

BMJ Open Development trend of primary healthcare after health reform in China: a longitudinal observational study

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ABSTRACT

Objectives Reconstructing the primary healthcare system is the focus of the new round of Chinese health reform. Nevertheless, there have been few studies focusing on the strengthening of primary healthcare in Chinese health system.

Design This study was a longitudinal observational study.

Primary and secondary outcome measures The data of this study came from China Health Statistical Yearbook (2009–2018). We evaluated the development of primary healthcare based on the absolute values of health resources allocation and health service provision and evaluated the status of primary healthcare throughout the health system based on the composition ratios of the indicators across the health system. The Cochran-Armitage trend test and linear trend test were used to identify the indicators' trends over time.

Results From 2009 to 2018, the amounts of health resources allocation and health service provision of Chinese primary healthcare institutions showed a significant upward trend ($p < 0.001$). However, compared with the indicators in 2009, excepting that the proportion of grants from the government in the whole health system has an upward trend, the proportions of other indicators had an escalating trend in 2018 by 3.66% for practicing (assistant) physicians, by 2.69% for nurses, by 3.99% for total revenues, by 5.87% for beds, by 8.39% for outpatient visits.

Conclusion The primary healthcare system has developed rapidly, but its development speed lagged behind the entire health system, resulting in the weakening of its actual functions, which is not in line with the goal of health reform. The government should be more aware of the importance of primary healthcare at all levels of local governments and ensure adequate financial input.

INTRODUCTION

Primary healthcare (PHC) is the key to achieving the goal of 'health for all'.¹ Chinese government had established a relatively complete primary healthcare system in the late 1950s,² which has been promoted and introduced by WHO to other countries as a model.³ However, after 1978, the primary healthcare system, which mainly relied on government funding to maintain normal operation, collapsed almost overnight.^{4,5} At

Strengths and limitations of this study

⇒ This study was a longitudinal observational study based on China Health Statistics Yearbook (2009–2018), which provided information on health resources and health services of different kinds of medical institutions in China.

⇒ This study was the first to use the Cochran-Armitage trend test and linear trend test to examine trends in health resources allocation and health service provision, which somewhat increased the statistical validity of the results.

⇒ Due to the limited data provided by the Yearbook, we could not analyse the development of primary healthcare institutions (PHIs) before 2009. Second, due to the limited data provided by the Yearbooks, we could only analyse the development of primary healthcare (PHC) based on health resources allocation and health service provision. Other important evaluation dimensions, such as the health service quality and the development equity of PHC and regional heterogeneity, were not analysed, which could limit the overall understanding of primary healthcare development in China.

⇒ In addition, the data used in this study were panel data, so that we could only carry out descriptive and trend analysis. Therefore, it was difficult for us to make an in-depth analysis and comparison.

the same time, some problems, such as lacking adequate health resources, inadequate staff capacity, unregulated health services provision, outdated medical facilities, low levels of trust among the population and so on, have hindered the development of primary healthcare institutions (PHIs), resulting in their health service provision at a low level for a long time.^{6–10} Based on the reasons above, PHIs have become the least developing and most vulnerable part of the health system in China, seriously impeding the realisation of the goal of 'healthcare for all'. Previous studies focused on the impact of socioeconomic status on individual health status,^{11 12} but fewer researches on the impact of health

resources allocation and health service provision on individual health outcomes.

In response to the above problems, the government began to launch a new round of health reform in 2009,^{13–15} aiming at optimising the distribution of health resources, strengthening the capacity of primary care and guiding residents to seek medical treatment from PHIs.^{16 17} Reconstructing the PHC system is the focus of this reform,^{13 15} and it is also the key to realising the reform goal. In the first 3 years from 2009, the government health investment amounted to about CNY 1409.9 billion (US\$ 206 billion), and 44% of the funds were allocated for PHIs.¹⁸ In addition, the Chinese Government is actively promoting the construction of PHC workforce with general practitioners at its core, standardising service programmes including 17 basic public health services, promoting family doctor contracting services, improving the multilevel medical security system supported by the basic medical insurance and other forms of supplementary insurances, integrating the sharing of regional health resources, and other improvements to the PHC system.^{14 19 20} Moreover, in 2019, China has implemented Basic Healthcare and Health Promotion Law,²¹ which elevated the policy of strengthening PHC to the legal level and opened up new opportunities for the development of PHIs. Therefore, it is timely and particularly important to evaluate the current situation of the development of PHC and find the problems existing in the PHC or sum up successful experiences in China.

