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Does health reform achieve the goal of strengthening primary health care in China?

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Abstract:

Objectives: Re-constructing the primary healthcare system is the focus of the new round of Chinese health reform. Nevertheless, there have been few studies focusing on whether the role of primary healthcare in the health system is strengthened in China.

Design: This study was a longitudinal observational study.

Primary and secondary outcome measures: The data of this study came from the 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.

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 the indicators in 2009, excepting for 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 4.04% for practicing (assistant) physicians, by 2.55% for nurses, by 4.06% for total revenues , by 5.54% for beds, by 7.37% 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 improve the awareness of the importance of primary healthcare at all levels of local governments and ensure adequate financial input.

Keywords: primary healthcare, health reform, development

Strengths and limitations of this study:

1. This study was a longitudinal observational study based on the China Health Statistics Yearbook (2009-2018), which provided information on health resources and health services of different kinds of medical institutions in China.
2. This study used the absolute value of each indicator to analyze the development of primary healthcare institutions and the linear regression analysis to test the trend of absolute values over time.
3. This study 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.
4. Due to the limited data provided by the China Health Statistics Yearbook, we could only analyze the development of primary healthcare based on health resource allocation and health service provision. Other important evaluation dimensions, such as the health service quality and the development equity of primary healthcare, were not analyzed, which could limit the overall understanding of primary healthcare development in China.
5. In addition, the data we used came from the China Health Statistical 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.

Main Manuscript Text:

INTRODUCTION

Primary healthcare is the key for achieving the goal of "health for all".[1] Chinese government had established a relatively complete primary healthcare system in the late 1950s.[2] Under the conditions of social and economic backwardness and health resource shortages at the time, this system played an important role in protecting the health of population.[3-6] However, after 1978, when a market-oriented economy reform was implemented in Chinese health sector,[7-10] Chinese primitive health system had undergone tremendous changes, which mainly manifested was that the government funding in the health system has been extremely reduced.[5, 7, 11] Subsequently, the primary healthcare system, which mainly relied on government funding to maintain normal operation, collapsed almost overnight,[6, 12] and health costs increased rapidly in the next 30 years. There are some problems in primary healthcare institutions, including lacking of adequate health resources, sharp decline in health service provision and lack of trust for residents.[13-19] Based on the reasons above, primary healthcare institutions have become the least developing and most vulnerable part of health system in China.

In response to the above problems, the government began to launch a new round of health reform in 2009.[3, 20, 21] Re-constructing the primary healthcare system is the focus of this reform,[21, 22] and it is also the key to realizing the reform goal. The government stated that increasing the input in primary healthcare was one of the five top priorities of this plan. In the first three years from 2009, the government health investment amounted to approximate CNY 1409.9 billion (equivalent of $ 206 billion), and 44% of those were allocated for primary healthcare institutions.[23] The 12th 5-Year Plan for Health, announced in 2012, reconfirmed the government's commitment to the ongoing reform and set new targets for 2015, including continuous improvements in primary healthcare infrastructure and training of general practitioners.[24]

Up to now, Chinese health reform has been launched for 10 years. In the context of this still developing healthcare system, efforts are needed to assess the development of Chinese primary healthcare system. Such assessments would provide indications of the health reforms domains that are performing successfully, as well as the domains that require further attention and improvement. At present, studies mainly summarized the history and development of Chinese primary healthcare,[2, 3, 25] and

evaluated the fairness of resource allocation and utilization of primary healthcare service.[26-30] Moreover, many studies have found that there are great variations in the primary healthcare resource allocation and health service provision among rural and urban areas or among the east, middle and west districts in China.[6, 27, 30, 31] However, due to the lack of support for the projects from the government, the lack of attention from researchers and other reasons, there have been few studies focusing on 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. Primary healthcare is an important part of the whole health system, analyzing it's the constituent ratio of health resources allocation and health service provision in the whole health system which is the main way to analyze its role in the whole health system. Based on the Chinese health statistics data in the past 10 years, this study evaluated the development of primary healthcare system via analyzing the changing trend of health resources and health service quantities, and evaluated the role of primary healthcare in the whole health system by analyzing the proportion of health resources allocation and health service provision in the whole health system. This study could provide a reference for the continuous improvement of Chinese health reform policies and measures which could promote the realization of the goal of reconstructing the primary healthcare system.

METHODS

Study design and data source

This study was a longitudinal observational study based on the 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 toward primary healthcare institutions and whether the service quantity of primary healthcare services has been increased, we analyzed the dynamic changes in the absolute value and the constituent ratio of health resource allocation and health service provision in primary healthcare institutions from 2009 to 2018.

