



Trend and Equity in Maternal and Child Health Resource Allocation in China Since the New Health System Reform: A Nationwide Study from 2008 to 2020

Yuanna Zhou*, Lin Han*, Wuxing Zhang, Yujun Fan, Wenjian Liu , Muzi Liu, Yishan Fan, Xiaoyuan Qu *

School of Nursing and Health, Henan University, Kaifeng, Henan, People's Republic of China

*These authors contributed equally to this work

Correspondence: Xiaoyuan Qu, School of Nursing and Health, Henan University, Jinming Avenue, Kaifeng City, Henan Province, People's Republic of China, Email quxiaoyuan@henu.edu.cn

Purpose: China has made considerable efforts to promote the development of maternal and child health (MCH) care since the new health system reform in 2009. This study aims to evaluate the trend and equity of MCH resources allocation in China from 2008 to 2020 and provide a reference for rational distribution of MCH resources.

Methods: Data were collected from the China Health Statistics Yearbook and China Statistics Yearbook. The number of MCH hospitals, licensed (assistant) physicians, registered nurses and beds were selected for the measurement of the equity of MCH resources allocation. The Health Resource Agglomeration Degree and Theil index were used in evaluating MCH resource allocation equity and to compare differences among regions.

Results: From 2008 to 2020, the average annual growth rates for MCH hospitals, beds, licensed (assistant) physicians, and registered nurses were 0.72%, 6.95%, 5.04%, and 9.57%, respectively. However, regional disparities in the equity of MCH resource allocation have been identified. Although the western region has shown growth in MCH resource allocation by geography, the agglomeration degree of the four indicators remains less than 1, significantly lower than the average value of greater than 2 in the eastern region. Additionally, the equity of human resource allocation in the western region is lower than the equity in the allocation of institutions. In the densely populated eastern region, the equity of MCH resource allocation by population is decreasing, with the agglomeration degree of all four indicators below 1 in 2020. The disparity in healthcare resource allocation within regions is the main cause of inequitable MCH resource allocation in China.

Conclusion: The allocation of MCH resources in China has improved since 2009, however, geographic equity needs further improvement, particularly in densely populated regions. Population and geographic balances should be considered in the development and implementation of MCH resource allocation policies, and improving intraregional equity should be the focus.

Keywords: maternal and child health, resources allocation, equity, health resource agglomeration degree, theil index

Introduction

The Millennium Development Goals (MDGs) of the United Nations include two indicators for maternal and child health (MCH): reducing under-five mortality and improving maternal health.¹ The World Health Organization reported that in 2015, approximately 303,000 women died during and after pregnancy and childbirth, with roughly 830 women dying daily from related complications worldwide.² In 2018, 5.3 million children under five died, with high mortality rates for pregnant women and children mainly in developing countries.³ The Global Strategy for the Health of Women, Children, and Adolescents (2016–2030) proposes that by 2030, every woman, child, and adolescent in diverse environments should

have the right to physical and mental health and happiness.⁴ As a vital part of the public health system, the allocation of MCH care resources is crucial to the health of women and children and directly impacts the quality of MCH services.

As the world's largest developing country, China became a signatory to the MDGs in September 2000 and included women and children as focus groups in the Healthy China 2030 Planning Outline.⁵ Over the past decades, China has made significant efforts to develop MCH care, especially after the 2009 health system reform. China has consistently increased investment in MCH care through several key measures. First, China established universal health insurance coverage.⁶ Second, China implemented the “National Essential Public Health Programmes (NEPHPs)” and the “National Major Public Health Services (NMPHSs).” NEPHPs are provided free at community, township, and village health centers, while NMPHSs are free or subsidized, prioritizing rural and poor areas in central and western China.^{7,8} NEPHPs include immunization, health management for children 0–6 years old, and antenatal and postnatal healthcare. For NMPHSs, central government funding for MCH was 29.05 billion RMB from 2009 to 2020. Third, China added two elements to the Maternal and Child Health Surveillance System. In 2010, hospital-based maternal near-miss monitoring was introduced to collect in-depth information on severe maternal morbidity. In 2012, population-based data on growth and anemia in children under five were added.⁹ There has been a remarkable improvement in MCH in China. The maternal and under-five mortality rates decreased from 31.9/100,000 and 17.2/1000 in 2009 to 16.1/100,000 and 7.1/1000 in 2021.^{10,11} A systematic analysis from the Global Burden of Disease Study 2017 predicts that China will meet four MCH-related SDGs by 2030, including targets for maternal mortality, neonatal mortality, under-five mortality, and skilled birth attendance.¹²

However, progress has been uneven and inequitable among different regions within China. Low- and middle-income areas, such as Southwest China, have higher maternal and child mortality rates compared to economically developed regions.¹³ These geographic disparities may partly result from differences in the equity of MCH resource allocation among these regions.^{14–17} Additionally, China is undergoing a rapid demographic transition with an increasingly aging population and low fertility rates, and thus improving MCH care is vital for the country.⁹ Consequently, research on the equity of MCH resource allocation has long been a priority. Most studies have focused on MCH resource allocation equity in a particular region or province and health human resource allocation equity in MCH institutions.^{14–17} However, these studies did not observe changes in MCH resource allocation equity because of their short time spans, and no studies have analyzed MCH resource allocation equity at the national level in China. Therefore, it is necessary to assess the equity of MCH resource allocation in different regions of China over a period of time.

The Gini coefficient has been used in analyzing MCH resource allocation equity in China.¹⁴ However, it can only reflect the overall degree of fairness and cannot evaluate regional unfairness.¹⁸ The equity of MCH resource allocation involves two aspects: population allocation equity, which refers to the number of human resources for health per thousand people in different regions; and geographical distribution equity, which refers to the public equity of the spatial distance of human resources for health. The number of human resources for health in each square kilometer of a region should be equal.¹⁹ The Health Resource Agglomeration Degree (HRAD) is a new index introduced by Chinese scholars Yuan et al in recent years to evaluate the equity of health resource allocation. It considers the influence of both population and geography simultaneously, measures the inequity in regional health resource allocation in different groups, and prevents bias caused by a single population and geographical factors.^{20,21}

Based on the above reasons, this study collected longitudinal data spanning 13 years and used the HRAD and Theil index to comprehensively evaluate and analyze the current situation, trend, and levels of MCH resource allocation equity in China since the new health system reform. The aims were to provide valuable information for policymakers to plan the allocation of MCH resources and improve the health status of mothers and children.

Methods

Data Sources

The year-end population and jurisdiction area of each region were obtained from the China Statistics Yearbook (2009–2021). Data related to MCH resources and services were obtained from the China Health Statistics Yearbook (2009–2013;2018–2021), and the China Health and Family Planning Statistics Yearbook (2014–2017), covering all public MCH

hospitals and their practicing (assistant) physicians, registered nurses, and beds in 31 provinces, autonomous regions, and municipalities (except the Macao Special Administrative Region, Hong Kong Special Administrative Region, and Taiwan Province). The 31 provinces, autonomous regions, and municipalities were divided into eastern, central, and western regions, according to the China Health Statistics Yearbook (2021). The eastern region included Beijing, Hebei, Tianjin, Liaoning, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Guangdong, and Hainan (11 areas). The central region included Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan (eight areas). The western region includes Inner Mongolia, Chongqing, Guangxi, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang (12 areas; Figure 1).

Indicators

Referring to previous studies, Human and material resources are considered important for the delivery of health services.^{14,21} Human resource indicators include the number of licensed (assistant) physicians and registered nurses in MCH hospitals (MCHHs). The material resource indicators include the number of MCHHs and beds in MCHHs. These indicators are commonly used to evaluate the equity of health resource allocation, and can reflect the overall health resource allocation situation.^{14,21} Given the availability and continuity of data, this study selected these four indicators to evaluate equity in MCH care resource allocation. These data are all sourced from records in the national official statistical yearbooks. The definitions of the four indicators are shown in Box 1.