At present, there have been some studies on PHC in China, but there are more deficiencies. First, the evaluation perspective is relatively single, most researchers evaluate from a single aspect of health resources allocation or service provision,²² lacking a combination of the two aspects. Second, most studies were based on specific regions or groups of the population and lacked a comprehensive national evaluation.^{23 24} In addition, most of the existing studies used cross-sectional data or only intercept short-term data for effect evaluation,²⁵ resulting in certain problems such as the ineffectiveness of policy construction due to the insufficient time span of the data, which weakened the accuracy of the research results to a certain extent. Therefore, it is not clear whether the role of primary healthcare in the overall health system is strengthened, which is the core goal of this round of health reform in China. Health resources allocation and health service provision are the two core contents of health service research. According to the resource allocation theory, the rational allocation of health resources and the adequate guarantee of health services are the crucial basis for the normal operation of the whole health system.²⁶ Therefore, analysing PHC's constituent ratio of health resources allocation and health service provision in the whole health system is the main approach to analysing its role in the whole health system.

Therefore, based on the Chinese health statistics data in the past 10 years, the trend test^{27 28} was being used to analyse the changing tendency of various indicators of

PHC system construction since the health reform. This study evaluated the development of the PHC system via analysing the changing trend of health resources and health service quantities and evaluated the role of primary healthcare in the whole health system by analysing the proportion of health resources allocation and health service provision in the whole health system. This study was of great practical significance to evaluate the effect of the construction of PHC effectively and to summarise the construction experience and existing problems, adjusting the relevant policies and measures of health reform, promoting high-quality development of medical care, accelerating the realisation of the goal of reconstructing the PHC system.

METHODS

Study design and data source

This study was a longitudinal observational study based on China Health Statistics Yearbook (2009–2018), which provided information on health resources and health services of different kinds of medical institutions in China. In order to assess whether Chinese health resources were tilted towards PHIs and whether the service quantity of PHIs has been increased, we analysed the dynamic changes in the absolute value and the constituent ratio of health resources allocation and health service provision in PHIs from 2009 to 2018.

Indicators and definitions

In this study, the definition of PHIs refers to the statistical calibre of the China Health Statistics Yearbook. In China, PHIs include community health service centres (stations), township health centres, village clinics, outpatient departments, clinics, infirmaries and nursing stations. The main indicators of this study are health resources allocation and health service provision. Health resources include human resources, financial resources and material resources. Human resources include the number of health workers, practicing (assistant) physicians, nurses and pharmacists. Financial resources include total revenues, grants from the government and incomes from charges for services. Material resources include a total number of equipment at or above CNY 10 000, building areas and the total number of beds. Health service provision includes an annual number of outpatient visits and inpatient care. The details about the indicators are shown in online supplemental appendix 1.

Patient and public involvement

No patient involved.

Statistical analysis

The trend test is used to count whether there is some trend in the change of a certain indicator with the change of the year and to test whether this trend is statistically significant. In this study, the linear regression test and the Cochran-Armitage trend test were used to test the trend

of relevant indicators,²⁸ so as to ensure the robustness of the results. The more detail about the linear regression test and the Cochran-Armitage trend test are shown in online supplemental appendix 2. We used the absolute value of each indicator to analyse the development of PHIs and the linear regression analysis to test the trend of absolute values over time. When the regression coefficient β was positive, the absolute value of each indicator had an upward trend, on the contrary, when β was negative, the absolute value of each indicator showed a downward trend. We evaluated the status of primary healthcare throughout the health system based on the composition ratio of the indicators across the health system and used the Cochran-Armitage trend test to examine the trend of composition ratio for each indicator over time. The *Z* value was positive, which means that the composition ratio of each indicator has shown an upward trend, oppositely, the *Z* value was negative, which means that the composition ratio of each indicator presented a downward trend.

In this study, analyses were performed using SAS V.9.2 (SAS, Cary, North Carolina). All statistical tests were two tailed, and a *p* value <0.05 was considered to be statistically significant.

RESULTS

The dynamic changes in the quantities of the health resources allocation and health service provision in all medical institutions and PHIs in China

The quantities of human resources

From 2009 to 2018, the quantities of human resources in China showed a significant dynamic upward trend over time, which were statistically significant (*p*<0.001). Compared with the human resources in 2009, the quantities of the total health workers, practicing (assistant) physicians, nurses and pharmacists in 2018 have increased by 58.07%, 54.87%, 120.97% and 36.79%, respectively. For PHIs, the amounts of health resources had an escalating trend, but the rate of increases were slower than the whole health system, by 25.78% for the total health workers, by 40.63% for practicing (assistant) physicians, by 101.86% for nurses and by 23.21% for pharmacists (tables 1 and 2).

