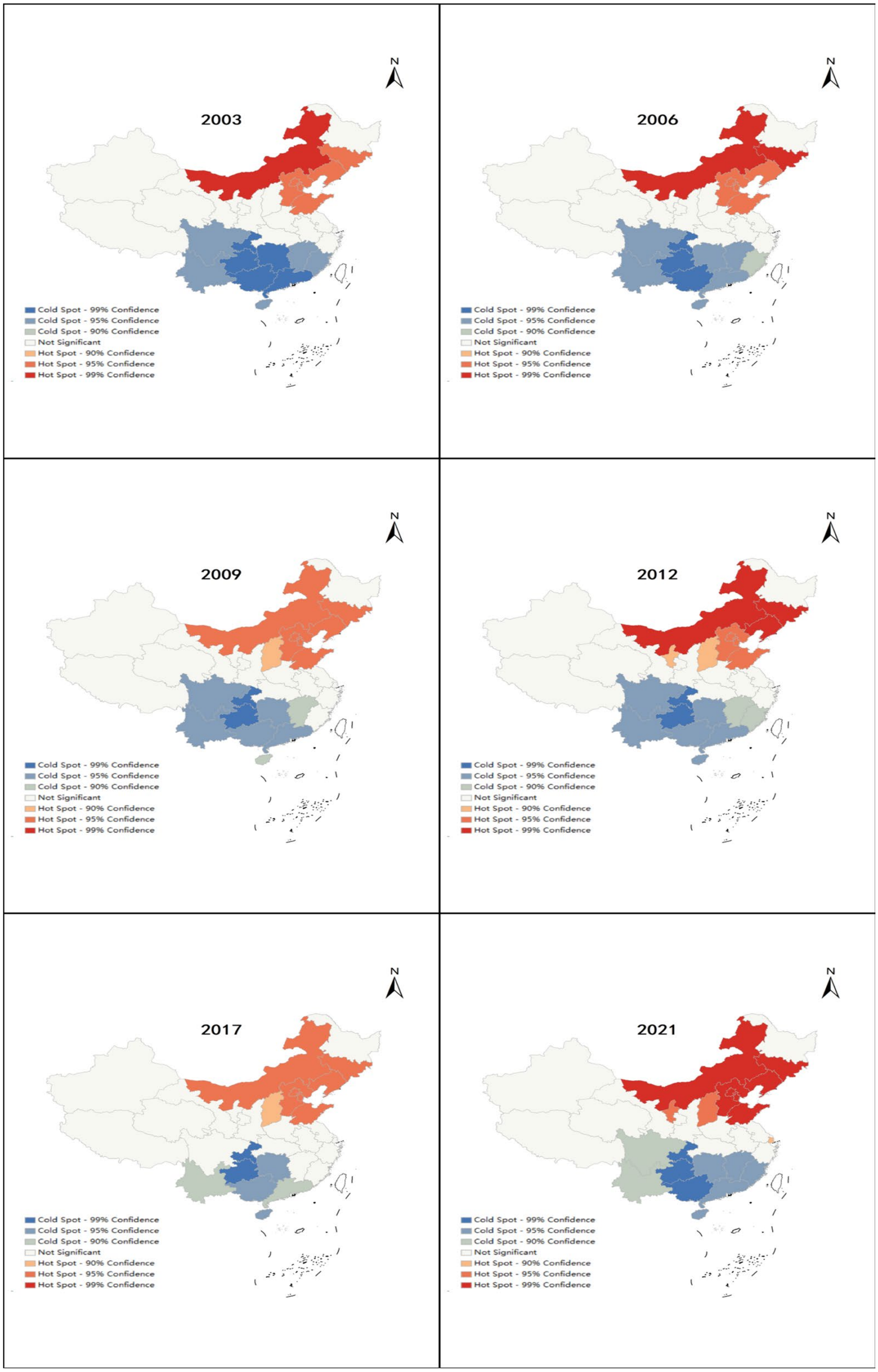

Fig. 5 Results of Hotspot analysis of physician density in Mainland China from 2003 to 2021

What this study adds?

The decline in young physicians and worsening regional disparities pose challenges despite improvements in the quantity and quality of physicians.

How this study might affect research, practice or policy

To retain and attract medical talent, the government may offer competitive salaries, improved working conditions, and career development opportunities, especially for young physicians.

To address regional disparities, the government may focus on enhancing the primary healthcare system, improving facilities, talent, and technology to alleviate the imbalance in medical resources across regions.

Abbreviation

GDP Gross domestic product

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Author contributions

Y.X. conceived and designed the study, conducted the investigation, curated the data, and prepared the original draft. Z.Z. contributed to the conceptualization and reviewed and edited the manuscript. C.M.X. developed the methodology, performed formal analysis, and curated the data. J.Y.Y. curated the data and reviewed and edited the manuscript. T.T.C. contributed to the methodology, curated the data, and created the visualizations. S.W.J. conducted the investigation, provided resources, and validated the results. N.D. developed the methodology, curated the data, and created the visualizations. S.Y.Z. validated the results and reviewed and edited the manuscript. J.H.W. contributed to the conceptualization and reviewed and edited the manuscript. All authors reviewed the manuscript.

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Data availability

The data can be obtained from a public, open-access database. Information regarding data access policies and procedures can be found at https://data.cnki.net/yearbook.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Author details

[1]Psychosomatic Medical Center, The Fourth People's Hospital of Chengdu, No.8, Huli West Lane 1, Yingmenkou Road, Chengdu 610036, People's Republic of China. [2]Department of Gastroenterology, Xiangyang No.1 People's Hospital, Hubei University of Medicine, 15 Liberation Road, Xiangyang 441000, People's Republic of China. [3]Mental Health Center, West China Hospital of Sichuan University, Chengdu, People's Republic of China. [4]Department of Psychiatry, Shantou University Mental Health Center, Shantou, People's Republic of China.

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