

The allocation and fairness of health human resources in Chinese maternal and child health care institutions: a nationwide longitudinal study

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Abstract Background

In response to an aging population, the Chinese government implemented the three-child policy in 2021 based on the comprehensive two-child policy. With the implementation of the new birth policy, people's maternal and child health (MCH) needs will also increase. The allocation and equity of MCH human resources directly affect people's access to MCH services. The purpose of this study is to analyze the allocation of health human resources in Chinese maternal and child health care institutions, evaluate the fairness of the allocation, to provide a reference for the rational allocation of MCH human resources.

Methods

The data of health technicians, licensed (assistant) physicians, and registered nurses in maternal and child health care institutions nationwide from 2016 to 2020 were included. The health resource density index (HRDI) was used to evaluate the allocation level of MCH human resources. The Gini coefficient (G) and Theil index (T) were used to evaluate the fairness of the allocation of MCH human resources from the perspectives of population and geographic area.

Results

From 2016 to 2020, the average annual growth rate of the number of health technicians, licensed (assistant) physicians, and registered nurses in Chinese maternal and child health care institutions was 7.53%, 6.88%, and 9.12%, respectively. The G of the three types of MCH human resources allocated by population are all below 0.23, and the G allocated by geographical area are all above 0.65. The total T of the three types of MCH human resources allocated by population was all lower than 0.06, and the total T allocated by geographical area was all higher than 0.53. In addition, the three categories of MCH human resources allocated by population and geographic area contributed more than 84% of the T to the total T.

Conclusions

China's MCH human resources are equitable in terms of population allocation, but unfair in terms of geographical area allocation. In the future, more attention should be paid to the geographical accessibility of MCH human resources, and the allocation of resources should comprehensively consider the two factors of serving the population and geographical area.

Background

The World Health Organization (WHO) has always regarded maternal and child health (MCH) as a priority area of healthcare security [1]. China is the most populous country in the world and also has the world's

largest group of women and children. Actively and effectively doing a good job in MCH is an important task of the Chinese government, which has important strategic significance for improving the health level of the whole people and promoting the construction of a healthy China [2].

The Chinese government has always attached great importance to the health of women and children. It has successively promulgated the Law on MCH, the Law on the Protection of Women's Rights and Interests, the Law on the Protection of Minors, the Outline for the Development of Chinese Women, and the Outline for the Development of Chinese Children, etc., and has continuously improved the legal system and policy system for MCH [3–5]. On the other hand, implement the national basic public health service project, promote the sinking of high-quality resources for MCH, continuously strengthen the construction of the MCH service network, increase investment in the construction of maternal and child health care institutions, and continue to improve the MCH service system [4, 6]. Based on these series of measures, China's MCH care has made remarkable achievements. The maternal mortality rate has dropped from 1,500/100,000 before the founding of New China to 16.9/100,000 in 2020, and the infant mortality rate has dropped from 200‰ before the founding of New China to 5.4‰ in 2020 [7, 8]. All in all, the Chinese government has made great efforts in the field of MCH, and the rights to survival and health of Chinese women and children have been fully guaranteed.

At this stage, the population of all countries in the world has an aging development trend, which is also China's basic national condition. In the 1970s, to control population growth and improve the quality of the population, the Chinese government launched a nationwide family planning program [9]. This plan has achieved the expected goals well, but on the other hand, it has also led to an aging structure. According to China's seventh census bulletin, the country's total population is 1.412 billion, of which 191 million are aged 65 and above, accounting for 13.50% [10]. China's population structure is rapidly advancing in the direction of aging and is about to enter a deeply aging society. To actively cope with this situation, the Chinese government fully implemented the two-child policy in 2015, that is, a couple can have two children [11]. On this basis, the Chinese government promulgated the three-child policy in 2021, that is, a couple can have three children [12]. From a strategic perspective, the new birth policy is conducive to improving the country's population structure, expanding the supply of labor, maintaining the advantages of human resource endowments, and thus promoting stable economic and social development [13]. It is worth mentioning that after the implementation of this policy, people's demand for MCH services will also increase. In the new era, it is particularly important to allocate limited MCH resources fairly and reasonably to ensure that people's needs for MCH services are met.