Indicators and definitions

In this study, the definition of primary healthcare institutions refers to the statistical caliber of the China Health Statistics Yearbook. In China, primary healthcare institutions include community health service centers (stations), township health

centers, village clinics, outpatient departments, clinics, infirmaries and nursing stations. The main indicators of this study are health resource 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 business incomes. Material resources include total number of equipment at or above CNY 10,000, building areas, and the total number of beds. Health service provision includes annual number of outpatient visits and inpatient care.

Statistical Analysis

In this study, analyses were performed using SAS version 9.2 (SAS Inc., Cary, NC, USA). We used the absolute value of each indicator to analyze the development of primary healthcare institutions 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 showed an upward trend, oppositely, the Z value was negative which means that the composition ratio of each indicator presented a downward trend. All statistical tests were two-tailed, and a P value <0.05 were considered to be statistically significant.

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.

RESULTS

Basic information on health resources allocation and health service provision of Chinese medical institutions

From 2009 to 2018, the quantities of human resources, financial resources and physical resources of Chinese medical institutions 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. Compared with the financial resources 2009, Chinese medical institutions' total revenues, grants from the government and business incomes in 2018 have increased by 246.56%, 354.18% and 223.39%, respectively. Compared with the values in 2009, the total number of equipment at or above CNY 10,000 has increased by 189.30%, building areas has increased by 81.76%, and the number of beds has increased by 90.28% in 2018. The quantities of outpatient visits for Chinese medical institutions significantly increased by 53.80% from 2009 to 2018, and the quantities of inpatient care for Chinese medical institutions significantly increased by 92.01% from 2009 to 2018. (Table 1)

Basic information on health resources allocation and health service provision of Chinese primary healthcare institutions

Table 2 suggested that in addition to the number of inpatient care, the indicators of health resources and service provision had an apparent upward trend (P<0.001). In comparison with the indicators in 2009, the amounts of health resources had an escalating trend in 2018 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. The amounts of total revenues, grants from the government and business incomes had increased by 173.26%, 628.51% and 93.70% from 2009 to 2018, respectively. As to material resources, the growth rates of total number of equipment at or above CNY 10,000, building areas and the total number of beds were 140.30%, 37.85% and 45.11%, respectively. Furthermore, the outpatient visits in Chinese primary healthcare institutions increased from 3,145.14 million people in 2009 to 4,167.90 million people in 2018, which the growth rate was 32.52%.

Table 1. Health Resources Allocation and Health Service Provision of Medical Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	%[a]	β	P[b]
Human Resources													
Total Health Workers / person	7,781,448	8,207,502	8,616,040	9,115,705	9,790,483	10,234,213	10,693,881	11,172,945	11,748,972	12,300,325	58.07	505594	<0.001
Practicing (Assistant) Physicians / person	2,329,206	2,413,259	2,466,094	2,616,064	2,794,754	2,892,518	3,039,135	3,191,005	3,390,034	3,607,156	54.87	141397	<0.001
Nurses / person	1,854,818	2,048,071	2,244,020	2,496,599	2,783,121	3,004,144	3,241,469	3,507,166	3,804,021	4,098,630	120.97	250044	<0.001
Pharmacists / person	341,910	353,916	363,993	377,398	395,578	409,595	423,294	439,246	452,968	467,685	36.79	14262	<0.001
Financial Resources													
Total Revenues / million yuan	1,186,291.18	1,372,627.83	1,647,299.36	1,998,578.88	2,314,754.80	2,643,488.53	2,953,787.71	3,316,611.68	3,697,532.03	4,111,172.38	246.56	328116	<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	354.18	52679	<0.001
Business Incomes / million yuan	1,034,124.24	1,184,722.31	1,392,683.83	1,653,952.71	1,914,745.48	2,197,213.63	2,414,403.39	2,709,985.97	3,015,316.40	3,344,278.71	223.39	259127	<0.001
Material Resources													
Total Number of Equipment at or above CNY 10,000 / set	2,528,796	2,824,445	3,176,357	3,586,935	4,172,171	4,833,818	5,290,731	5,924,738	6,578,025	7,315,901	189.30	538630	<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	81.76	36.32	<0.001
Beds / unit	4,416,612	4,786,831	5,159,889	5,724,775	6,181,891	6,601,214	7,015,214	7,410,453	7,940,252	8,404,078	90.28	445482	<0.001
Service Provision													
Outpatient Visits / million	5,187.41	5,521.32	5,944.81	6,529.94	6,960.52	7,258.64	7,366.24	7,600.34	7,847.83	7,978.16	53.80	318.10	<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	92.01	13.91	<0.001

[a] "%" were the value's growth rates in 2018 compared with the value in 2009; [b]P values were associated with linear regression analysis.