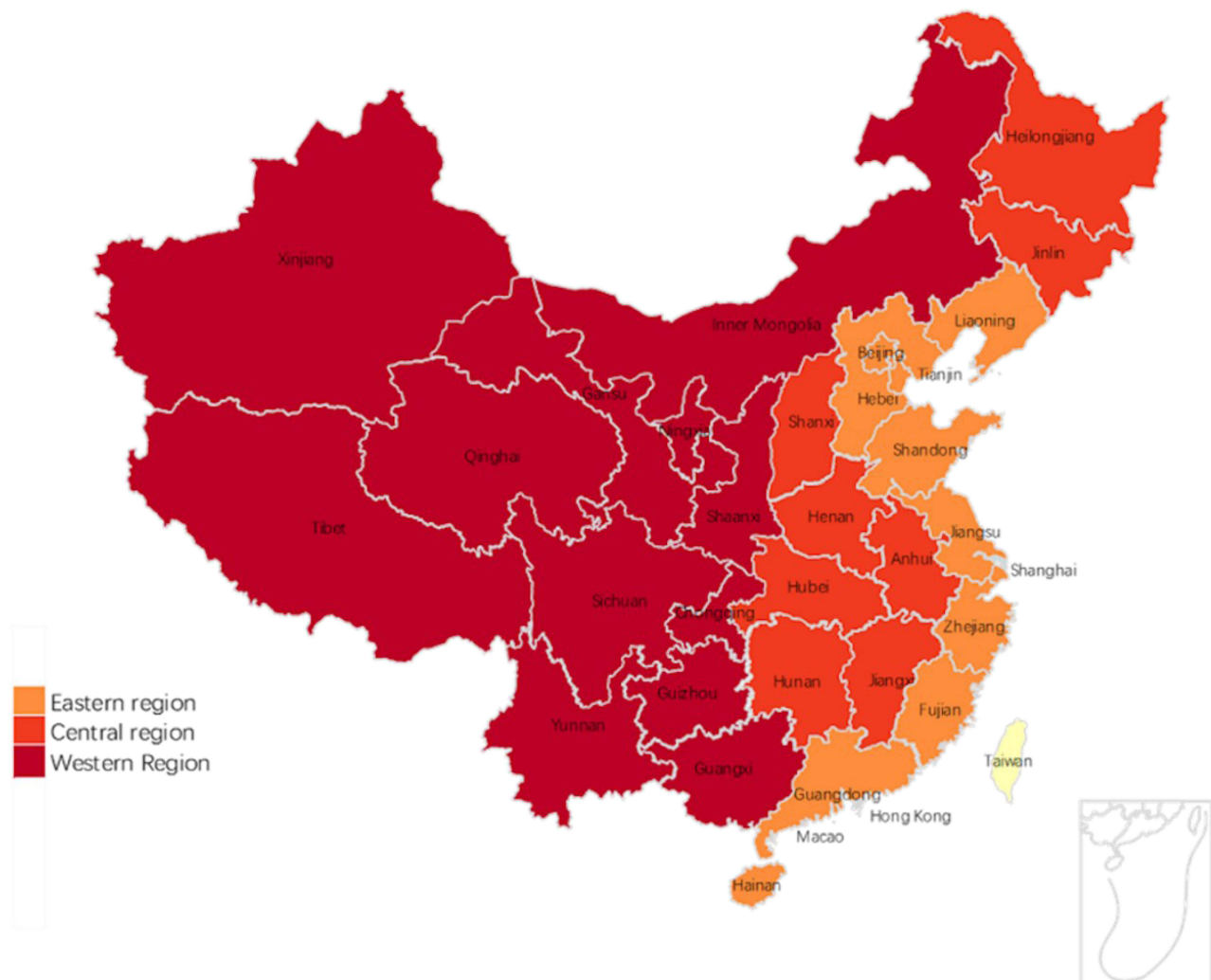


Figure 1 Division of eastern, central and western regions of China.

Box 1 Definition of Four Indicators

Indicators	Definition
Number of MCHHs	The total number of maternal and child health hospitals at the end of the year from national healthcare databases
Number of beds in MCHHs	Practical beds in MCHHs (also referred to as the number of actual beds)
Number of licensed (assistant) physicians	The total number of doctors and assistant doctors in MCHHs at the end of the year who have obtained registration certificates and are actually engaged in disease prevention and control, medical treatment or maternal and child health care
Number of registered Nurses	The total number of nurses at the end of the year who are certified nurses and are actually engaged in nursing work in MCHHs

Analysis Strategy

We analyzed the trend and equity in MCH resource allocation in 2008–2020 in China from the national and area levels. The analyzed parameters included the HRAD and the Theil index. We also used absolute numbers and average growth rates to analyze changes and reflect average development trends in the total amount of MCH resources, and numbers per 10,000 people indicated the resource allocation based on population. The research findings can prompt the government to comprehend the current state of MC resource allocation across various regions in China, guiding their focus towards areas with insufficient resources and thereby providing appropriate policy support.

Health Resource Agglomeration Degree

By using the HRAD to evaluate the equity of health resource allocation, we can consider the influences of both population and geography. The formula of agglomeration degree based on geographical area as follows:

$$HRAD_i = \frac{HR_i/HR_n \times 100\%}{A_i/A_n \times 100\%} = \frac{HR_i/A_i}{HR_n/A_n}$$

In the above formula, HRAD_i represents the health resource agglomeration degree of region *i*, HR_i represents the quantity of MCH resources in region *i*, and the HR_n represents the total amount of MCH resource, A_i represents the land area in region *i*, and A_n represents the total land area. This formula measures the agglomeration degree of health resources in a particular region according to the geographic dimension.

Population agglomeration degree (PAD) is used in demographic research to reflect the indicator of the degree of population agglomeration of a region relative to the whole country,²² and the calculated formula is as follows:

$$PAD_i = \frac{(P_i/P_n) \times 100\%}{(A_i/A_n) \times 100\%} = \frac{P_i/A_i}{P_n/A_n}$$

where PAD_i represents the PAD in the *i* region, P_i represents the number of population in the *i* region, and P_n represents the total number of population in China.

Evaluation criteria: If the HRAD_i is 1, the allocation of MCH resource according to geographical distribution is absolutely equitable in the *i* region. An HRAD_i close to 1 means that the amount of MCH resources in the area of the land occupying 1% of the country is close to 1%, indicating that the equity in MCH care resources allocation in the *i* region is good. If the ratio of HRAD_i to PAD_i is 1, the allocation of MCH resource according to population distribution is absolutely equitable in the *i* region. If the ratio of HRAD_i to PAD_i close to 1, the equity of distribution in terms of population is better, shows that the MCH care resources in the *i* region basically meet the medical needs of the concentrated population and the residents have better access to health services.^{22,23} In this study, the concept of HRAD is further embodied as the evaluation of the agglomeration degree of MCH hospitals, bed numbers, licensed (assistant) physicians and registered nurses.

Theil Index

The Theil index named for the researcher who first proposed it in 1967,²⁴ is used to measure the equity in resource allocation in a certain region and is a relative indicator that ranges from 0 to 1. A smaller Theil index value indicates

a more equitable condition.²⁵ The advantage of the Theil index is that it can measure the contribution of intra- and inter-regional differences to total inequity.²⁶ The Theil index can be calculated as follows:

$$T = \sum_{i=1}^n P_i \log \frac{P_i}{Y_i}$$

T: Theil index.

P_i: proportion of population in one area accounting for the total population.

Y_i: proportion of MCH care resources in one area accounting for the total MCH care resources.

China can be divided into three regions: eastern, central, and western; thus, the Theil index can be decomposed into T_{inter} and T_{intra}. Calculating the contribution rate of inequity in various regions allows us to assess how regional disparities influence the overall inequity of health resource allocation across the entire country. This analysis enhances our understanding of the causes behind these inequities and can guide efforts to improve the equitable distribution of health resources. The contribution rate of intra-class inequity is the ratio of T_{intra} to the Theil index, and the contribution rate of inter-class inequity is the ratio of T_{inter} to the Theil index.²⁶

$$T = T_{intra} + T_{inter}$$

$$T_{intra} = \sum_{g=1}^k P_g T_g$$

$$T_{inter} = \sum_{g=1}^k P_g \log \frac{P_g}{Y_g}$$

T_{intra}: degree of equity in MCH care resources distribution within the group.

T_{inter}: degree of equity in MCH care resources between the groups.

P_g: proportion of population in one group accounting for the total population.

Y_g: proportion of MCH care resources in one group accounting for the total MCH care resources.

T_g: Theil index of MCH care resources distribution in subgroups.

Results

The Situation of MCH Care Resource Allocation in China

At the end of 2020, a total of 3052 MCHHs were operating in China, with 948 (31.06%) in the eastern region, 968 (31.72%) in the central region, and 1136 (37.22%) in the western region. The total number of beds in MCHHs nationwide was 250,864, with 92,087 (36.71%) in the eastern region, 82,359 (32.83%) in the central region, and 76,418 (30.46%) in the western region. The total number of MCH healthcare workers was 348,076, comprising 152,076 licensed (assistant) physicians and 196,000 registered nurses. The eastern region had the highest number of licensed (assistant) physicians (61,983, 40.76%) and registered nurses (74,317, 37.92%), whereas the western region had the fewest physicians (43,695, 28.73%), and the central region had the fewest nurses (59,626, 30.42%) (Table 1).

The total number of MCHHs in China showed a growing trend from 3011 in 2008 to 3144 in 2013, with an average growth rate of 0.72%. However, it decreased from 3098 in 2014 to 3052 in 2020, and the reduction in the number of institutions was mainly in Hebei Province in the eastern region. The number of MCHHs in the eastern and western regions increased from 938 and 1104 in 2008 to 948 and 1136 in 2020, with an average annual growth rate of 0.08% and 0.22%, respectively. Meanwhile, the number of MCHHs in the central region shows an upward and then downward trend, with an average annual growth rate of -0.01%. Compared with 2008, the number of MCHHs per 10,000 people nationwide dropped from 0.023 to 0.022 in 2020. The number in the eastern regions dropped from 0.018 to 0.016, whereas the number in the central and western regions remained unchanged at 0.023 and 0.030, respectively.