Existing studies on equity have mostly focused on other types of health resources, such as primary health care resources [14], traditional Chinese medicine health resources [15], public health facilities [16, 17], and emergency medical services [18], etc. Several of the studies on health human resources are focused on regional overall health human resources [19–22], and few studies have been conducted on women and children's institutions. In addition, most of the studies prefer to divide China into three regions according to geographic affiliation to discuss the issue of fairness [23, 24]. However, this division method cannot clarify the impact of regional economic differences on the fairness of resource allocation. Therefore, based on

the data on health human resources in China's maternal and child health care institutions during the 13th Five-Year Plan period, this study divides different regions according to the level of regional per capita Gross Domestic Product (GDP) and explores the allocation and equity of MCH human resources. The research aims to provide decision-making reference for the Chinese government to optimize the allocation of MCH human resources during the 14th Five-Year Plan period, to achieve fair and accessible MCH services as a whole, and to contribute to the construction of a healthy China.

Methods

Data source

The data on health human resources (health technicians, licensed (assistant) physicians, and registered nurses) in maternal and child health care institutions in this study were obtained from the 2017 China Health and Family Planning Statistical Yearbook and the 2018–2021 China Health and Health Statistical Yearbook. Regional per capita GDP and regional resident population data are from the 2017–2021 China Statistical Yearbook. The geographic area data is derived from the administrative division information of the Ministry of Civil Affairs of China. In particular, the data included in the study only included 31 provinces, municipalities, and autonomous regions in mainland China, excluding Hong Kong, Macau, and Taiwan.

Setting

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

Allocation level and fairness assessment

The health resources density index (HRDI) was used to measure the allocation level of health human resources in maternal and child health care institutions in different economic regions. The fairness of the allocation is evaluated according to the calculation results of the Gini coefficient (G) and Theil index (T). The research results reflect the development of China's MCH human resources during the 13th Five-Year Plan period.

Health Resource Density Index

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

$$HRDI = rac{R_i}{\sqrt{A_iP_i}}$$

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

Gini Coefficient

The Lorentz curve is often used in the medical and health field to explore the fairness of the allocation of health resources [24, 26]. However, the curve can only be displayed visually and cannot be quantified. Therefore, scholars introduce the G for quantitative evaluation. In essence, the G is the numerical embodiment of the Lorentz curve, with the same geometric meaning [27]. The calculation formula is:

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

In the formula, G is the Gini coefficient, τ_i is the cumulative proportion of the population (geographical area) of the ith region in the country, and φ_i is the cumulative proportion of the ith region's MCH human resources in the country. The G ranges from 0 to 1. When G < 0.2, it is very fair. When $0.2 \le G < 0.3$, it is fairer. When $0.3 \le G < 0.4$, it is relatively fair. When $0.4 \le G < 0.5$, it is relatively unfair. When $G \ge 0.5$, it is very unfair [28].

Theil index

The T is derived from the concept of entropy in information theory and is used to measure the fairness of the allocation of health resources in a region [23]. At the same time, the T can be divided into the T between groups and the T within the group, which further reflects that the unfair allocation of regional resources is mainly caused by differences between groups or differences within groups [29]. Compared with the G, the T can examine the contribution of differences between groups and within groups to the total difference, making up for the limitation that it can only reflect the total difference [14]. The T calculation formula is:

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

In the formula, *T* is the T, δ_i is the proportion of the population (geographical area) of the region *i* in the whole country, and ε_i is the proportion of human resources for MCH in the region *i* in the whole country. The T ranges from 0 to 1, and the smaller the value, the better the fairness of the allocation of MCH human resources in the region [30].

The decomposition formula of the T is:

$$T=T_1+T_2$$
 $T_1=\sum_{j=1}^k \delta_j T_j$ $T_2=\sum_{j=1}^k \delta_j ext{lg}(\delta_j/\epsilon_j)$

 $\omega_1 = T_1/T$

 $\omega_2 = T_2/T$

In the formula, T_1 is the T within the group, T_2 is the T between groups, δ_j is the proportion of the population (geographical area) of region *j* to the whole country, and T_j is the T of region *j*, ε_j is the proportion of MCH human resources in region *j* to the whole country, ω_1 is the difference contribution rate within the group, and ω_2 is the difference contribution rate between the groups.