The quantities of financial resources

Compared with the financial resources in 2009, for PHIs, besides grants from the government had a greater increase than the one for all medical institutions (628.51% vs 354.18%) in 2018, the other indicators' rates of increases were slower than in all medical institutions, for total revenues (173.26% vs 246.56%) and for incomes from charges for services (93.70% vs 223.39%). (tables 1 and 2)

The quantities of material resources

From 2009 to 2018, the quantities of all indicators both in all medical institutions and PHIs had an apparent upward trend (*p*<0.001). However, for PHIs, all indicators' rates

of increases were slower than in all medical institutions, for beds (45.11% vs 90.28%), building areas (37.85% vs 81.76%) and the total number of equipment at or above CNY, 10 000 (140.30% vs 189.30%) (tables 1 and 2).

The quantities of service provision

From 2009 to 2018, in addition to the number of inpatient care in PHIs, the quantities of the indicators for service provision in China had an upward trend (*p*<0.001). The quantities of outpatient visits and inpatient care significantly increased by 53.80% and 92.01% for Chinese all medical institutions from 2009 to 2018. Compared with the rate of increases with all medical institutions, PHIs have grown more slowly, whose growth rate was 32.52% and 6.44% (tables 1 and 2).

Proportions of health resources allocation and health service provision by PHIs

Figure 1A shows the trend of human resource allocation in Chinese PHIs from 2009 to 2018. The results indicated that the proportion of health workers had decreased year by year, which was statistically significant (*p*<0.001). The proportion of the number of health workers in the whole health system declined from 40.51% in 2009 to 32.23% in 2018. Among them, practicing (assistant) physicians declined from 39.84% in 2009 to 36.18% in 2018, nurses declined from 22.77% in 2009 to 20.80% in 2018, and pharmacists declined from 34.85% in 2009 to 31.39% in 2018.

In the allocation of financial resources, the proportion of grants from the government has increased by about 10 percentage points, increasing from 22.33% in 2009 to 32.60% in 2018. On the contrary, the proportions of total revenues and incomes from charges for services had a significant down, which were a decrease of 3.99% and 7.37% in these two departments, respectively, compared with proportions in 2009 (figure 1B).

As to 2018, among material resources, the proportions of the total number of equipment at or above CNY 10 000, building areas and the total number of beds had decreased by nearly 2, 8 and 6 percentage points, respectively (figure 1C).

The dynamic change of the proportion of service provision in PHIs from 2009 to 2018 is shown in figure 1D. The number of outpatient visits in PHIs dropped from 60.63% in 2009 to 52.24% in 2018, a decrease of approximately 8 percentage points. The proportion of inpatient care decreased from 31.01% in 2009 to 17.19% in 2018, a decline of approximately 13 percentage points. All (*p*<0.001) showed a significant downward trend.

The results of all the indicators' trend tests are shown in online supplemental appendix 3.

DISCUSSION

On the occasion of the 10th anniversary of Chinese health reform, there have been some studies expounding the effectiveness of health reform,^{20 24 29 30} such as Meng and

Table 1 Health resources allocation and health service provision of medical institutions in China, 2009–2018