Table 2. Health Resources Allocation and Health Service Provision of Primary Healthcare Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	%[a]	β	P[b]
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	25.78	79889	<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	40.63	39176	<0.001
Nurses / person	422,262	466,503	492,554	528,178	576,630	603,900	646,607	695,781	769,206	852,377	101.86	44780	<0.001
Pharmacists / person	119,166	125,467	125,698	127,262	130,039	131,493	134,495	138,060	142482	146,827	23.21	2745.56	<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	173.26	43891	<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	628.51	18826	<0.001
Business Incomes / 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	338,332.33	368,005.51	93.70	20538	<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	140.30	49674	<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	37.85	5.35	<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	45.11	49523	<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	32.52	113.92	<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	6.44	0.423	=0.051

[a] "%" were the value's growth rates in 2018 compared with the value in 2009; [b]P values were associated with linear regression analysis.

Proportions of health resources allocation and service provision by primary healthcare institutions

Figure 1a showed the trend of human resource allocation in Chinese primary healthcare institutions over time 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 an increase of about 10 percentage points, increasing from 22.33% in 2009 to 32.60% in 2018. On the contrary, the proportions of total revenues and business incomes 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 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 primary healthcare institutions from 2009 to 2018 was showed in Figure 1d. The number of outpatient visits in primary healthcare institutions dropped from 60.63% in 2009 to 52.24% in 2018, a decrease of approximate 8 percentage points. The proportion of inpatient care decreased from 31.01% in 2009 to 17.19% in 2018, a decline of approximate 13 percentage points. All (P<0.001) showed a significant downward trend.

(The results of all the indicators' trend tests were shown in Supplementary File 1.To access Supplementary File 1, click on the Supplementary File 1 link in the box to the right of the article online.)

DISCUSSION

Based on continuous longitudinal data from 2009 to 2018, this study analyzed the development of primary healthcare in China from two interrelated aspects: health resource allocation and health service provision. The present study found that Chinese primary healthcare system has made some progress after the health reform during the past 10 years, but its development rate was slow, lagging behind the whole health

system, which indicated that the role of primary healthcare has been indeed weakened in China.

With the prosperity of Chinese economy, the government funding in the health system has steadily increased, and the total health expenditure has increased from CNY 1,720.5 billion (US$ 252.0 billion) in 2009 to CNY 5,912.2 billion (US$ 835.8 billion) in 2018.[32, 33] At the same time, the government was actively building an integrated health system and encouraging social capital to establish private medical institutions. [34] In addition, with the improvement of residents' living standards, the health service system need to meet higher healthcare requirements, such as the release of health demand, high quality of health services.[35] These factors have contributed to the rapid development of the Chinese health system over the past decade.

As an important part of the health system, the primary healthcare has been paid more attention by the Chinese government in terms of funding and policies.[23, 32, 36-41] Unfortunately, the results of this study showed that the development of Chinese primary healthcare 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 primary healthcare. The reasons for this result may be multifaceted. Firstly, in spite of the Chinese central government had formulated a series of policies and measures to promote the development of primary healthcare, the implementation of the policies were mainly done by local governments.[42] 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,[43-47] they might have allocated more resources to general hospitals and specialist hospitals. Secondly, current power structure inside the medical industries is more likely to elicit a trend that the general hospitals possess more the power of discourse than the primary healthcare institutions in same region. Thirdly, previous studies have consistently concluded that the development of primary healthcare lacked sufficient financial support in China,[16, 17] but how much financial investment is sufficient has been lack of research. Fourthly, compared with hospitals, primary healthcare institutions had lower remuneration and limited career development prospects in China, which led to extremely low attraction for excellent health professionals.[41] In this study, the proportion of health workers in primary healthcare institutions in the whole health system has decreased year by year, from 40.51% in 2009 to 32.23% in 2018. Furthermore, for a long time, residents had no confidence in primary healthcare

and blindly chose high-level hospitals.[13-15, 18, 19] In the past decade, the lag in the development of primary healthcare has further intensified patients to choose hospitals for medical services, resulting in reducing the business incomes of primary healthcare institutions 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".