Results

Allocation level of health human resources in maternal and child health care institutions

Figure 1 shows the overall allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020. As of 2020, there were 428,809 health technicians in China's maternal and child health care institutions, accounting for 83.31% of the total number of health personnel in that year. There are 152,076 licensed (assistant) physicians (accounting for 35.46% of health technicians) and 196,000 registered nurses (accounting for 45.71% of health technicians), with a medical-nursing ratio of 0.78. From 2016 to 2020, the number of health technicians, licensed (assistant) physicians, and registered nurses has been increasing year by year, with an average annual growth rate of 7.53%, 6.88%, and 9.12%, respectively. However, the medical-nursing ratio showed a fluctuating downward trend, from 0.84 in 2016 to 0.78 in 2020.

Table 1 shows the health human resource density index of maternal and child health care institutions in mainland China in 2020. In general, the HRDI values of health technicians, licensed (assistant) physicians and registered nurses are the highest in Guangdong, Beijing, and Guangdong, respectively, and the lowest are in Tibet. Analyze the situation of different economic development level groups. In the Q4 regions, the HRDI values of the three types of MCH human resources are the highest in Guangdong, Beijing, and Guangdong, and the lowest in Tianjin. Among the Q3 regions, the HRDI values of the three types of MCH human resources are in Liaoning, Inner Mongolia, and Liaoning. Among the Q2 regions, the HRDI values of the three types of MCH human resources are the highest in Henan and

the lowest in Qinghai. In the Q1 regions, Guangxi has the highest HRDI value of the three types of MCH human resources, and Tibet has the lowest.

Group types	HTDI	Rank	LPDI	Rank	RNDI	Rank
Q4 regions						
Beijing	0.309	2	0.130	1	0.130	3
Shanghai	0.202	10	0.077	7	0.094	10
Jiangsu	0.140	17	0.059	14	0.058	19
Tianjin	0.075	24	0.042	21	0.015	27
Zhejiang	0.263	4	0.101	3	0.117	6
Fujian	0.160	15	0.059	13	0.070	16
Guangdong	0.313	1	0.101	4	0.150	1
Shandong	0.282	3	0.102	2	0.131	2
Q3 regions						
Inner Mongolia	0.048	27	0.019	28	0.019	25
Chongqing	0.159	16	0.051	18	0.080	12
Hubei	0.208	9	0.071	11	0.104	8
Shaanxi	0.185	12	0.052	17	0.080	13
Liaoning	0.041	28	0.021	27	0.013	28
Hunan	0.218	7	0.081	6	0.106	7
Ningxia	0.140	18	0.056	15	0.056	20
Jilin	0.071	25	0.032	24	0.027	24
Q2 regions						
Hainan	0.188	11	0.063	12	0.085	11
Anhui	0.108	22	0.044	20	0.045	22
Henan	0.251	5	0.085	5	0.120	5
Sichuan	0.122	20	0.040	23	0.059	18
Xinjiang	0.023	29	0.009	29	0.008	29
Jiangxi	0.211	8	0.072	10	0.101	9
Qinghai	0.019	30	0.008	30	0.006	30

Table 1 Health Human Resource Density Index of Maternal and Child Health Care Institutions in Mainland China in 2020

Group types	HTDI	Rank	LPDI	Rank	RNDI	Rank
Q1 regions						
Hebei	0.181	13	0.075	9	0.072	15
Tibet	0.006	31	0.002	31	0.002	31
Shanxi	0.112	21	0.045	19	0.046	21
Guangxi	0.249	6	0.076	8	0.122	4
Heilongjiang	0.050	26	0.021	26	0.019	26
Guizhou	0.160	14	0.053	16	0.075	14
Yunnan	0.132	19	0.041	22	0.062	17
Gansu	0.081	23	0.029	25	0.038	23

Table 2 shows the health human resource density index of maternal and child health care institutions at different economic levels in mainland China from 2016 to 2020. In general, the HRDI values of health technicians, licensed (assistant) physicians, and registered nurses all showed an upward trend year by year, with an average annual growth rate of 7.25%, 6.60%, and 8.83%, respectively. In terms of intra-group comparison, the HRDI values of the three types of MCH human resources allocation showed a ladder distribution. It shows the Q4 regions hit the highest HRDI value, while the Q2 regions and the Q1 regions obtain the lowest HRDI value. The HRDI value of the Q3 regions is between the highest and the lowest.