Indicators/unit	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Increase*	%†	β	SE	P‡
Human resources															
Total health workers/person	7781.448	8207.502	8616.040	9115.705	9790.483	10234.213	10693.881	11172.945	11748.972	12300.325	4518.877	58.07	505.594	7612.33	<0.001
Practicing (assistant) physicians/person	2329.206	2413.259	2466.094	2616.064	2794.754	2892.518	3039.135	3191.005	3390.034	3607.156	1277.950	54.87	141.997	6827.13	<0.001
Nurses/person	1854.818	2048.071	2244.020	2496.599	2783.121	3004.144	3241.469	3507.166	3804.021	4098.630	2243.812	120.97	250.044	4954.78	<0.001
Pharmacists/person	341.910	353.916	363.993	377.398	395.578	409.595	423.294	439.246	452.968	467.685	125.775	36.79	14.262	244.40	<0.001
Financial resources§															
Total revenues/ million yuan	1186.291.18	1372.627.83	1647.299.36	1998.578.88	2314.754.80	2643.488.53	2953.787.71	3316.611.68	3697.532.03	4111.172.38	2924.881.2	246.56	328.116	8268.80	<0.001
Grants from the government/ million yuan	133.533.79	166.787.42	228.599.98	271.403.45	313.104.35	350.062.81	432.130.74	484.856.63	543.225.10	606.485.23	472.951.44	354.18	52.679	1613.26	<0.001
Incomes from charges for services/ million yuan	1034.124.24	1184.722.31	1392.683.83	1653.952.71	1914.745.48	2197.213.63	2414.403.39	2709.985.97	3015.316.40	3344.278.71	2310.154.47	223.39	259.127	6995.94	<0.001
Material resources															
Total number of equipment at or above CNY 10 000/set¶	2528.796	2824.445	3176.357	3586.935	4172.171	4833.818	5290.731	5924.738	6578.025	7315.901	4787.105	189.30	538.630	21795.00	<0.001
Building areas/ million square meters¶	463.34	500.98	582.48	553.87	584.75	614.42	652.56	682.26	728.55	842.17	378.83	81.76	36.32	3.68	<0.001
Beds/unit	4416.612	4786.831	5159.889	5724.775	6181.891	6601.214	7015.214	7410.453	7940.252	8404.078	3987.466	90.28	445.482	5618.70	<0.001
Service provision															
Outpatient visits/million	5187.41	5521.32	5944.81	6529.94	6960.52	7258.64	7366.24	7600.34	7847.83	7978.16	2790.75	53.80	318.10	23.71	<0.001
Inpatient care/ million	132.56	141.74	152.98	178.57	192.15	204.41	210.54	227.28	244.36	254.54	121.98	92.01	13.91	0.47	<0.001

*The change in the absolute value of each indicator in 2018 compared with the value in 2009.

†% was the value's growth rates in 2018 compared with the value in 2009.

‡P-values were associated with linear regression analysis.

§When choosing a medical institution for treatment, residents consider not only the qualifications of health workers but also the size of the medical institution and the configuration of its facilities and equipment. The dynamic changes of the total number of equipment at or above CNY 10 000 and building areas could reflect the residents' willingness to seek medical treatment.

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Table 2 Health resources allocation and health service provision of primary healthcare institutions in China, 2009–2018

Indicators/unit	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Increase*	%†	β	SE	P‡
Human resources															
Total health workers/person	3 152 040	3 282 091	3 374 993	3 437 172	3 514 193	3 536 753	3 603 162	3 682 561	3 826 234	3 964 744	812 704	25.78	79 889	4854.31	<0.001
Practicing (assistant) physicians/person	928 026	949 054	959 965	1 009 567	1 050 067	1 064 136	1 101 934	1 145 408	1 213 607	1 305 108	377 082	40.63	39 176	3231.70	<0.001
Nurses/person	422 262	466 503	492 554	528 178	576 630	603 900	646 607	695 781	769 206	852 377	430 115	101.86	44 780	2647.31	<0.001
Pharmacists/person	119 166	125 467	125 698	127 262	130 039	131 493	134 495	138 060	142 482	146 827	27 661	23.21	2745.56	192.00	<0.001
Financial resources§															
Total revenues/ million yuan	224 128.23	225 727.98	263 839.57	313 849.49	353 254.73	382 963.06	434 885.37	482 937.52	548 396.95	612 463.66	388 335.43	173.26	43 891	2330.64	<0.001
Grants from the government/ million yuan	27 142.39	40 547.58	67 934.89	90 153.68	104 919.08	113 195.10	139 736.03	157 679.73	178 440.41	197 735.18	170 592.79	628.51	18 826	487.21	<0.001
Incomes from charges for services/million yuan	189 990.72	177 344.00	185 422.60	197 907.09	220 406.55	240 606.31	262 031.70	288 862.13	328 332.33	368 005.51	178 014.79	93.70	20 538	2294.59	<0.001
Material resources															
Total number of equipment at or above CNY 10 000/set¶	354 402	405 494	435 463	439 640	482 336	532 575	579 740	640 344	719 543	792 199	462 524	140.30	49 674	2708.58	<0.001
Building areas/ million square meters¶	165.75	187.05	188.97	184.43	188.57	194.18	200.38	205.55	213.04	228.49	62.74	37.85	5.35	0.71	<0.001
Beds/unit	1 091 277	1 192 242	1 233 721	1 324 270	1 349 908	1 381 197	1 413 842	1 441 940	1 528 528	1 583 577	492 300	45.11	49 523	2701.05	<0.001
Service provision															
Outpatient visits/million	3 145.14	3 350.67	3 535.62	3 819.96	4 044.53	4 101.92	4 092.13	4 118.70	4 179.73	4 167.90	1 022.76	32.52	113.92	18.12	<0.001
Inpatient care/ million	41.11	39.50	37.75	42.54	43.01	40.94	40.37	41.65	44.50	43.76	2.65	6.44	0.42	0.18	=0.051

*The change in the absolute value of each indicator in 2018 compared with the value in 2009.