On the occasion of the 10th anniversary of Chinese health reform, there have been many studies expounding the effectiveness of health reform. Our study revealed an easily ignored problem in Chinese health reform process. Considering the importance of primary healthcare, the problem should be taken seriously. This study also had some limitations. Due to the limited data provided by the China Health Statistics Yearbook, we could only analyze the development of primary healthcare based on health resource allocation and health service provision. Other important evaluation dimensions, such as the health service quality and the development equity of primary healthcare, were not analyzed, which could limit the overall understanding of primary healthcare development in China. In addition, the data we used came from the China Health Statistical 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 analyze that how much of the changing trend in the development of primary healthcare could be attributed to the health reform.

CONCLUSIONS

After the implementation of the latest round of health reform in China, the primary healthcare 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. In the next stage of the health reform, the Chinese government should improve the awareness of the importance of primary healthcare at all levels of local governments, mobilize their enthusiasm, ensure adequate financial input, and improve the occupational attractiveness of primary healthcare. 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.

Figure legend:

Figure1. (a) Changes in percentage of human resources in primary healthcare institutions, 2009-2018. (b) Changes in percentage of financial resources in primary healthcare institutions, 2009-2018. (c) Changes in percentage of material resources in primary healthcare institutions, 2009-2018. (d) Changes in percentage of health service provision in primary healthcare institutions, 2009-2018.

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Contributors: J. Feng conceived the study and analyzed the data. Data collection was performed by J.X. Wu. J. Feng and Y.H. Gong wrote the draft of the paper. H. Li gave advice on statistical methodology. X.X. Yin and G.P. Zhang provided the critical revision of the manuscript for important intellectual content and supervision of the work. Z.X. Lu obtained funding. All authors read and approved the final manuscript.

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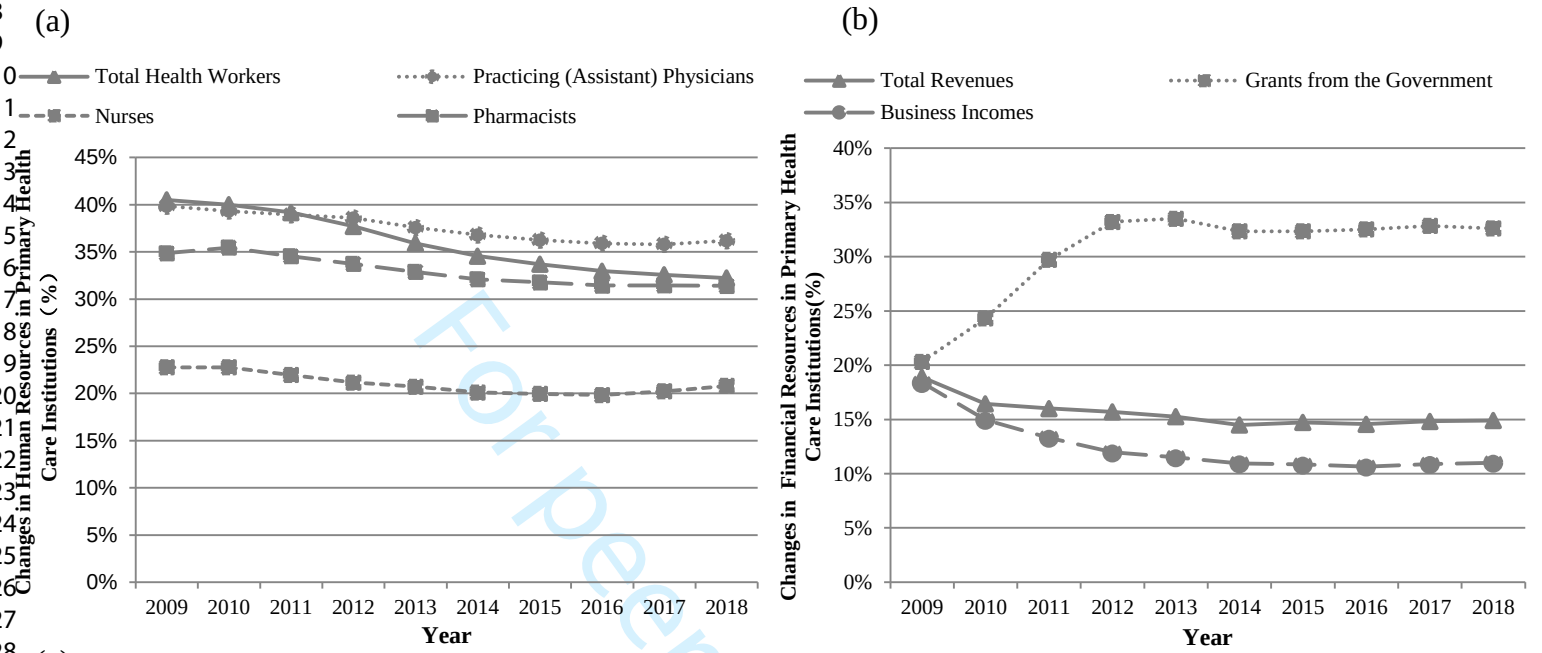
Figure 1. Changes in percentage of health resources allocation and health service provision of primary healthcare institutions in China, 2009-2018