Personnel category	2016	2017	2018	2019	2020
Health technicians					
entire country	0.088	0.096	0.103	0.110	0.116
Q4 regions	0.190	0.206	0.218	0.235	0.238
Q3 regions	0.088	0.096	0.099	0.106	0.112
Q2 regions	0.066	0.072	0.077	0.083	0.090
Q1 regions	0.071	0.081	0.089	0.095	0.103
Licensed (assistant) physicians					
entire country	0.032	0.035	0.037	0.039	0.041
Q4 regions	0.066	0.072	0.077	0.084	0.086
Q3 regions	0.033	0.036	0.037	0.038	0.040
Q2 regions	0.023	0.025	0.026	0.028	0.031
Q1 regions	0.028	0.031	0.033	0.034	0.036
Registered nurses					
entire country	0.038	0.042	0.046	0.050	0.053
Q4 regions	0.084	0.092	0.098	0.107	0.109
Q3 regions	0.038	0.041	0.043	0.049	0.052
Q2 regions	0.030	0.033	0.036	0.039	0.042
Q1 regions	0.028	0.034	0.039	0.042	0.046

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

Quality structure of health human resource allocation in maternal and child health care institutions

Table 3 shows the quality structure of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020. In terms of age, the majority of health technicians and registered nurses are 25–34 years old, and the proportion is increasing, while the proportion of licensed (assistant) physicians is mainly concentrated in 35–44 years old, and the proportion is decreasing. In terms of educational background, health technicians and registered nurses are mainly college graduates, while licensed (assistant) physicians are mostly college graduates. Overall, the proportion of the three types of MCH human resources with a college degree or above shows an increasing trend. In terms of

professional titles, the majority of health technicians and licensed (assistant) physicians are at the division/assistant level, while registered nurses are concentrated at the doctoral level.

Category	Health te /%	chnicians	Licensed (assis physicians /%	Registered nurses /%		
	2016	2020	2016	2020	2016	2020
Age						
<25	8.6	6.0	0.1	0.3	13.8	9.2
25	38.6	39.7	21.9	23.3	46.5	50.2
35	29.1	28.4	38.9	34.2	24.2	25.2
45	19.8	19.2	31.2	29.7	14.0	12.5
55	2.3	4.8	4.0	8.5	1.0	2.4
≥ 60	1.7	1.9	3.9	4.0	0.3	0.5
Education						
Postgraduate	2.5	3.8	5.0	8.7	0.1	0.1
Undergraduate	29.4	39.7	44.9	54.1	15.1	28.3
College	43.2	40.9	35.2	28.2	51.2	51.1
Technical secondary school	24.1	15.1	14.3	8.6	33.1	20.2
High school and below	0.9	0.4	0.5	0.2	0.6	0.2
Job title						
Positive height	1.2	1.8	3.1	4.3	0.2	0.3
Deputy high	6.3	7.8	14.1	15.9	2.4	3.5
Intermediate	23.1	22.7	36.8	32.7	18.0	18.5
Teacher/Assistant	29.8	30.9	36.1	34.9	26.4	28.6
Bachelor	29.8	29.4	6.0	7.6	45.5	43.3
Unknown	9.9	7.4	3.9	4.6	7.5	5.7

Equity of health workforce allocation in maternal and child health care institutions

Gini coefficient measurement results

Figure 2 shows the G of the allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020. The G of health technicians, licensed (assistant) physicians and registered nurses by population were 0.1844–0.1924, 0.1435–0.1599, and 0.2131–0.2285, respectively. The allocation of health technicians and licensed (assistant) physicians is fair, while the allocation of registered nurses is relatively fair. If allocated according to the geographical area, the G of health technicians, licensed (assistant) physicians and registered nurses were 0.6730–0.6765, 0.6547–0.6689, and 0.6858–0.6965, respectively. All three types of resources are in a very unfair state. In addition, it can also be found that the G of the three types of MCH human resources allocated by population are all smaller than those allocated by geographical area. Notably, the G by population and by geographic area for health technicians and registered nurses showed a slight downward trend over the five years, while the opposite was true for licensed (assistant) physicians.