The number of beds, licensed (assistant) physicians, and registered nurses in MCHHs all continued to increase from 2008 to 2020, with average annual growth rates of 6.95%, 5.04%, and 9.57%, respectively (Table 1). In the MCHHs in the western region, the number of beds increased from 33,054 to 76,148, and the number of registered nurses increased from 15,620 to 62,057 from

Table I MCH Resource Allocation in China from 2008 to 2020

		2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Average Annual Growth Rate (%)
MCHHs	Eastern	938	937	934	942	950	1034	995	971	955	960	957	954	948	0.08
	Central	969	980	986	985	982	986	985	983	984	979	984	975	968	-0.01
	Western	1104	1103	1105	1109	1112	1124	1118	1124	1124	1138	1139	1142	1136	0.22
	Total	3011	3020	3025	3036	3044	3144	3098	3078	3078	3063	3077	3080	3071	3052
Beds	Eastern	44915	47,350	50,343	54,085	61,161	66,078	68,996	72,711	75,810	82,161	85,996	91,076	92,087	5.68
	Central	38842	42,553	45,282	48,507	53,814	58,976	63,021	66,873	70,823	74,334	79,172	80,085	82,359	5.95
	Western	33504	36,206	38,739	42,359	46,585	50,422	52,798	55,768	59,905	64,641	67,680	72,071	76,418	6.55
	Total	117261	126,109	134,364	145,866	161,560	175,476	184,815	195,352	206,538	221,136	232,848	243,232	250,864	6.95
Licensed (assistant) physician	Eastern	31454	32,419	33,567	34,588	36,981	39,737	40,169	42,884	46,233	51,150	54,668	58,986	61,983	5.36
	Central	26292	27,854	28,512	28,312	29,473	30,524	31,696	34,284	37,833	40,741	43,313	44,009	46,398	4.47
	Western	22493	23,487	23,853	24,169	24,881	26,292	26,883	28,664	32,458	35,508	37,349	39,884	43,695	5.24
	Total	80239	83,760	85,932	87,069	91,335	96,553	98,748	105,832	116,524	127,399	135,330	142,879	152,076	5.04
Registered nurses	Eastern	25369	27,744	29,592	33,995	38,505	42,917	45,664	49,763	54,246	60,700	64,723	70,825	74,317	8.62
	Central	18781	21,310	23,511	26,203	30,266	33,125	36,749	39,916	44,420	48,354	52,592	57,153	59,626	9.29
	Western	15620	17,974	20,092	22,293	25,294	28,183	31,799	34,735	39,600	46,136	41,297	56,732	62,057	11.20
	Total	59770	67,028	73,195	82,131	94,065	104,225	114,212	124,414	138,266	155,190	167,702	184,710	196,000	9.57

2008 to 2020, showing average annual growth rates of 6.55% and 11.2%, respectively. The number of licensed (assistant) physicians in MCHHs in the eastern region rapidly increased from 31,454 in 2008 to 61,983 in 2020, with an average annual growth rate of 5.36%. In terms of the total number of beds, licensed (assistant) physicians, and registered nurses in MCHHs, the central and western regions had fewer resources than the eastern region in 2020.

As shown in [Figure 2](#), the number of beds in MCHHs per 10,000 people nationwide increased from 0.343(2008) to 0.653 (2020). The number in the eastern, central, and western regions increased from 0.859, 0.924, and 0.917 to 1.517, 1.960, and 1.995, respectively. The number of beds in MCHHs per 10,000 people increased in 31 provinces, except in Shanghai and Tibet. Hainan showed the largest increase (from 0.898 in 2008 to 2.158 in 2020). The values in three provinces were >2, and five areas had values <1. In the central region, four provinces had values higher than 2, and no province showed a decrease. In the western region, Guangxi ranked first in 2008 and 2020, showing a value of 3.19 in 2020 and being the only province with a value higher than 3. Shaanxi (2.407), Guizhou (2.356), and Ningxia (2.222) were ranked first nationwide. The number of beds in MCHHs per 10,000 people in Guangxi (1.396) was 5.3 times greater than that in Jiangsu (0.259) in 2008 and 7.4 times greater than that in Liaoning (0.429).

The number of licensed (assistant) physicians in MCHHs per 10,000 people nationwide increased from 0.240 in 2008 to 0.440 in 2020, and the number in the eastern, central, and western regions increased from 0.602, 0.626, and 0.616 to 1.021, 1.104, and 1.141, respectively. Compared with 2008, the number of licensed (assistant) physicians in MCHHs per 10,000 people increased in 2020 in all areas except for Shanghai, Liaoning, and Tianjin in the eastern region and Tibet in the western region. In the eastern region, Hainan, Guangdong, Fujian, Zhejiang, Shandong, Hebei, and Beijing had more than 1 licensed (assistant) physician in the MCHHs per 10,000 people. In the central region, all provinces had more than one licensed (assistant) physician in the MCHHs per 10,000 people, except for Shanxi, Anhui, Heilongjiang, and Jilin. In the western region, differences were found among provinces, and Ningxia (1.687) and Guangxi (1.659) had the highest values.

The number of registered nurses in MCHHs per 10,000 people nationwide increased from 0.194 in 2008 to 0.527 in 2020, and the number in the eastern, central, and western regions increased from 0.485, 0.447, and 0.428 to 1.225, 1.419, and 1.620, respectively. Only Shanghai and Tianjin in the eastern region showed a decrease, while the other provinces showed an increase. Guangxi (2.663) in the western region had the largest number of registered nurses in MCHHs per 10,000 people and was the only area with a value higher than 2. In the eastern region, seven provinces had values exceeding 1, but the number in Liaoning remained unchanged compared with the number in 2008, and had the lowest number of registered nurses per 10,000 people among all provinces. In the central region, Henan, Hubei, Hunan, and Jiangxi had more than 1.5 registered nurses in MCHHs per 10,000 people, whereas the other four provinces had less than 1. In the western region, except for Tibet, Xinjiang, and Qinghai, the number of registered nurses in MCHHs per 10,000 people in the other provinces was higher than 1.2.

It is worth noting that in 2008, the central region had the highest number of beds and licensed (assistant) physicians in MCHHs per 10,000 people, and the eastern region had the highest number of registered nurses per 10,000 people. However, by 2020, the western region had surpassed both the central and eastern regions, having the highest number of beds, licensed (assistant) physicians, and nurses in MCHHs per 10,000 people.

Agglomeration Analysis of the MCH Care Resource Allocation Nationwide The Overall Situation in 2020

Agglomeration Analysis Based on Geographic Area Allocation

As shown in [Table 2](#), considerable differences in the degree of agglomeration of the four indices were found among regions and within a region. At the geographical level, the degree of agglomeration of MCHHs (0.52), beds (0.43), licensed (assistant) physicians (0.40), and nurses (0.44) was far below the value of 1 in the western region, indicating the inequity of MCH care resources allocation. In the central region, the degree of agglomeration of MCHHs (1.84), beds (1.90), licensed (assistant) physicians (1.77), and nurses (1.76) was greater than 1, indicating a relatively equitable allocation of MCH care resources. In the eastern region, the degree of agglomeration of MCHHs (2.78), beds (3.28), licensed (assistant) physicians (3.64), and nurses (3.39) was far greater than 1, indicating a high concentration of MCH care resource allocation. The degree of agglomeration of the four indicators of MCH care resources in Beijing, Shanghai, and Hainan provinces were far greater than 1, indicating that the allocation of MCH care resources was overconcentrated in terms of geographical area, and these provinces were distributed in the eastern region. The degree of agglomeration of the four indicators of MCH care resources in Inner Mongolia, Heilongjiang, Tibet,