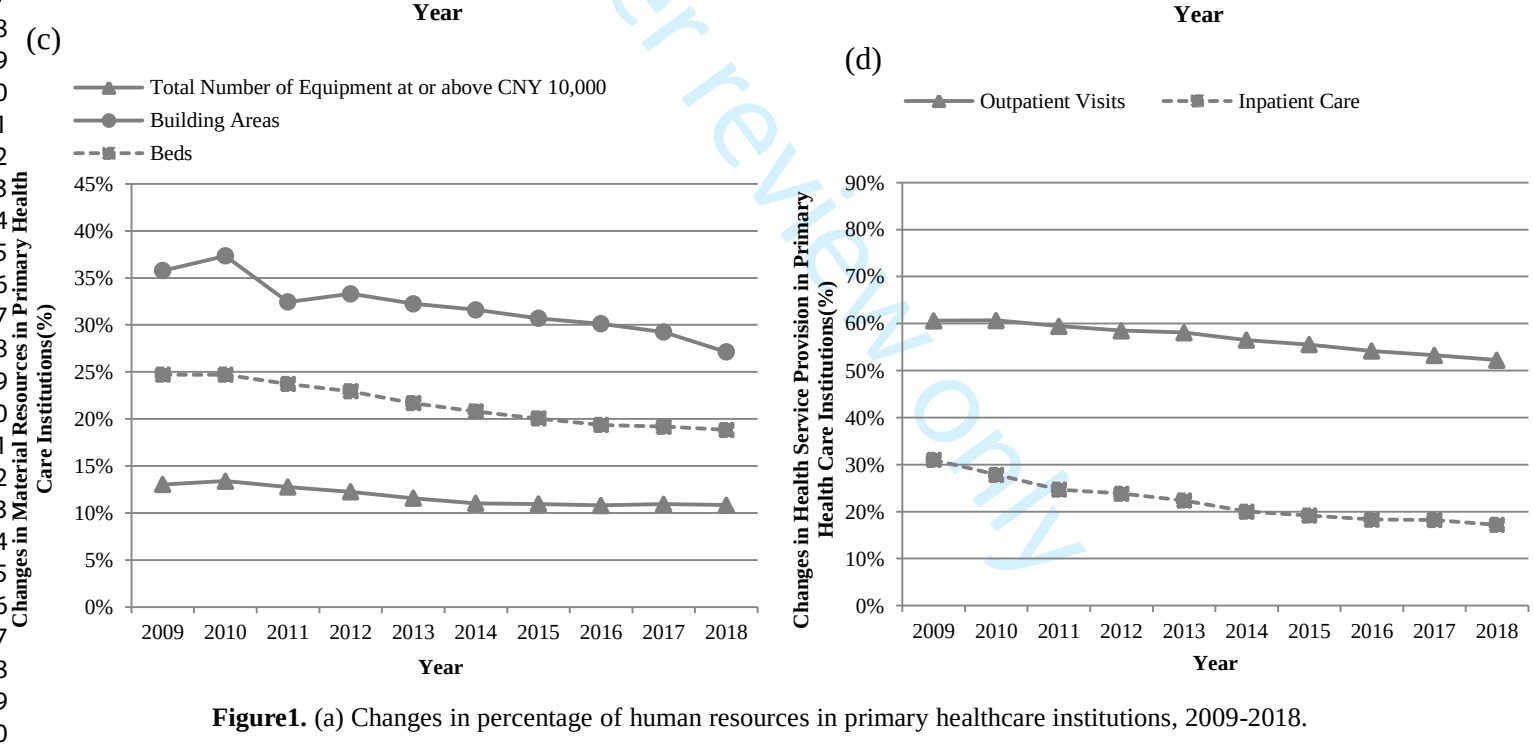


Figure1. (a) Changes in percentage of human resources in primary healthcare institutions, 2009-2018. (b) Changes in percentage of financial resources in primary healthcare institutions, 2009-2018. (c) Changes in percentage of material resources in primary healthcare institutions, 2009-2018. (d) Changes in percentage of health service provision in primary healthcare institutions, 2009-2018.