Theil index calculation results

Table 4 shows the T of the allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020. The total T of health technicians, licensed (assistant) physicians, and registered nurses by population are 0.027–0.035, 0.016–0.022, 0.044–0.052, respectively, and the total T indices by geographical area are 0.586–0.617, 0.538 ~ 0.593, 0.654 ~ 0.675, respectively. Overall, the total T of the three types of MCH human resources allocated by geographic area was significantly greater than that allocated by population. In addition, the overall T of the three types of MCH human resources allocated an upward trend.

By decomposing the total T, it can be found that the T of health technicians, licensed (assistant) physicians, and registered nurses within groups by population and by geographic area is greater than between groups. The contribution rates of the T within groups of the three categories of MCH human resources allocated by population to the total T are 97.22–98.58%, 90.13–95.95%, and 98.55–99.53%, respectively. The contribution rates of the T between groups to the total T were 84.55%-86.47%, 84.15%-85.22%, and 85.56%-87.69%, respectively.

Table 4 The T of the allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020

Personnel	Configured by population					Configured by geographic area				
category	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
Health technicians										
Total T	0.027	0.029	0.032	0.035	0.033	0.586	0.586	0.609	0.613	0.617
T between groups	0.001	0.001	0.001	0.000	0.001	0.091	0.088	0.086	0.087	0.083
T within groups	0.027	0.029	0.031	0.034	0.032	0.496	0.498	0.523	0.526	0.533
Licensed (assistant) physicians										
Total T	0.016	0.018	0.020	0.022	0.021	0.538	0.546	0.576	0.586	0.593
T between groups	0.002	0.002	0.001	0.001	0.001	0.085	0.086	0.086	0.090	0.088
T within groups	0.015	0.016	0.019	0.021	0.020	0.453	0.460	0.489	0.495	0.505
Registered nurses										
Total T	0.044	0.046	0.048	0.052	0.048	0.657	0.654	0.675	0.669	0.674
T between groups	0.001	0.000	0.000	0.000	0.001	0.095	0.091	0.086	0.087	0.083
T within groups	0.043	0.045	0.048	0.052	0.047	0.562	0.563	0.589	0.583	0.591

Table 5 shows the contribution rate of the T to the total T of the allocation of health human resources in maternal and child health care institutions at different economic levels in mainland China from 2016 to 2020. The contribution rates of the T of health technicians and registered nurses to the national total T are all in the Q2 regions < Q1 regions < Q3 regions < Q4 regions, while the licensed (assistant) physicians were in the Q1 regions < Q2 regions < Q3 regions < Q4 regions. If allocated according to the geographical area, the contribution rate of the T of the three types of MCH human resources to the national total T is Q4 regions < Q3 regions < Q1 regions.

The contribution rate of the T of the health workforce allocation of maternal and child health care institutions in different economic levels in mainland China to the total T from 2016 to 2020