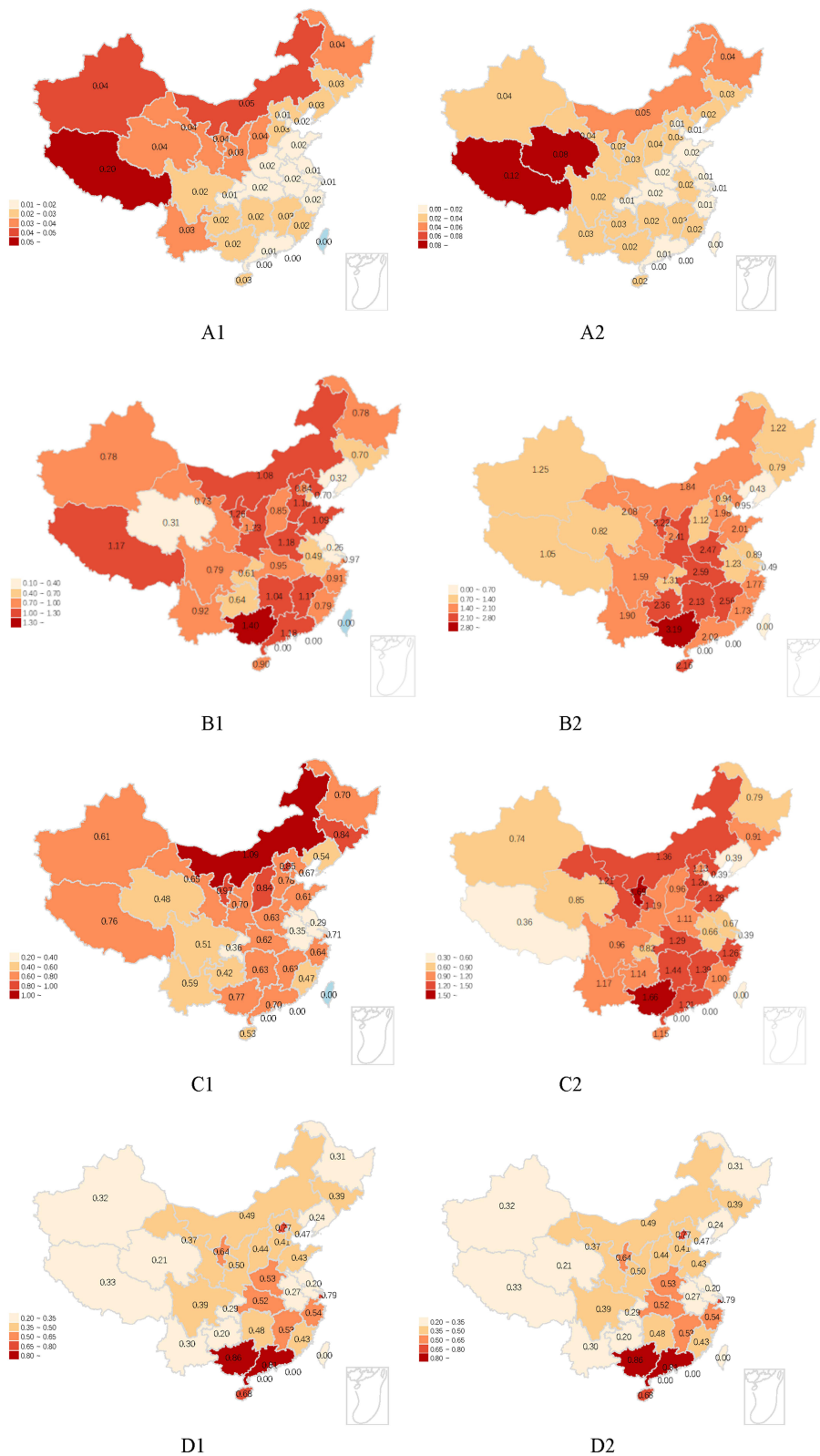


Figure 2 Distribution map of MCH care resources per 10,000 people in 2008 and 2020. **(A1)** Distribution map of MCHHs in 2008. **(A2)** Distribution map of MCHHs in 2020. **(B1)** Distribution map of the beds of MCHHs in 2008. **(B2)** Distribution map of the beds of MCHHs in 2020. **(C1)** Distribution map of the licensed (assistant) physicians of MCHHs in 2008. **(C2)** Distribution map of the licensed (assistant) physicians of MCHHs in 2020. **(D1)** Distribution map of registered nurses in MCHHs in 2008. **(D2)** Distribution map of registered nurses in MCHHs in 2020.

Table 2 Analysis of MCH Resources Agglomeration in China in 2020

Area	PADI	MCHHs		Beds		Physician		Nurses	
		HRADi	Ratio	HRADi	Ratio	HRADi	Ratio	HRADi	Ratio
Eastern region	3.85	2.78	0.72	3.28	0.85	3.64	0.95	3.39	0.88
Central region	1.73	1.84	1.06	1.90	1.10	1.77	1.02	1.76	1.02
Western region	0.38	0.52	1.37	0.43	1.12	0.40	1.06	0.44	1.17
Beijing	5.450	2.089	0.383	2.903	0.533	5.742	1.054	4.361	0.800
Tianjin	5.420	2.865	0.529	/	/	1.744	0.322	1.254	0.231
Hebei	1.656	1.871	1.130	1.798	1.086	1.800	1.087	1.168	0.705
Liaoning	1.216	1.141	0.938	0.285	0.234	0.425	0.350	0.300	0.247
Shanghai	15.899	5.707	0.359	4.415	0.278	5.866	0.369	4.509	0.284
Jiangsu	3.165	2.087	0.659	1.647	0.520	2.057	0.650	1.521	0.481
Zhejiang	2.299	1.658	0.721	2.513	1.093	2.940	1.279	2.195	0.955
Fujian	1.333	1.462	1.097	1.352	1.014	1.291	0.969	0.899	0.675
Shandong	2.639	1.924	0.729	2.991	1.133	3.138	1.189	2.245	0.851
Guangdong	2.660	1.377	0.518	3.278	1.232	3.234	1.216	2.283	0.858
Hainan	5.229	6.092	1.165	6.745	1.290	5.909	1.130	4.407	0.843
Shanxi	0.987	1.566	1.587	0.575	0.583	0.816	0.827	0.563	0.570
Jilin	0.756	0.902	1.193	0.296	0.392	0.562	0.744	0.396	0.523
Heilongjiang	0.398	0.637	1.602	0.228	0.574	0.246	0.617	0.168	0.422
Anhui	1.886	1.671	0.886	1.239	0.657	1.098	0.582	0.766	0.406
Jiangxi	1.160	1.300	1.121	1.605	1.383	1.443	1.243	1.023	0.881
Henan	2.439	1.892	0.776	3.469	1.422	2.565	1.052	1.700	0.697
Hubei	1.622	1.268	0.782	2.276	1.403	1.868	1.152	1.290	0.796
Hunan	1.461	1.327	0.908	1.671	1.143	1.867	1.278	1.310	0.896
Inner Mongolia	0.159	0.327	2.059	0.155	0.974	0.188	1.184	0.131	0.823
Guangxi	0.861	0.837	0.971	1.553	1.802	1.331	1.546	0.941	1.092
Chongqing	1.574	0.948	0.602	1.181	0.750	1.216	0.772	0.881	0.560
Sichuan	1.800	1.992	1.106	1.592	0.884	1.590	0.883	1.128	0.627
Guizhou	1.463	1.833	1.254	2.048	1.400	1.638	1.120	1.090	0.745
Yunnan	1.032	1.433	1.388	1.063	1.030	1.083	1.049	0.721	0.698
Tibet	0.017	0.094	5.620	0.010	0.611	0.006	0.341	0.003	0.167
Shaanxi	0.784	1.095	1.397	1.075	1.371	0.875	1.117	0.595	0.759
Gansu	0.286	0.491	1.716	0.314	1.097	0.301	1.051	0.204	0.712
Qinghai	1.407	5.307	3.772	0.631	0.449	1.080	0.768	0.707	0.503

(Continued)

Table 2 (Continued).

Area	PADi	MCHHs		Beds		Physician		Nurses	
		HRADi	Ratio	HRADi	Ratio	HRADi	Ratio	HRADi	Ratio
Ningxia	0.488	0.740	1.518	0.627	1.286	0.785	1.611	0.539	1.106
Xinjiang	0.458	0.792	1.727	0.329	0.717	0.322	0.702	0.205	0.447

Note: Number of beds of MCHHs in Tianjin City in 2020 was missing.

Abbreviations: MCH, maternal and child health; MCHHs, maternal and child health hospitals.

Gansu and Xinjiang provinces was far lower than 1, suggesting high level of inequity in MCH care resource allocation in terms of geographical area, and most of these provinces were distributed in the western region. The degree of agglomeration of the four indicators of MCH care resources in Chongqing Municipality in the western region was close to 1, indicating that the distribution of MCH resources was fairly allocated according to area compared with the distributions in the other provinces. The degree of agglomeration of MCHHs in Liaoning (1.141) and Shaanxi (1.095) was close to 1, but the other three resources in Liaoning and Jiangxi provinces were relatively low. MCHHs, beds, and licensed (assistant) physicians in Fujian, Anhui, Yunnan, and Shaanxi provinces were efficiently allocated in terms of geographical area, whereas equity in the allocation of registered nurses was poor. Detailed data are provided in [Table 2](#).

Agglomeration Analysis Based on Population Allocation

As shown in [Table 2](#), the agglomeration degree of the four indicators of MCH care resources based on the population allocation of the eastern regions was less than 1, indicating that the MCH care resources allocation based on population was insufficient. The ratios of HRAD to PAD in Liaoning, Fujian, Hunan, and Guangxi were close to 1, showed good fairness in the population allocation of MCHHs, whereas Tibet, Qinghai, and Inner Mongolia had a relatively surplus allocation of resources when their populations were considered, and Beijing, Tianjin, Shanghai, and Guangdong had a relatively insufficient allocation. Regarding the beds in MCHHs, the ratios in Hebei, Zhejiang, Fujian, Inner Mongolia, Yunnan, and Gansu were close to 1, indicating better equity in population allocation. The ratios of Liaoning, Shanghai, Jilin, and Qinghai were far lower than 1, indicating that these regions had relatively insufficient allocation of bed resources according to population, whereas Jiangxi, Henan, Hubei, Guangxi, and Guizhou had relatively surplus allocation. In terms of licensed (assistant) physicians in MCHHs, Beijing, Hebei, Fujian, Henan, Yunnan, and Gansu had better equity in population allocation, whereas the allocation of licensed (assistant) physicians in Tianjin, Liaoning, Shanghai, and Tibet was insufficient compared with the agglomeration population, and Guangxi and Ningxia had a surplus allocation. Finally, in terms of registered nurses in MCHHs, the ratios of Zhejiang and Guangxi were close to 1, indicating improved allocation of resources, whereas the ratios in Tianjin, Liaoning, Shanghai, and Tibet were far lower than 1, indicating that registered nurses in these provinces were unevenly distributed according to the population.

Trend of MCH Resource Agglomeration in China from 2008 to 2020

As shown in [Table 3](#), the allocation of MCH care resources in the central region was better than that in the eastern and western regions. From 2008 to 2020, the degree of agglomeration of MCH care resources in the western region increased, indicating an improvement in the equity of resource allocation based on geographical area in the western region. In the eastern region, except licensed (assistant) physician resources, the degree of the agglomeration of the other three resources decreased. Resource agglomeration in the central region generally showed a downward trend, in which bed and registered nurse resources first increased and then decreased, indicating that the equity of resource allocation in the central region was continuously improving.