Supplementary File 1.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[α]
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	-552.4248	<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	-148.5132	<0.001
Nurses (%)	22.77	22.78	21.95	21.16	20.72	20.10	19.95	19.84	20.22	20.80	-116.3311	<0.001
Pharmacists (%)	34.85	35.45	34.53	33.72	32.87	32.10	31.77	31.43	31.46	31.39	-56.0395	<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	-110.1276	<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	648.0410	<0.001
Business Incomes (%)	18.37	14.97	13.31	11.97	11.51	10.95	10.85	10.66	10.89	11.00	-185.3357	<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	-160.7850	<0.001
Building Areas (%)	35.77	37.34	32.44	33.30	32.25	31.60	30.71	30.13	29.24	27.13	-3.4715	<0.001
Beds (%)	24.71	24.71	23.73	22.94	21.69	20.80	20.04	19.37	19.46	18.84	-364.6406	<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	-12.4802	<0.001
Inpatient Care (%)	31.01	27.87	24.67	23.82	22.38	20.03	19.17	18.32	18.21	17.19	-3.7799	<0.001

[α] The Cochran–Armitage trend test was used to calculate *P* values.

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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 4.04% for practicing (assistant) physicians, by 2.55% for nurses, by 4.06% for total revenues, by 5.54% for beds, by 7.37% 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.

Keywords: primary healthcare, health reform, development

Strengths and limitations of this study:

1. 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.

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

3. Due to the limited data provided by the Yearbook, we could not analyze the development of PHIs before 2009. Secondly, due to the limited data provided by the Yearbooks, we could only analyze the development of PHC based on health resource 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 analyzed, which could limit the overall understanding of primary healthcare development in China.

4. 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.

Main Manuscript Text:

INTRODUCTION

Primary healthcare (PHC) is the key to achieving the goal of "health for all". [1]A state-led "low-level welfare" health service network has been established in China,[2] which has been promoted and introduced by WHO to other countries as a model.[3] However, after 1978, when a market-oriented economy reform was implemented in the Chinese health sector,[4 5] Chinese primitive health system had undergone tremendous changes, which mainly manifested that the government funding in the health system has been extremely reduced.[6]Subsequently, the primary healthcare system, which mainly relied on government funding to maintain normal operation, collapsed almost overnight.[7 8] At 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.[9-13] Based on the reasons above, PHIs have become the least developing and most vulnerable part of the health system in China, seriously impeding the realization of the goal of "health care for all". Previous studies focused on the impact of socioeconomic status on individual health status,[14 15] but fewer researches on the impact of health resource 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,[16-18] aiming at optimizing the distribution of health resources, enhancing the capacity of PHIs services, and guiding residents to seek medical treatment from PHIs.[4 19] Reconstructing the PHC system is the focus of this reform,[16 18] and it is also the key to realizing the reform goal. In the first three 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.[20] In addition, the Chinese Government is actively promoting the construction of PHC talent pool with general practitioners at its core, standardizing service programs including 17 basic public health services, promoting family doctor contracting services, improving the basic medical

security system, integrating the sharing of regional health resources, and other improvements to the PHC system.[17 21 22] Moreover, in 2019, China has implemented Basic Healthcare and Health Promotion Law,[23] 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. Firstly, the evaluation perspective is relatively single, most researchers evaluate from a single aspect of health resource allocation or service provision,[24] lacking a combination of the two aspects. Secondly, most studies were based on specific regions or groups of the population and lacked a comprehensive national evaluation.[25 26] In addition, most of the existing studies used cross-sectional data or only intercept short-term data for effect evaluation,[27] 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's 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 is the crucial basis for the normal operation of the whole health system.[28]Therefore, analyzing PHC's constituent ratio of health resources allocation and health service provision in the whole health system is the main approach to analyzing its role in the whole health system.

Therefore, based on the Chinese health statistics data in the past 10 years, the Trend Test was being used to analyze the changing tendency of various indicators of PHC system construction since the health reform. This study evaluated the development of the PHC system via analyzing the changing trend of health resources and health service quantities and evaluated the role of primary healthcare in the whole health system by

analyzing 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 timely, objectively, and effectively and to summarize the construction experience and existing problems, adjusting the relevant policies and measures of health reform, promoting high-quality development of medical care, accelerating the realization of the goal of reconstructing the PHC system.

METHODS

Ethical 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.