Table 5

Personnel category	Contrib /%	ution rate	e by popu	lation all	ocation	Contribution rate by geographic area /				ea /%
	2016	2017	2018	2019	2020	2016	2017	2018	2019	2020
Health technicians										
Q4 regions	35.99	36.54	37.33	36.01	35.89	0.42	0.43	0.43	0.45	0.41
Q3 regions	27.49	28.36	28.16	31.28	32.84	11.98	12.06	11.67	11.75	11.76
Q2 regions	16.46	16.07	16.96	14.64	13.88	36.08	35.17	34.33	34.62	35.22
Q1 regions	18.15	17.16	15.71	16.65	14.62	36.07	37.25	39.46	38.98	39.08
Licensed (assistant) physicians										
Q4 regions	35.43	36.45	37.54	36.79	37.23	0.38	0.36	0.36	0.36	0.34
Q3 regions	30.98	31.22	29.31	31.87	33.78	11.18	11.11	10.63	10.51	10.72
Q2 regions	15.10	13.20	15.03	13.84	13.33	35.47	34.43	33.10	33.11	33.60
Q1 regions	8.62	10.63	11.20	13.20	11.61	37.12	38.35	40.95	40.59	40.56
Registered nurses										
Q4 regions	28.77	32.01	33.63	33.41	34.94	0.43	0.48	0.49	0.53	0.48
Q3 regions	31.42	31.44	30.41	32.86	32.85	12.76	12.50	11.98	12.33	12.26
Q2 regions	16.06	16.94	18.17	15.34	14.50	36.22	36.35	35.60	36.05	36.27
Q1 regions	22.33	19.05	17.25	17.92	16.25	36.15	36.78	39.14	38.15	38.68

Discussion

This study uses longitudinal data from 2016 to 2020, divides regions according to regional economic levels, and explores the allocation and equity of health human resources in maternal and child health care institutions in mainland China. The results of the analysis can reveal the remaining problems in the current development, help rationally allocate the human resources for MCH, provide more equitable and accessible MCH services, and promote the high-quality development of the cause of MCH. To the best of our knowledge, this is the first study on the allocation of MCH human resources using nationwide longitudinal data after the adjustment of the new fertility policy.

In terms of allocation level, the allocation level of MCH human resources in mainland China has been continuously improved. From 2016 to 2020, the number of health technicians, licensed (assistant) physicians, and registered nurses in maternal and child health care institutions showed an increasing trend year by year. By the end of 2020, health technicians have accounted for 83.31% of the total number of health personnel, and the ratio of medical care to nurses has reached 1:1.28, which has completed the "China Medical and Health Service System Planning Outline (2015–2020)." The staff ratio is not less than 80% of the total number and the mission target of a medical-to-care ratio of 1:1.25 [31]. This shows that the Chinese government's efforts to improve the MCH service system are very effective.

However, there are differences in the level of MCH staffing in regions with different economic development levels. In 2020, the HRDI value of Guangdong health technicians and registered nurses will be about 52 times and 75 times that of Tibet, respectively, while the HRDI value of Beijing licensed (assistant) physicians will be about 65 times that of Tibet. In the five-year comparison, the HRDI values in the Q4 regions were the highest, followed by the Q3 regions, and the lowest in the Q2 regions and the Q1 regions. Analyzing the reasons, on the one hand, may be related to the level of economic development and population density between regions. The more developed the regional economy and the higher the population density, the greater the investment in MCH resources. On the other hand, regions with better economic development are more attractive to health professionals and have more development opportunities [32]. Therefore, in the future, government health investment should focus on balancing regional differences, and appropriately tilt towards regions with lower levels of economic development. At the same time, a talent incentive policy was formulated to encourage health personnel to go to poor areas with relatively scarce health resources [33].

We found that when analyzing the allocation of health human resources, few studies have explored the quality structure of allocation. This study adds to this section. The results show that health technicians and registered nurses in maternal and child health care institutions in mainland China are mainly college graduates while licensed (assistant) physicians are mainly college graduates, which is similar to the findings of Ren Z et al. [34]. A previous study found that in 2005, 67.2% of licensed (assistant) physicians and 97.5% of registered nurses in China had only junior college or technical secondary education [35]. Compared with the national average, the education level of MCH personnel has been greatly improved, and they can provide higher quality MCH services. In addition, the professional titles of health technicians and licensed (assistant) physicians are mainly at the division level/assistant level, and registered nurses are concentrated at the doctoral level. The WHO has recommended that the ratio of professional titles for health personnel should be 1:3:1 in the ratio of senior, intermediate, and junior [36]. At present, there is still a gap in this standard. It is suggested to improve the continuing education mechanism of MCH personnel, reasonably standardize the scale and structure of personnel training, and continuously improve their knowledge.