According to the level of population allocation presented in [Table 4](#), the equity of resource allocation in the eastern region was lower than in the central and western regions. The degree of agglomeration of MCH care resources in the eastern region showed a downward trend. The degree of agglomeration of resources in the central region fluctuated upward and then decreased with a degree close to 1. The degree of agglomeration of institutional resources was 1 in 2013, indicating that the allocation of institutional resources in the region reached the optimal state in 2013. The MCH care resources in the western region showed an upward trend, and the allocation of institutional resources was relatively

Table 3 HRAD of MCH Resources in China from 2008 to 2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MCHHs													
Eastern	1.717	1.710	1.702	1.710	1.720	1.813	1.770	1.739	1.718	1.720	1.713	1.712	1.712
Central	1.234	1.244	1.250	1.244	1.237	1.203	1.219	1.225	1.232	1.220	1.225	1.218	1.216
Western	0.657	0.655	0.655	0.655	0.655	0.641	0.647	0.655	0.658	0.663	0.663	0.667	0.667
Beds													
Eastern	2.111	2.069	2.065	2.078	2.086	2.075	2.058	2.051	2.023	2.048	2.036	2.064	2.068
Central	1.270	1.294	1.292	1.275	1.277	1.289	1.308	1.313	1.315	1.289	1.304	1.263	1.259
Western	0.512	0.515	0.517	0.521	0.517	0.515	0.512	0.512	0.520	0.524	0.521	0.531	0.546
Licensed (assistant) physicians													
Eastern	2.161	2.133	2.153	2.189	2.232	2.268	2.242	2.233	2.187	2.213	2.226	2.275	2.246
Central	1.257	1.275	1.272	1.247	1.238	1.212	1.231	1.242	1.245	1.226	1.227	1.181	1.170
Western	0.503	0.503	0.498	0.498	0.488	0.488	0.488	0.486	0.499	0.500	0.495	0.500	0.515
Registered Nurses													
Eastern	2.339	2.201	2.228	2.257	2.256	2.269	2.204	2.204	2.162	2.156	2.127	2.113	2.090
Central	1.205	1.176	1.232	1.224	1.234	1.219	1.234	1.230	1.232	1.195	1.203	1.187	1.167
Western	0.469	0.527	0.492	0.487	0.482	0.485	0.499	0.501	0.513	0.533	0.539	0.551	0.568

Abbreviations: MCH, maternal and child health; HRAD, Health Resource Agglomeration Degree.

Table 4 Trend of Ratio of HRAD to PAD of MCH Resources in China from 2008 to 2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MCHHs													
Eastern	0.791	0.785	0.752	0.754	0.757	0.796	0.777	0.714	0.752	0.751	0.746	0.743	0.743
Central	1.017	1.027	1.034	1.032	1.028	1.000	1.015	1.020	1.027	1.019	1.023	1.017	1.016
Western	1.265	1.265	1.332	1.333	1.335	1.308	1.321	1.491	1.346	1.358	1.364	1.377	1.379
Beds													
Eastern	0.973	0.950	0.913	0.916	0.918	0.912	0.903	0.842	0.885	0.895	0.887	0.896	0.898
Central	1.047	1.068	1.069	1.057	1.061	1.072	1.089	1.093	1.097	1.077	1.088	1.055	1.052
Western	0.986	0.994	1.051	1.060	1.054	1.051	1.046	1.166	1.064	1.073	1.072	1.097	1.128
Licensed (assistant) physicians													
Eastern	0.996	0.979	0.952	0.965	0.982	0.996	0.984	0.917	0.957	0.967	0.970	0.988	0.975
Central	1.035	1.053	1.052	1.034	1.028	1.008	1.025	1.034	1.038	1.024	1.025	0.987	0.978
Western	0.967	0.971	1.012	1.013	0.996	0.996	0.996	1.106	1.022	1.023	1.018	1.034	1.064
Registered Nurses													
Eastern	1.078	1.010	0.985	0.995	0.992	0.997	0.967	0.905	0.946	0.942	0.927	0.917	0.907
Central	0.993	0.971	1.019	1.014	1.025	1.013	1.027	1.024	1.027	0.998	1.004	0.992	0.975
Western	0.901	1.018	1.001	0.991	0.983	0.989	1.019	1.140	1.050	1.091	1.108	1.138	1.173

Abbreviations: MCH, maternal and child health; HRAD, Health Resource Agglomeration Degree; PAD, Population Agglomeration Degree.

in surplus. The resource agglomeration of beds, licensed (assistant) physicians, and registered nurses gradually reached optimal levels and then surplus.

Equity Analysis Based on Theil Index

Total Theil Index and Regional Distribution Theil Index Analysis

As shown in Table 5 and 6, from 2008 to 2020, the total Theil index of resource allocation by geographical area in MCHHs in China ranged from 0.139 to 0.161, the total Theil index of bed resources ranged from 0.341 to 0.406, the

Table 5 Theil Index of Distribution of MCH Resources by Geographical of China from 2008 to 2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MCHHs													
Eastern	0.016	0.015	0.015	0.016	0.015	0.022	0.017	0.015	0.015	0.015	0.015	0.015	0.016
Central	0.029	0.027	0.025	0.024	0.025	0.025	0.025	0.026	0.028	0.025	0.025	0.026	0.030
Western	0.170	0.169	0.172	0.169	0.170	0.177	0.177	0.179	0.180	0.185	0.183	0.181	0.210
Tintra-class	0.105	0.104	0.105	0.103	0.104	0.109	0.108	0.110	0.110	0.113	0.111	0.111	0.128
Tinter-class	0.035	0.036	0.035	0.036	0.036	0.040	0.038	0.036	0.035	0.034	0.034	0.034	0.033
Total	0.141	0.140	0.141	0.139	0.141	0.149	0.146	0.146	0.145	0.147	0.145	0.145	0.161
Beds													
Eastern	0.093	0.091	0.094	0.102	0.105	0.101	0.106	0.109	0.117	0.118	0.112	0.096	0.080
Central	0.106	0.114	0.123	0.129	0.133	0.145	0.157	0.165	0.168	0.175	0.173	0.180	0.188
Western	0.395	0.410	0.420	0.421	0.434	0.410	0.403	0.394	0.393	0.409	0.482	0.456	0.495
Tintra-class	0.264	0.275	0.283	0.287	0.296	0.285	0.285	0.283	0.284	0.295	0.334	0.319	0.339
Tinter-class	0.076	0.074	0.074	0.072	0.074	0.074	0.075	0.075	0.072	0.071	0.072	0.070	0.065
Total	0.341	0.349	0.357	0.358	0.370	0.359	0.360	0.357	0.356	0.366	0.406	0.389	0.404
Licensed (assistant) physician													
Eastern	0.048	0.045	0.043	0.046	0.048	0.053	0.054	0.057	0.058	0.060	0.067	0.076	0.080
Central	0.057	0.062	0.067	0.070	0.073	0.078	0.089	0.097	0.098	0.103	0.109	0.122	0.131
Western	0.354	0.367	0.371	0.382	0.405	0.399	0.408	0.416	0.436	0.456	0.507	0.518	0.532
Tintra-class	0.221	0.229	0.232	0.240	0.254	0.253	0.260	0.268	0.279	0.292	0.323	0.335	0.346
Tinter-class	0.080	0.079	0.081	0.082	0.086	0.087	0.087	0.087	0.082	0.082	0.084	0.084	0.079
Total	0.301	0.308	0.314	0.322	0.340	0.340	0.347	0.355	0.361	0.374	0.407	0.419	0.425
Registered nurses													
Eastern	0.098	0.102	0.100	0.099	0.102	0.108	0.114	0.118	0.123	0.125	0.130	0.139	0.135
Central	0.113	0.121	0.129	0.130	0.138	0.144	0.160	0.166	0.163	0.166	0.166	0.190	0.190
Western	0.461	0.492	0.524	0.544	0.567	0.576	0.537	0.577	0.579	0.581	0.598	0.606	0.621
Tintra-class	0.304	0.324	0.344	0.356	0.371	0.378	0.362	0.386	0.388	0.390	0.400	0.413	0.421
Tinter-class	0.096	0.090	0.085	0.089	0.089	0.088	0.082	0.082	0.077	0.072	0.094	0.066	0.062
Total	0.400	0.414	0.429	0.444	0.460	0.467	0.444	0.468	0.465	0.462	0.494	0.479	0.482

Abbreviation: MCH, maternal and child health.