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 toward primary healthcare institutions and whether the service quantity of primary healthcare services has been increased, we analyzed the dynamic changes in the absolute value and the constituent ratio of health resource allocation and health service provision in primary healthcare institutions from 2009 to 2018.

Indicators and definitions

In this study, the definition of primary healthcare institutions refers to the statistical caliber of the China Health Statistics Yearbook. In China, PHIs include community health service centers (stations), township health centers, village clinics, outpatient departments, clinics, infirmaries, and nursing stations. The main indicators of this study are health resource 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 number of health workers, including practicing (assistant) physicians, nurses, pharmacists, and other health technicians, as well as management workers and logistics workers. 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. Nurses refer to those who have the Registered Nurse Certificate and are actually engaged in nursing. Pharmacists, including chief pharmacists, deputy chief pharmacists, in-charge pharmacists, and pharmacists. Total revenues are defined as non-reimbursable funds legally obtained by medical institutions for the conduct of their operations and other activities. Grants from the government refer to the financial business funding received by the government. Incomes from charges for services refer to the income derived by medical institutions from carrying out medical services. A total number of equipment at or above CNY 10,000 refer to the total number of equipment over CNY10,000 actually owned by medical institutions. Building areas refer to the building areas purchased by the medical institutions and with the title deed, excluding the area of rented housing. The total number of beds refers to the number of beds in medical institutions per year. 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. The annual number of inpatient care refers to the total number of inpatient care the number of registrations in medical institutions per year.

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,[29] so as to ensure the robustness of the results (The more detail about the linear regression test and the Cochran-Armitage trend

test were shown in online supplemental appendix 1.). We used the absolute value of each indicator to analyze the development of primary healthcare institutions 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 version 9.2 (SAS Inc., Cary, NC, USA). All statistical tests were two-tailed, and a *P-value* <0.05 was considered to be statistically significant.

RESULTS

The dynamics changes of the health resources allocation and health service provision' quantities 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. (Table 1 and Table 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' rate of increases were slower than in all medical institutions, for total revenues (173.26% VS 246.56%) and for grants from the government (93.70% VS 223.39%). (Table 1 and Table 2)

The quantities of material resources

From 2009 to 2018, the quantities of all indicators both in all medical institutions and

Table 1. Health Resources Allocation and Health Service Provision of Medical Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	increase[a]	%[b]	β	SE	*P*[c]
Human Resources															
Total Health Workers / person	7,781,448	8,207,502	8,616,040	9,115,705	9,790,483	10,234,213	10,693,881	11,172,945	11,748,972	12,300,325	4,518,877	58.07	505594	7612.33	<0.001
Practicing (Assistant) Physicians / person	2,329,206	2,413,259	2,466,094	2,616,064	2,794,754	2,892,518	3,039,135	3,191,005	3,390,034	3,607,156	1,277,950	54.87	141397	6827.13	<0.001
Nurses / person	1,854,818	2,048,071	2,244,020	2,496,599	2,783,121	3,004,144	3,241,469	3,507,166	3,804,021	4,098,630	2,243,812	120.97	250044	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	14262	244.40	<0.001
Financial Resources[d]															
Total Revenues / million yuan	1,186,291.18	1,372,627.83	1,647,299.36	1,998,578.88	2,314,754.80	2,643,488.53	2,953,787.71	3,316,611.68	3,697,532.03	4,111,172.38	2,924,881.2	246.56	328116	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	606485.23	472,951.44	354.18	52679	1613.26	<0.001
Incomes from charges for services / million yuan	1,034,124.24	1,184,722.31	1,392,683.83	1,653,952.71	1,914,745.48	2,197,213.63	2,414,403.39	2,709,985.97	3,015,316.40	3,344,278.71	2,310,154.47	223.39	259127	6995.94	<0.001
Material Resources															
Total Number of Equipment at or above CNY 10,000 / set[e]	2,528,796	2,824,445	3,176,357	3,586,935	4,172,171	4,833,818	5,290,731	5,924,738	6,578,025	7315901	4,787,105	189.30	538630	21795.00	<0.001
Building Areas / million square meters[f]	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	4,416,612	4,786,831	5,159,889	5,724,775	6,181,891	6,601,214	7,015,214	7,410,453	7,940,252	8404078	3,987,466	90.28	445482	5618.70	<0.001
Service Provision															
Outpatient Visits / million	5,187.41	5,521.32	5,944.81	6,529.94	6,960.52	7,258.64	7,366.24	7,600.34	7,847.83	7978.16	2,790.75	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

a: the change in the absolute value of each indicator in 2018 compared with the value in 2009. b:"%" was the value's growth rate in 2018 compared with the value in 2009. c:*P* values were associated with linear regression analysis. d: This study did not correct for the effect of inflation on the financial resources indicators. e and f: 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 dynamics 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.