In terms of allocation equity, this study shows that the allocation of MCH technicians, licensed (assistant) physicians, and registered nurses in mainland China is equitable by population, but not by geographical area. This conclusion is consistent with previous research results [27, 37, 38]. The reason may be that

government health departments usually use the number of health resources per 1,000 population as the standard for regional planning and allocation, and pay less attention to the geographic availability of health resources [39]. However, the fairness of the allocation of health resources by geographical area is very critical to the utilization rate of health resources. Therefore, it is suggested that in the formulation of MCH plans in the new era, the two factors of the service population and geographical area should be comprehensively considered, to improve the geographical accessibility of MCH services and meet the needs of residents for MCH services.

The T was also decomposed in this study. The results show that the inequity in the allocation of MCH human resources is mainly caused by differences within regions, which is consistent with the results of previous studies [14, 40, 41]. The contribution rate of different economic regions to the national total T is further analyzed. The study found that if allocated by population, the main reasons for the inequity in the allocation of MCH human resources were the Q2 regions and the Q1 regions. It is worth noting that if the allocation is based on geographical area, the Q4 regions are the main reason for the unfair allocation. It is not difficult to understand that Tibet, Xinjiang, and other places are sparsely populated and have a large service radius, while Beijing, Shanghai, and other places are on the contrary, and the economic development levels of the two are also far from each other. At this time, the allocation of MCH resources according to the population is Obviously in favor of the latter, geographically in favor of the former. Therefore, it is suggested that policymakers need to fully understand the impact of intra-regional differences on the allocation of MCH human resources, increase financial support for regions with medium and low GDP per capita, introduce corresponding employment guidance policies, and attract more outstanding health professionals.

This study has some limitations. First, the research subjects were only included in the 31 provinces, municipalities, and autonomous regions in mainland China, excluding Hong Kong, Macau, and Taiwan. The medical and health systems in these regions are somewhat different from those in mainland China. In the future, we can further explore their impact on the fairness of China's overall MCH human resources allocation. Secondly, the research objects are divided into regions based on the level of economic development, and the contribution rates of differences between groups and within groups to the total T are analyzed to reflect the overall fair impact of economic factors on the equity of MCH staffing has not been studied. Finally, this study only discusses the fairness of allocation and ignores the efficiency of allocation. In the future, evaluation can be made on this basis, so that the allocation of MCH human resources can take into account both fairness and efficiency.

Conclusions

This study focuses on the distribution of health human resources in maternal and child health care institutions in mainland China and the fairness of their distribution. Although the Chinese government has made great efforts in MCH work in the past, our research shows that there are still differences in the distribution of MCH personnel in different economic development regions in China, and the fairness of

allocation by population is better than allocation by geographical area. In addition, the quality structure of MCH personnel is still far from the standard recommended by the WHO. In the future, policymakers should especially focus on considering the impact of intra-regional differences on the allocation of MCH human resources, and continuously improve the geographic accessibility of MCH services.

Abbreviations

GDP: Gross Domestic Product; **HRDI:** Health resources density index; **G:** Gini coefficient; **FA:** Fairness assessment; **T:** Theil index; **MCH:** maternal and child health; **WHO:** World Health Organization; **HTDI:** Health Technician Density Index; **LPDI:** Licensed (Assistant) Physician Density Index; **RNDI:** Registered Nursing Density Index.

Declarations

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Authors' contributions

YM conceived and designed this study. HF N, CJ T and YX H collected data and prepared preliminary work. YM and PX conducted methodological studies. YM, PX and ZG Z analyzed and interpreted results and YM was a major contributor to the manuscript. SY H, MX W, LY, LY and LL conducted research guidance. ZG Z reviewed and edited manuscripts. All authors read and approved the final manuscript.

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Availability of data and materials

The data for this study came from: a). China National Health Commission official website (http://www.nhc.gov.cn/wjw/index.shtml), b). China National Bureau of Statistics official website (http://www.stats.gov.cn/) and c). China Ministry of Civil Affairs official website (http://www.mca.gov.cn/)

Ethics approval and consent to participate

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

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Figures

Figure 1

The allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020.



Figure 2

The Gini coefficient of the allocation of health human resources in maternal and child health care institutions in mainland China from 2016 to 2020.