Table 6 Theil Index of Distribution of MCH Resources by Population of China from 2008 to 2020

	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MCHHs													
Eastern	0.018	0.021	0.023	0.023	0.022	0.037	0.028	0.025	0.023	0.024	0.022	0.023	0.026
Central	0.017	0.018	0.017	0.018	0.017	0.017	0.018	0.017	0.016	0.019	0.018	0.018	0.021
Western	0.033	0.032	0.030	0.031	0.030	0.031	0.030	0.031	0.031	0.034	0.034	0.035	0.033
Tintra-class	0.022	0.023	0.023	0.023	0.023	0.029	0.025	0.024	0.023	0.025	0.024	0.024	0.026
Tinter-class	0.010	0.011	0.013	0.013	0.013	0.010	0.011	0.012	0.013	0.013	0.013	0.014	0.016
Total	0.032	0.035	0.036	0.036	0.035	0.039	0.036	0.036	0.036	0.038	0.038	0.038	0.042
Beds													
Eastern	0.054	0.052	0.055	0.068	0.058	0.060	0.066	0.073	0.077	0.086	0.084	0.040	0.025
Central	0.017	0.022	0.021	0.022	0.028	0.035	0.043	0.048	0.047	0.049	0.045	0.048	0.029
Western	0.019	0.014	0.015	0.017	0.017	0.018	0.018	0.017	0.019	0.017	0.017	0.018	0.020
Tintra-class	0.032	0.032	0.033	0.040	0.038	0.041	0.046	0.050	0.052	0.056	0.054	0.037	0.025
Tinter-class	0.000	0.001	0.001	0.002	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.004
Total	0.033	0.033	0.034	0.041	0.039	0.042	0.048	0.052	0.054	0.057	0.056	0.038	0.028
Licensed (assistant) physician													
Eastern	0.019	0.022	0.020	0.019	0.018	0.021	0.021	0.020	0.019	0.022	0.027	0.031	0.030
Central	0.012	0.012	0.010	0.010	0.012	0.013	0.015	0.019	0.016	0.016	0.017	0.018	0.014
Western	0.018	0.016	0.015	0.015	0.015	0.015	0.014	0.012	0.011	0.012	0.013	0.013	0.014
Tintra-class	0.017	0.017	0.016	0.015	0.015	0.017	0.018	0.018	0.016	0.018	0.020	0.022	0.021
Tinter-class	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
Total	0.017	0.017	0.016	0.015	0.016	0.017	0.018	0.018	0.016	0.018	0.020	0.022	0.021
Registered nurses													
Eastern	0.044	0.045	0.044	0.044	0.042	0.046	0.052	0.053	0.057	0.061	0.066	0.072	0.065
Central	0.012	0.016	0.017	0.017	0.025	0.029	0.037	0.039	0.037	0.040	0.039	0.045	0.034
Western	0.038	0.036	0.044	0.048	0.051	0.048	0.042	0.035	0.030	0.025	0.160	0.024	0.025
Tintra-class	0.032	0.033	0.036	0.036	0.039	0.041	0.044	0.043	0.043	0.045	0.083	0.051	0.045
Tinter-class	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.000	0.002	0.003
Total	0.033	0.033	0.036	0.036	0.039	0.041	0.045	0.044	0.044	0.046	0.084	0.052	0.048

Abbreviation: MCH, maternal and child health.

total Theil index of licensed (assistant) physician resources ranged from 0.301 to 0.425, and the total Theil index of registered nurses ranged from 0.4 to 0.494. In comparison, the total Theil index of MCH care resources at the level of demographic allocation was lower, ranging from 0.032 to 0.042 for MCHHs, 0.033 to 0.057 for beds, 0.015 to 0.022 for licensed (assistant) physician resources, and 0.033 to 0.084 for registered nurses. The best equity of resource allocation by geographic area was observed in the eastern region; and the worst in the western region. The central

region was in the middle, but the equity of institutional resource allocation was lower than that in the western region. At the demographic allocation level, the best equity of resource allocation in term of MCHHs, licensed (assistant) physicians, and registered nurses was observed in the central region. The equity in the western region was in the middle, and the allocation of bed resources in the western region was better than that in the eastern and central regions. However, the intra-regional Theil index of all health resources at both allocation levels was greater than the inter-regional Theil index and tended to fluctuate upward, indicating that the inequity within the region was gradually increasing.

Contribution Rate Analysis of Theil Index

As shown in Figure 3, the contribution rates of MCHHs, bed resources, licensed (assistant) physician resources, and registered nurse resources to the eastern, central, and western regions of China on the basis of geographical and population factors, were more than 60%. Figure 3 demonstrates that at the population level, the inequity in regional MCH care resources allocation in China showed a downward trend from 2008 to 2020, and intra-regional and inter-regional differences in the allocation of beds, licensed (assistant) physicians, and registered nurses of MCHHs were observed. At the geographical level, the intra-regional and inter-regional differences in health resources were lower than those at the level of population level, but the contribution of the Theil index to the total Theil index increased, and the allocation of bed resources was the most inequitable

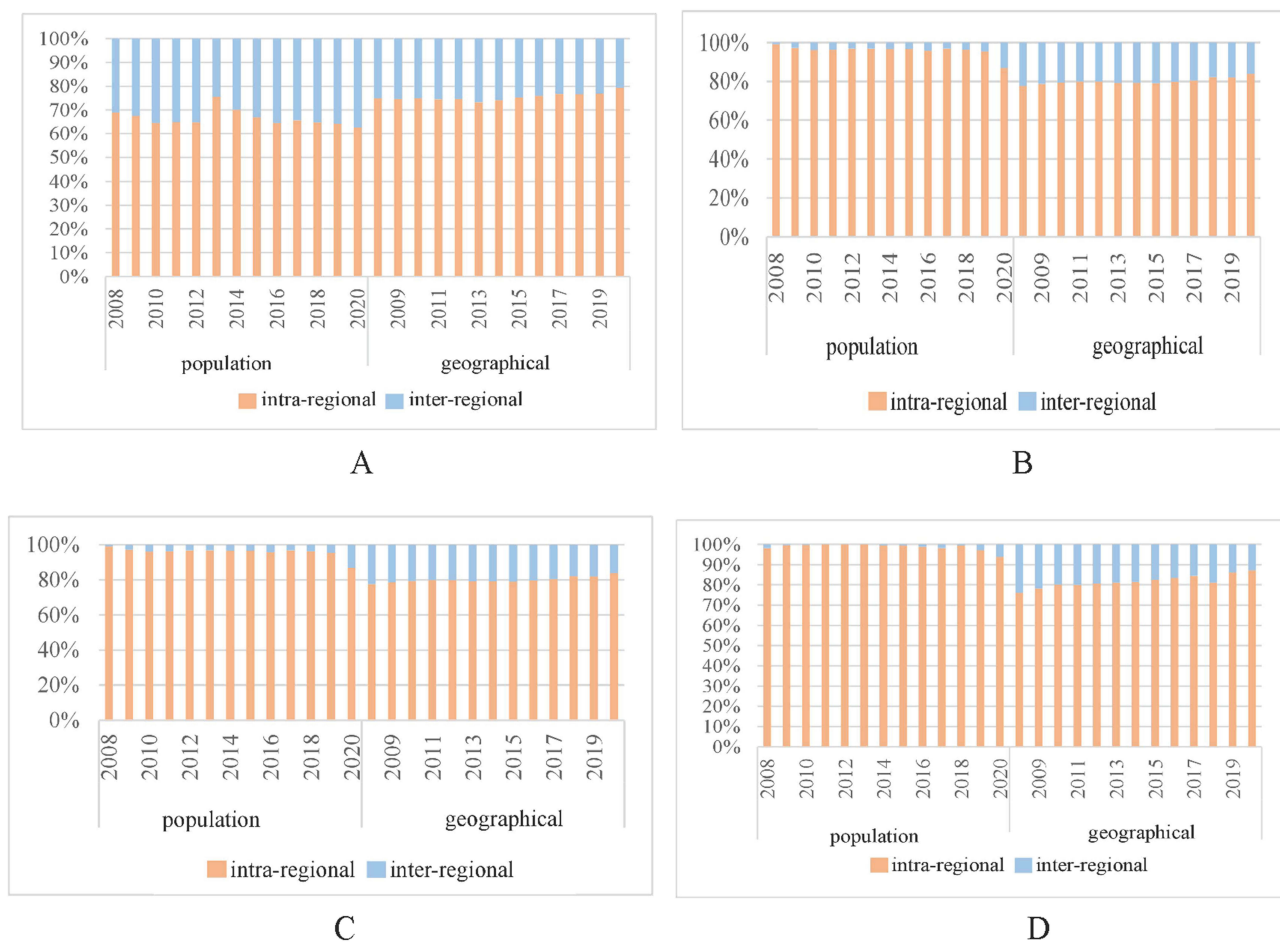


Figure 3 Contribution rate for Theil index of MCH resource allocation from 2008 to 2020. The figure shows the contribution rate in the four indicators of MCH resources, including the intraregional and inter-regional parts at the population and geographical levels of allocation. The intraregional part was divided into three regions which were mentioned in the text. X-axis represents the year, and Y-axis the contribution rate for Theil index. (A) MCHHs. (B) beds in MCHHs. (C) licensed (assistant) physicians in MCHHs. (D) registered nurses in MCHHs.

Discussion

This study provides a comprehensive and comparative analysis of trends and inequities in MCH care resource allocation in China from 2008 to 2020 using the HRAD and Theil indices to measure equity. To the best of our knowledge, this study is the first to analyze the equity and trends in MCH care resource allocation since the implementation of the new health system reform at the national level in China. Our study had three major findings.

First, the total amount of MCH care service resources in China have steadily increased since the implementation of the new health system reform in 2009, and the disparities between different regions are narrowing. The average annual growth rates for MCHHS, beds, licensed (assistant) physicians, and registered nurses are 0.72%, 6.95%, 5.04%, and 9.57%, respectively. The primary reason was the implementation of a series of supportive policies in the field of MCH care by the Chinese government, including financial inputs, policy support, and personnel training.⁹ The central government launched the National Essential Public Health Services program from 2009, which provides an essential public health services package.²⁷ In 2013, the Targeted Poverty Alleviation programme was initiated with a goal of eliminating extreme poverty by 2020. A focus of this programme has been improving the health of women and children. In 2016, China launched its blueprint for Healthy China 2030, which aims to achieve high-quality universal health coverage by 2030. From 1998 to 2017, government investment in MCH facilities increased from ¥0.92 billion to ¥27.63 billion. In 2017, government investment accounted for 26% of total income in MCH facilities, compared to 8% in general hospitals. By that year, China had 3,077 MCH facilities, with nearly all (99.6%) being government-owned.²⁸ Investments in sectors other than health, such as poverty reduction, women's literacy, and road building, have accelerated the progress in MCH care.⁹ In 2019 the Healthy China Initiative (2019–30) was issued, and the central and local governments are accountable for measurable improvement. Investment in MCH care resources plays an important role in promoting the health of mothers and children in China.