†-% was the value's growth rates in 2018 compared with the value in 2009.

‡P values were associated with linear regression analysis.

§This study did not correct for the effect of inflation on the financial resources indicators.

¶When choosing a medical institution for treatment, residents consider not only the qualifications of health workers but also the size of the medical institution and the configuration of its facilities and equipment. The dynamic change of the 'total number of equipment at or above CNY 10 000' and 'building areas' could reflect the residents' willingness to seek medical treatment.

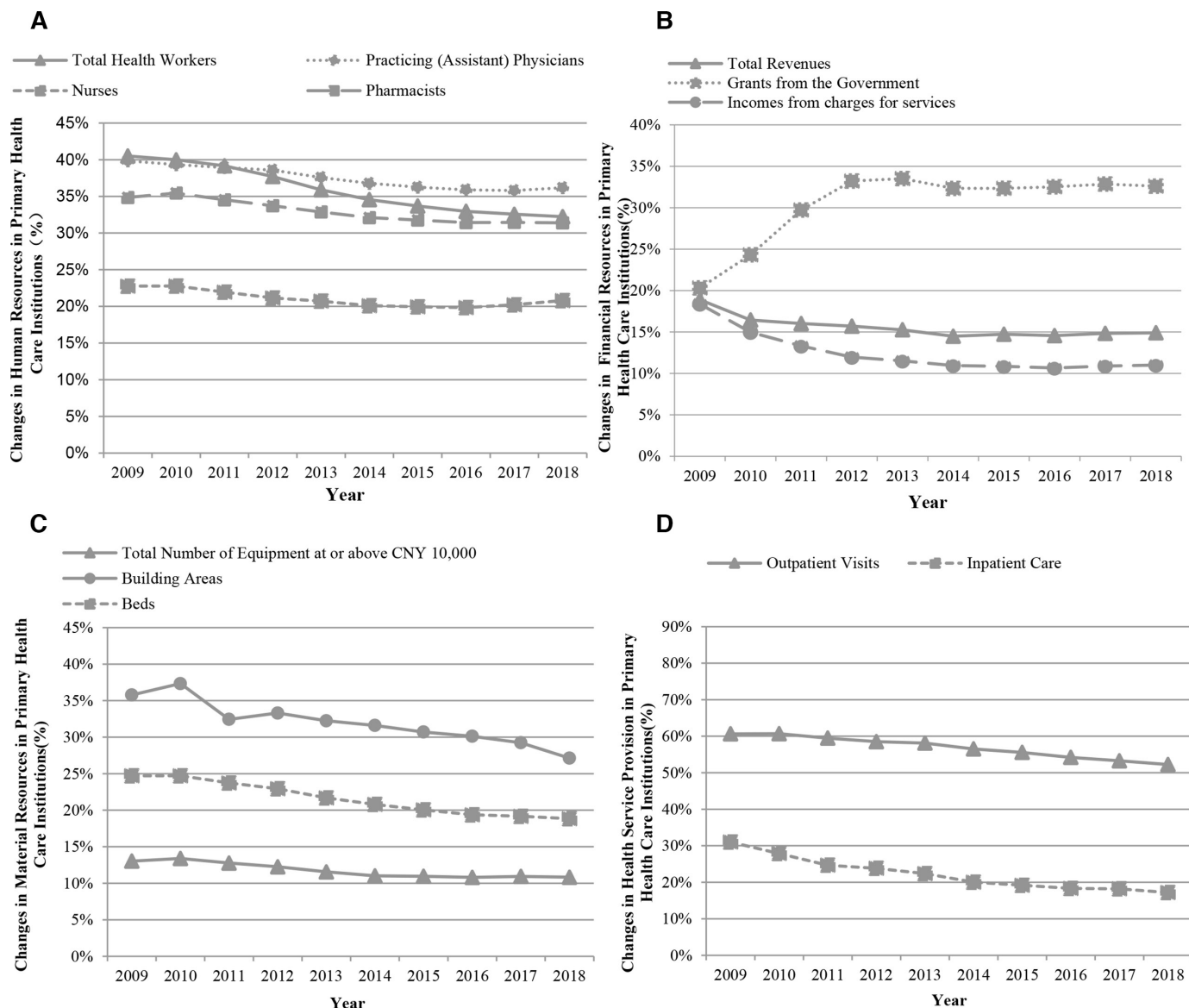


Figure 1 (A) Changes in the percentage of human resources in primary healthcare institutions, 2009–2018. (B) Changes in the percentage of financial resources in primary healthcare institutions, 2009–2018. (C) Changes in the percentage of material resources in primary healthcare institutions, 2009–2018. (D) Changes in the percentage of health service provision in primary healthcare institutions, 2009–2018.