Although regional differences still exist in the allocation of MCH resources in China in 2020, the gap between the eastern and western regions is narrowing compared with that in 2008. The number of beds and human resources in the western region has increased, mainly because of the Chinese government's efforts to strengthen health financing, infrastructure construction and poverty reduction initiatives to improve local MCH services from 2009.^{29,30} Rapid growth in resources for MCH care means that more women and children have access to MCH services, contributing to the improvement in MCH health. According to the China Health Statistics Yearbook, the average maternal mortality rate in 12 provinces in the western region was 55.79/100,000 in 2008, compared with 12.99/100,000 in 11 provinces in the eastern region. However, in 2020, the maternal mortality rates in the western and eastern regions were 16.192/100,000 and 8.19/100,000, respectively, indicating that the gap between the two regions significantly narrowed.^{31,32}

In 2020, the western region had the highest number of MCH hospital beds, licensed (assistant) physicians, and registered nurses per 10,000 people, with values of 1.995, 1.141, and 1.620, respectively, but there were still disparities among the different areas still existed. Some areas in the western region, such as Guizhou, Guangxi, Gansu, and Qinghai provinces, have experienced a greater increase in the number of MCH care resources per 10,000 people since the new healthcare reform. These provinces have implemented various initiatives to strengthen their MCH service systems and improve MCH personnel training. For example, the Guangxi Autonomous Region has set up a four-level MCH service system covering provinces, cities, counties, and townships, and implemented a training program for MCH personnel, which included training targeted at admitting medical students to work in rural areas after graduation and strengthening the training of registered nurses.³³ Guizhou has integrated MCH services into its systematic basic medical and health services for women and children.³⁴ These initiatives have helped increase the number of human resources available for local MCH services and may have contributed to the overall increase in MCH care resources per 10,000 people in the western region.

Second, we found that after the new health system reform, although the geographical equity of resource allocation has gradually improved, the equity of MCH care resources still differs among different regions and provinces. At the geographical level, the degree of agglomeration for the four indicators of MCH care resources was well below 1 in the western region, indicating a obviously insufficiency of resources, low equity, and poor geographical accessibility. In the central region, the degree of agglomeration for these indicators was greater than 1, reflecting a more equitable allocation.

In contrast, in the eastern region, the degree of agglomeration was obviously higher, indicating a high concentration of resources. This result is consistent with the results of other studies on the HRAD of health resources in China.^{35,36} Specifically, in western region, equity in the allocation of MCHHs according to geographical area was better than that of the allocation of human health resources of MCH care. This result suggested that although the Chinese government has made efforts to strengthen the construction of MCHHs in western China since the new health system reform, the recruitment of human resources in these institutions remains a challenge. Some possible reasons were as follows: First, the physical resources, such as medical institutions are mainly implemented under the guidance of the Chinese government, whereas health professionals are often attracted by monetary incentives and opportunities for career progression;³⁶ second, the western region has a large geographical area, a large number of deserts and plateaus, thin air, uninhabitable areas, and a poor economy, reducing the attractiveness of human resources;²⁹ third, the western region is generally underdeveloped and more rural than the eastern and central regions (as indicated by the 2020 census data showing an urbanization rate of 67.27% in the western region and 70.76% in the east region).³⁷ Moreover, MCHHs in China are specialized public health institutions, whose incomes rely mainly on financial support. In the absence of adequate financial support, some MCHH staff may leave.³⁸ By contrast, developed areas are more likely to attract staff because of their higher levels of financial support and better opportunities for career development.^{39,40} The lack of human resources in the western region creates a gap in the quality of MCH health services between the eastern and western regions, posing a challenge that hinders universal health coverage in China.³⁰

However, in densely populated eastern regions, the allocation of MCH resources according to population was less equitable, and the degree was lower than that in geographical area allocation. From a historical trend perspective, the ratio of HRAD to PAD of the four indicators in the eastern region has been decreasing over the years and gradually farther away from 1, indicating that the equity of MCH resources allocated according to population is decreasing. In 2020, developed and densely populated eastern provinces and cities, such as Beijing, Shanghai, Tianjin, and Jiangsu, had an HRAD-to-PAD ratio far lower than 1, indicating that the supply of resources for MCH care in these areas is insufficient and may not be able to meet the needs of the population, especially for human resources, which are critical for the provision of health services. This insufficiency may be due to the fact that the economy of the eastern region is more developed than the economies of the central and western regions (GDP of the eastern region reaches 51.75% of total GDP in 2020),⁴¹ and there are more employment opportunities,⁴² attracting a large increase in the floating population (from 2010 to 2020, the eastern region assimilated 91.81 million cross-provincial floating populations, accounting for 73.54% of the total floating population).³⁷ Therefore, the eastern region should optimize the allocation structure of MCH resources, especially for provinces and cities with large floating populations, such as Shanghai, Beijing, Jiangsu, and Guangdong. Additionally, the utilization efficiency of MCH resources should be improved by establishing an integrated health information system that covers the entire life course of MCH, linking key events and trajectories at each stage and providing good services and interventions.^{9,43}

Third, intraregional differences in the current allocation of MCH care resources in China under both allocation levels are the main cause of inequity. Similar results have been reported in other studies.^{44,45} The degree of regional differences in the allocation of MCH care institutions at population and geographical levels are lower than that of any of the other three resources, and the contribution rates are 62.53–75.19% and 73.19–79.25%, respectively. In 2008 and 2013, the contribution rate of the Theil index to the total Theil index in the allocation of licensed (assistant) physicians and registered nurses in the region reached 100%, which may be related to the tendency of regions to focus on infrastructure construction in resource investment and difference in the level of economic development within each region. Regions with low levels of economic development are unattractive to human resources. Therefore, in the allocation of health resources in MCHHs, the levels of economic development of provinces and cities in each region vary. Improving intraregional equity, formulating reasonable regional health planning, adjusting the prominent problems of equity, and fully considering the impact of intra-regional differences on the allocation of health resources should be emphasized. While narrowing inter-regional differences in China, policymakers should focus their attention to narrowing the impact of intraregional differences to effectively solve differences in the equity of inter-regional and intraregional health resource allocation, to achieve the overall consideration of health resources between and within regions, and to avoid the excessive concentration of a certain health resource.^{36,46}

The study has some limitations. First, that although the selection of indicators was based on published literature reviews and expert opinions, other indicators related to health resource allocation were not investigated, such as the systematic management coverage for pregnant women and the number of diagnostic equipment. Future studies should consider additional indicators for a comprehensive evaluation of MCH resource allocation. Second, the inequality problem was not only affected by factors such as socio-economic development and government financial inputs discussed in this study, but might also have been affected by the difference between urban and rural areas, health system, technology (eg, information technology) and other factors, related variables should be considered in future research.

Conclusion

The total amount of MCH care service resources has steadily increased, and equity in MCH care resource allocation in China has improved since the implementation of the new health system reform. However, regional disparities persist. The allocation of MCH care resources in the central region is better than in the eastern and western regions. The western region faces a shortage of MCH care service human resources relative to its geographical area, while the eastern region experiences an excessive concentration of resources. These disparities are influenced by differences in government policy guidance and economic development among regions. With the rising demand for MCH care services driven by economic development, the government should aim to enhance the overall level of MCH care resource allocation and increase investment in MCH services. In the densely populated eastern regions, measures are needed to improve the efficiency of health resource utilization and to engage private medical institutions in providing maternal and child health services. In the sparsely populated western regions, telemedicine systems should be utilized to improve service quality in maternal and child health institutions. Future analysis will focus on trends in resource allocation at different time points and the impact of regional socio-economic environments on MCH resource allocation.

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by the Ethics Committee of Biomedical Research, Henan University (Ethics Committee No. HUSOM2023-486). All research was performed in accordance with the Declaration of Helsinki. Written informed consent was obtained from each volunteering participant based on inclusion criteria. Participants were informed that they could withdraw from the study at any point in time without any consequences and were also ensured of anonymity and confidentiality within the study.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Funding

This work is supported by Soft Science Research Program of Henan Province (grant ref No.202400410319), Science and Technology Research Program Project of Henan Province (grant ref No. 242102320179), Science and Technology ThinkTank Survey and Research Project of Henan Province (HNKJZK-2021-46C). The funders had no involvement in study design, data collection, statistical analysis and manuscript writing.

Disclosure

The authors report no conflicts of interest in this work.