colleagues, based on the Chinese Health Statistics Yearbook, using descriptive analysis to highlight changes in government and social health expenditure and changes in unmet health needs and disparities in maternal and infant mortality as the health output and outcome.¹⁴ This study was the first to use the trend test to analyse the development of PHC in China from two inter-related aspects: health resources allocation and health service provision. With the rapid development of China's health system in the past 10 years, the absolute value of health resources allocation and health service provision of the PHIs has increased significantly, but the rate of increases of PHIs was slower than the whole health system. At the same time, the proportion of health resources allocation and health service provision of the PHIs in the whole health system has continued to decline, which suggested

that the Chinese PHIs has made some progress after the health reform, but its development rate was slow, lagging behind the whole health system, which indicated that the role of PHC has been indeed weakened in China.

From 2009 to 2018, a total amount of health resources allocation and health service provision have been increasing of PHIs, and the hardware conditions of diagnosis and treatment services gradually improved at the same time, which was similar to the findings of Xu *et al*³¹ and Zhang *et al*.³² In addition, under the regulation of the policy to strengthen PHC, the Chinese government has continued to increase financial investment in PHIs, and the proportion of grants from the government of PHIs has an apparent increase, from 20.33% to 32.60%, which was consistent with the existing studies.^{33 34} These measures have effectively improved the hardware conditions and

diagnosis and treatment environment of PHIs in a short period of time, including the reconstruction and expansion of business rooms, the purchase of equipment, the training or introduction of talented health workers.

It is worth noting that from the dynamic changes of the constituent ratio of health resources allocation and health service provision for PHIs, except for the proportion of grants from the government, other indicators all have decreased in varying degrees, which indicated that with the change of time, the basic conditions and service output of PHC are constantly improving, but its development speed is lower than that of the whole health system. To some extent, this study showed that the development of Chinese PHC might have lagged behind the whole health system in the past decade, which had not yet reached the goal of health reform to strengthen the role of PHC. The reasons for this result may be multifaceted.

First, in spite that the Chinese central government has formulated a series of policies and measures to promote the development of primary healthcare,^{14 35–37} the implementation of the policies was mainly done by local governments.²⁵ The implementation of policies was inevitably accompanied by the allocation of health resources. Due to lacking awareness of the importance of primary healthcare among local governments,^{5 38 39} they might have allocated more resources to general hospitals and specialist hospitals. Second, the current power structure inside the medical industries is more likely to elicit a trend that the general hospitals possess more power of discourse than the PHIs in the same region. Third, previous studies have consistently concluded that the development of primary healthcare lacked sufficient financial support in China,^{8 40} but how much financial investment is sufficient has been a lack of research. Fourth, compared with hospitals, PHIs had lower remuneration and limited career development prospects in China, which led to the extremely low attraction for excellent health professionals.¹⁴ In this study, the proportion of health workers in PHIs in the whole health system has decreased year by year, from 40.51% in 2009 to 32.23% in 2018, which was consistent with the results of Zhong *et al.*⁴¹ Moreover, at present, the strengthening PHC measures implemented put too much emphasis on the standardisation and the improvement of hardware conditions of PHIs in China,^{30 42–44} while ignoring the improvement of PHIs service capacity and the construction of supporting mechanisms, so that the trust of residents in PHIs has not been effectively improved. As a result, the number of outpatient visits and inpatient care in PHIs decreased at an average annual rate of about 0.8% and 1.4%, respectively, resulting in reducing the incomes from charges for services of PHIs and aggravating the shortage of health funds, then forming a vicious circle of ‘the development backwardness of primary healthcare-low attractiveness for patients-more backward of primary healthcare’.

The strength of this study was that this study was the first to use the trend test to examine trends in health resources allocation and health service provision, which

somewhat increased the statistical validity of the results. Second, the existing studies’ evaluation perspective was scattered, analysing the effectiveness of the health reform more at a microlevel, such as the expenditure on health costs and the improvement of the health status of the population. This study used longitudinal data to evaluate the development of PHC in China at a macrolevel, which could improve the understanding of scholars and policymakers at home and abroad about the practical experience and existing problems in building the Chinese PHC system. Moreover, this study has strong implications for low-income and middle-income countries, particularly those with social systems compatible with China, strengthening their decision-making on PHC planning, health resources allocation and health service provision.

This study also had some limitations. First, some of the indicators were introduced to the yearbooks after the health reform in 2009, and few of them were aggregated at a provincial level. Therefore, due to the limited data provided by the Yearbook, we could not analyse the development of PHIs before 2009. Second, due to the limited data provided by the Yearbooks, we could only analyse the development of PHC based on health resources allocation and health service provision. Other important evaluation dimensions, such as the health service quality and the development equity of PHC, and regional heterogeneity were not analysed, which could limit the overall understanding of primary healthcare development in China. In addition, the data we used came from the Yearbook, which was panel data, so that we could only carry out descriptive and trend analysis and was difficult to make a more in-depth analysis and comparison. It was also impossible for us to analyse how much of the changing trend in the development of PHC could be attributed to the health reform.

CONCLUSIONS

Based on continuous longitudinal data provided by China Health Statistical Yearbook from 2009 to 2018, this study found that the absolute values of health resources allocation and health service provision of the PHIs have increased significantly, but the proportions of health resources allocation and health service provision of the PHIs in the whole health system have continued to decline, which suggested that the PHC system developed rapidly, but its development speed lagged behind the whole health system, resulting in the weakening of its actual functions, which is not in line with the goal of health reform. All these indicate that in the next stage of the health reform, the Chinese government should improve the awareness of the importance of PHC at all levels of governments, mobilise their enthusiasm and strengthen their responsibility to optimise health resources allocation. Second, it is also crucial to set up special funds for PHC to ensure that the relevant funds, equipment, talents and other resources are directly sunk to PHIs, so as to enhance PHIs’ capacity of services and

guide residents to seek medical treatment from PHIs. Additionally, health education and reasonable payment methods of medical insurance should be introduced to change residents' health-seeking patterns and guide residents to use primary healthcare services.

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Contributors JF conceived the study and analysed the data. Data collection was performed by JW, JF and YG wrote the draft of the paper. HL, GZ and ZL gave advice on statistical methodology. JF, XZ and XY brought up connected suggestions for revising the manuscript and checked the revised manuscript. XY and XZ provided the critical revision of the manuscript for important intellectual content and supervision of the work. XY obtained funding. All authors read and approved the final manuscript. XY acts as guarantor for the final manuscript.

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Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval The data we used came from China Health Statistical Yearbook, which was published by the government and did not require approval from the Ethics Committee.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request. The data that support the findings of this study are available from the corresponding author, Professor Xiaoxv Yin. Email: yxx@hust.edu.cn.

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Online supplemental appendix 1. The indicators and definitions about this study

Indicator	Definition	Unit
Human resources		
The number of health workers	including practicing (assistant) physicians, nurses, pharmacists, and other health technicians, as well as management workers and logistics workers	person
Practicing (assistant) physicians	refer to those whose level in the Medical Practitioner's License is Practicing (Assistant) Physician and who are actually engaged in medical and preventive health care works	person
Nurses	refer to those who have the Registered Nurse Certificate and are actually engaged in nursing	person
Pharmacists	including chief pharmacists, deputy chief pharmacists, in-charge pharmacists, and pharmacists	person
Financial resources		
Total revenues	Total revenues are defined as non-reimbursable funds legally obtained by medical institutions for the conduct of their operations and other activities	million yuan
Grants from the government	refers to the financial business funding received by the government	million yuan
Incomes from charges for services	refers to the income derived by medical institutions from carrying out medical services	million yuan
Material resources		
A total number of equipment at or above CNY 10,000	refers to the total number of equipment over CNY10,000 actually owned by medical institutions	set
Building areas	refers to the building areas purchased by the medical institutions and with the title deed, excluding the area of rented housing	million square meters
The total number of beds	refers to the number of beds in medical institutions per year	unit
Health service provision		
The annual number of outpatient visits	refers to the total number of outpatient and emergency visits by the number of registrations in medical institutions per year	million
The annual number of inpatient care	refers to the total number of inpatient care the number of registrations in medical institutions per year	million

Online supplemental appendix 2

The linear regression test and the Cochran-Armitage trend test

The Trend Test is used to count whether there is some trend in the change of a certain indicator with the change of the year and to test whether this trend is statistically significant.