References

- Murray CJ, Frenk J, Evans T. The global campaign for the health MDGs: challenges, opportunities, and the imperative of shared learning. *Lancet*. 2007;370(9592):1018–1020. doi:10.1016/S0140-6736(07)61458-5
- World Health Organization. Maternal mortality. Available from: <https://www.who.int/zh/news-room/fact-sheets/detail/maternal-mortality>. Accessed 22, February 2023.
- World Health Organization. Child-Mortality /causes of death. Available from: <https://platform.who.int/data/maternal-newborn-child-adolescent-ageing/child-data/child—mortality-causes-of-death>. Accessed 22, February 2023.
- Zhang T, Lu W, Tao H. Efficiency of health resource utilisation in primary-level maternal and child health hospitals in Shanxi Province, China: a bootstrapping data envelopment analysis and truncated regression approach. *BMC Health Serv Res*. 2020;20(1):179. doi:10.1186/s12913-020-5032-y
- Li Y, Zhang Y, Fang S, et al. Analysis of inequality in maternal and child health outcomes and mortality from 2000 to 2013 in China. *Int J Equity Health*. 2017;16(1):66. doi:10.1186/s12939-017-0558-2
- Zhou L, Antwi HA, Wang W, et al. The effect of herd formation among healthcare investors on health sector growth in China. *Int J Equity Health*. 2016;15(1):113. doi:10.1186/s12939-016-0393-x
- Tao W, Zeng Z, Dang H, et al. Towards universal health coverage: achievements and challenges of 10 years of healthcare reform in China. *BMJ Glob Health*. 2020;5(3):e002087. doi:10.1136/bmjgh-2019-002087
- Department of Maternal and Child Health, National Health Commission of China. Evaluation report of major public health service projects for women and children. 2012. Available from: http://www.gov.cn/xwfb/201204/12/content_2111891.htm. Accessed September 22, 2020.
- Qiao J, Wang Y, Li X, et al. A lancet commission on 70 years of women's reproductive, maternal, newborn, child, and adolescent health in China. *Lancet*. 2021;397(10293):2497–2536. doi:10.1016/S0140-6736(20)32708-2
- The State Council of the People's Republic of China. 2009 China's health development statistical bulletin. Available from: http://www.gov.cn/gzdt/2010-04/09/content_1576944.htm. Accessed 9, April 2010.
- The State Council of the People's Republic of China. 2021 China's health development statistical bulletin. Available from: http://www.gov.cn/xinwen/2022-07/12/content_5700670.htm. Accessed 12, July 2022.
- Collaborators GS. Measuring progress from 1990 to 2017 and projecting attainment to 2030 of the health-related sustainable development goals for 195 countries and territories: a systematic analysis for the global burden of disease study 2017. *Lancet*. 2018;392(10159):2091–2138.
- Liang J, Li X, Kang C, et al. Maternal mortality ratios in 2852 Chinese counties, 1996–2015, and achievement of millennium development goal 5 in China: a subnational analysis of the global burden of disease study 2016. *Lancet*. 2019;393(10168):241–252. doi:10.1016/S0140-6736(18)31712-4
- Huang M, Luo D, Wang Z, et al. Equity and efficiency of maternal and child health resources allocation in Hunan Province, China. *BMC Health Serv Res*. 2020;20(1):300. doi:10.1186/s12913-020-05185-7
- Shen Y, Yan H, Reijja K, et al. Equity in use of maternal health services in Western Rural China: a survey from Shaanxi province. *BMC Health Serv Res*. 2014;14(1):155. doi:10.1186/1472-6963-14-155
- Gai R, Zhou C, Xu L, et al. Health resource allocation and productive efficiency of Chinese county hospitals: data from 1993 to 2005. *Biosci Trends*. 2010;4(5):218–224.
- Huang Y, Peng R, Feng J. Study on the allocation of health human resources and its equity in maternal and child health institutions in Guangxi since the 13th five-year plan. *Med Soc*. 2021;34(09):33–38.
- Tao Y, Henry K, Zou Q, et al. Methods for measuring horizontal equity in health resource allocation: a comparative study. *Health Eco Rev*. 2014;4(1):10. doi:10.1186/s13561-014-0010-x
- Doull L, Campbell F. Human resources for health in fragile states. *Lancet*. 2008;371(9613):626–627. doi:10.1016/S0140-6736(08)60278-0
- Yuan S, Wei F, Liu W, et al. Methodology discussion of health resource allocation equity evaluation based on agglomeration degree. *China Hosp Manag*. 2015;35(02):3–5.
- Fu Y, Wang J, Sun J, et al. Equity in the allocation of general practitioner resources in mainland China from 2012 to 2019. *Healthcare-Basel*. 2023;11(3):398. doi:10.3390/healthcare11030398
- Wang Y, Li Y, Qin S, et al. The disequilibrium in the distribution of the primary health workforce among eight economic regions and between rural and urban areas in China. *Int J Equity Health*. 2020;19(1):1–10. doi:10.1186/s12939-020-1139-3
- Cui T, Xiong J. Analysis of the equity of Chinese medicine health resource allocation in China based on agglomeration degree. *China Hosp Manag*. 2017;37(07):18–20.
- Camporeale R, Caggiani L, Fonzone A, Ottomanelli M. Study of the accessibility inequalities of cordon-based pricing strategies using a multimodal Theil index. *Transport Plan Techn*. 2019;42(5):498–514. doi:10.1080/03081060.2019.1609222
- Zhu B, Hsieh C, Zhang Y. Incorporating spatial statistics into examining equity in health workforce distribution: an empirical analysis in the Chinese context. *Int J Environ Res Public Health*. 2018;15(7):1309. doi:10.3390/ijerph15071309
- Li Q, Wei J, Jiang F, et al. Equity and efficiency of health care resource allocation in Jiangsu Province. *China Int J Equity Health*. 2020;19:1–13.
- National Health and Family Planning Commission of PRC, National Essential Public Health Services Standards National health and family planning commission of PRC, Beijing(2009); 2009.
- China Health Statistics Yearbook. *National Health Commission of the People's Republic of China*. Beijing:Peking Union Medical College Press; 2018.
- Wang Z, He H, Liu X, et al. Health resource allocation in Western China from 2014 to 2018. *Arch Public Health*. 2023;81(1):30. doi:10.1186/s13690-023-01046-x
- Guo Y, Huang Y. Realising equity in maternal health: china's successes and challenges. *Lancet*. 2019;393(10168):202–204. doi:10.1016/S0140-6736(18)32464-4
- Ministry of Health of the People's Republic of China. *China Health Statistics Yearbook*. Beijing: Peking Union Medical College Press; 2009.
- National Health Commission of the People's Republic of China. *China Health Statistics Yearbook*. Beijing: Peking Union Medical College Press; 2021.
- Huang Y, Feng Y, Feng J. Research on the allocation of health human resources in maternal and child health institutions in Guangxi based on equity and efficiency. *Chin Health Stat*. 2022;39(03):400–404.

34. Xu Y, He L, Hong Y. Study on the fairness of maternal and child health human resources allocation in Guizhou Province. *Mod Prev Med.* 2022;49(22):4144–4150.
35. Yu Q, Yin W, Huang D, et al. Trend and equity of general practitioners' allocation in China based on the data from 2012-2017. *Hum Resour Health.* 2021;19(1):20. doi:10.1186/s12960-021-00561-8
36. Dai G, Li R, Ma S. Research on the equity of health resource allocation in TCM hospitals in China based on the gini coefficient and agglomeration degree: 2009-2018. *Int J Equity Health.* 2022;21(1):145. doi:10.1186/s12939-022-01749-7
37. Office of the Leading Group of the Seventh National Population Census of the State Council of the People's Republic of China. *China Population Census Yearbook-2020*. Beijing: China Statistics Press; 2022.
38. Zhang H, Liu X, Penn-Kekana L, Ronsmans C. A systematic review of the profile and density of the maternal and child health workforce in China. *Hum Resour Health.* 2021;19(1):125. doi:10.1186/s12960-021-00662-4
39. Qin X, Hsieh C. Economic growth and the geographic maldistribution of health care resources: evidence from China, 1949-2010. *China Econ Rev.* 2014;31:228–246. doi:10.1016/j.chieco.2014.09.010
40. Zhang X, Zhao L, Cui Z, Wang Y. Study on equity and efficiency of health resources and services based on key indicators in China. *PLoS One.* 2015.10
41. The National Bureau of Statistics of the People's Republic of China. Statistical bulletin of the People's Republic of China on national economic and social development for 2020. Available from: http://www.stats.gov.cn/sj/zxfb/202302/t20230203_1901004.html. Accessed 28, February 2021.
42. Liu Y, Lu M, Xiang K. Balance through agglomeration: a race between geography and policy in China's regional development. *China World Econ.* 2018;26(6):72–96. doi:10.1111/ewe.12262
43. Gao M, Fang Y, Liu Z, Xu X, You H, Wu Q. Factors associated with maternal healthcare utilization before and after delivery among migrant pregnant women in china: an observational study. *Risk Manag Healthc Policy.* 2023;16:1653–1665. doi:10.2147/RMHP.S423723
44. Lu X, Yin C, Li C, et al. An analysis of the equity of health human resources allocation in maternal and child health centers in China: based on the hypothesis of resource homogeneity. *China Health Care Manag.* 2018;35(04):263–265.
45. Liang Z, Yu Z, Tang M. Evaluation of the equity of resource allocation for maternal and child health care in China based on the thayer index and concentration index. *Mod Prev Med.* 2015;42(16):2930–2934.
46. Zhang T, Xu Y, Ren J, Sun L, Liu C. Inequality in the distribution of health resources and health services in China: hospitals versus primary care institutions. *Int J Equity Health.* 2017;16(1):42. doi:10.1186/s12939-017-0543-9

Risk Management and Healthcare Policy

Dovepress

Publish your work in this journal

Risk Management and Healthcare Policy is an international, peer-reviewed, open access journal focusing on all aspects of public health, policy, and preventative measures to promote good health and improve morbidity and mortality in the population. The journal welcomes submitted papers covering original research, basic science, clinical & epidemiological studies, reviews and evaluations, guidelines, expert opinion and commentary, case reports and extended reports. The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/risk-management-and-healthcare-policy-journal>