This study uses linear regression to test and judge the direction of change (increase or decline) and the magnitude of the change in the absolute value of each indicator of primary healthcare institutions over time, and then evaluate the development of primary healthcare institutions. Linear regression has been widely used to describe the changing trend of health resource allocation and service provision in China.¹⁻³

The formula of linear regression is as follows:

$$\hat{Y} = \alpha + \beta X$$

In the formula, \hat{Y} is the estimated value of the total average of the actually measured value Y corresponding to X ; α is the intercept of the regression model; β is the estimated value of the slope of the regression model. The regression coefficient β whose positive or negative and magnitude represents the change direction of each indicator and the change range of each additional unit of the independent variable X (mainly the year in this study). When $P < 0.05$ and β is a positive number, it means that the absolute value of each indicator has an upward trend. On the contrary, when $P < 0.05$ and β is a negative number, it means that the absolute value of each indicator shows a downward trend.

In this study, the Cochran-Armitage trend test was used to examine the changing trend of the constituent ratio of each indicator of primary healthcare institutions in the whole health system over time, and then evaluated the status of primary healthcare throughout the health system. The Cochran-Armitage trend test method is to analyze whether there is a linear trend between multiple percentages and hierarchical variables, which is widely used in the fields of epidemiology and genetics, such as the study of time trends of drug utilization rates, disease morbidity or mortality.⁴⁻⁷

The formula of the Cochran-Armitage trend is as follows:

$$Z_{CA} = \frac{N(N \sum r_i x_i - R \sum n_i x_i)^2}{R(N - R)[N \sum n_i x_i^2 - (n_i x_i)^2]}$$

In the equation, N is the total of various indicators in each year (such as the total number of health workers in all medical institutions); R is the total of the numerators that constitute the ratio in each year (numerator: the number of primary healthcare institutions' health resource allocation or health service provision. Such as the number of health workers of primary healthcare institutions); r_i is the number of primary healthcare institutions' health resource allocation or health service provision in year i (e.g., the number of health works in primary healthcare institutions in 2009); n_i is the total of various indicators in year i (e.g.: The total number of health workers in all medical institutions in 2009); x_i is the value assigned to the year (2009, 2010, 2011...). When $P < 0.05$ and the Z_{CA} value is positive, which means that the constituent ratio of each indicator shows an upward trend. On the contrary, when $P < 0.05$ and the Z_{CA} value is negative, it means that the constituent ratio of each indicator shows a downward trend.

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Online supplemental appendix 3. Changes in Health Resources Allocation and Health Service Provision of Primary Health Care Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Z	P ^a
Human Resources												
Total Health Workers (%)	40.51	39.99	39.17	37.71	35.89	34.56	33.69	32.96	32.57	32.23	-604.3300	<0.001
Practicing (Assistant) Physicians (%)	39.84	39.33	38.93	38.59	37.57	36.79	36.26	35.89	35.80	36.18	-150.9878	<0.001
Nurses (%)	22.77	22.78	21.95	21.16	20.72	20.10	19.95	19.84	20.22	20.80	-97.8796	<0.001
Pharmacists (%)	34.85	35.45	34.53	33.72	32.87	32.10	31.77	31.43	31.46	31.39	-59.2115	<0.001
Financial Resources												
Total Revenues (%)	18.89	16.44	16.02	15.70	15.26	14.49	14.72	14.56	14.83	14.90	-102.5970	<0.001
Grants from the Government (%)	20.33	24.31	29.72	33.22	33.51	32.34	32.34	32.52	32.85	32.60	608.3909	<0.001
Incomes from Charges for Services(%)	18.37	14.97	13.31	11.97	11.51	10.95	10.85	10.66	10.89	11.00	-194.3627	<0.001
Material Resources												
Total Number of Equipment at or above CNY 10,000 (%)	13.04	13.39	12.77	12.26	11.56	11.02	10.96	10.81	10.94	10.83	-166.8648	<0.001
Building Areas (%)	35.77	37.34	32.44	33.30	32.25	31.60	30.71	30.13	29.24	27.13	-4.5449	<0.001
Beds (%)	24.71	24.71	23.73	22.94	21.69	20.80	20.04	19.37	19.46	18.84	-408.5730	<0.001
Service Provisions												
Outpatient Visits (%)	60.63	60.69	59.47	58.50	58.11	55.55	56.51	54.19	53.26	52.24	-14.9343	<0.001
Inpatient Care (%)	31.01	27.87	24.67	23.82	22.38	20.03	19.17	18.32	18.21	17.19	-4.1641	<0.001

^a The Cochran–Armitage trend test was used to calculate *P* values.