Table 2. Health Resources Allocation and Health Service Provision of Primary Healthcare Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	increase[a]	%[b]	β	SE	*P*[c]
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	79889	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	39176	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	44780	2647.31	<0.001
Pharmacists / person	119,166	125,467	125,698	127,262	130,039	131,493	134,495	138,060	142482	146,827	27,661	23.21	2745.56	2647.31	<0.001
Financial Resources[d]															
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	43891	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	18826	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	20538	2294.59	<0.001
Material Resources															
Total Number of Equipment at or above CNY 10,000 / set[e]	354,402	405,494	435,463	439,640	482,336	532,575	579,740	640,344	719,543	816,199	462,524	140.30	49674	2708.58	<0.001
Building Areas / million square meters[f]	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	49523	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	0.423	0.18	=0.051

a: the change in the absolute value of each indicator in 2018 compared with the value in 2009. b:"%" was the value's growth rate in 2018 compared with the value in 2009. c:*P* values were associated with linear regression analysis. d: This study did not correct for the effect of inflation on the financial resources indicators. e and f: 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 dynamics 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.

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%).

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 to the rate of increases with all medical institutions, PHIs has grown more slowly, whose growth rate was 32.52% and 6.44%.

Proportions of health resources allocation and service provision by primary healthcare institutions

Figure 1a showed 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 was 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 were shown in online supplemental appendix 2.)

DISCUSSION

On the occasion of the 10th anniversary of Chinese health reform, there have been some studies expounding the effectiveness of health reform.[22 26 30 31] Such as Meng and 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.[17] This study was the first to use the Trend Test to analyze the development of PHC in China from two interrelated aspects: health resource allocation and health service provision. With the rapid development of China's health system in the past 10 years, the absolute value of health resource allocation and health service provision of the PHIs has increased significantly, but the rate of increases of PHIs were 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, the total amount of health resource 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[32] and Zhang[33]. 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.[34 35] 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 resource 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.

Firstly, in spite that the Chinese central government has formulated a series of policies and measures to promote the development of primary healthcare,[17 36-38] the implementation of the policies was mainly done by local governments.[27] 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,[8 39 40] they might have allocated more resources to general hospitals and specialist hospitals. Secondly, 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 primary healthcare institutions in the same region. Thirdly, previous studies have consistently concluded that the development of primary healthcare lacked sufficient financial support in China,[11 41] but how much financial investment is sufficient has been a lack of research. Fourthly, compared with hospitals, primary healthcare institutions had lower remuneration and limited career development prospects in China, which led to the extremely low attraction for excellent health professionals.[17] 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.[42] Moreover, at present, the strengthening PHC measures implemented put too much emphasis on the

standardization and the improvement of hardware conditions of PHIs in China,[31 43-45] 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 outpatients and outpatient visits 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 resource allocation and health service provision, which somewhat increased the statistical validity of the results. Secondly, the existing studies' evaluation perspective was scattered, analyzing the effectiveness of the health reform more at a micro level, 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 macro level, 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- and middle-income countries, particularly those with social systems compatible with China, strengthening their decision-making on PHC planning, health resource allocation, and health service provision.

This study also had some limitations. Firstly, 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 analyze the development of PHIs before 2009. Secondly, due to the limited data provided by the Yearbooks, we could only analyze the development of PHC based on health resource 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 analyzed, 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 analyze 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 resource 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 has 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, mobilize their enthusiasm, and strengthen their responsibility to optimize health resources' allocation. Secondly, 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.

Figure legend:

Figure1. (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.

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Contributors: J. Feng conceived the study and analyzed the data. Data collection was

performed by J.X. Wu. J. Feng and Y.H. Gong wrote the draft of the paper. H. Li and Z.X. Lu gave advice on statistical methodology. JF and X.X Yin brought up connected suggestions for revise the manuscript and checked the revised manuscript. X.X. Yin and G.P. Zhang provided the critical revision of the manuscript for important intellectual content and supervision of the work. X.X Yin obtained funding. All authors read and approved the final manuscript.

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Competing interests: None declared.

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.

Patient consent for publication: Not required.

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

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Figure 1. Changes in the percentage of health resources allocation and health service provision of primary healthcare institutions in China, 2009-2018

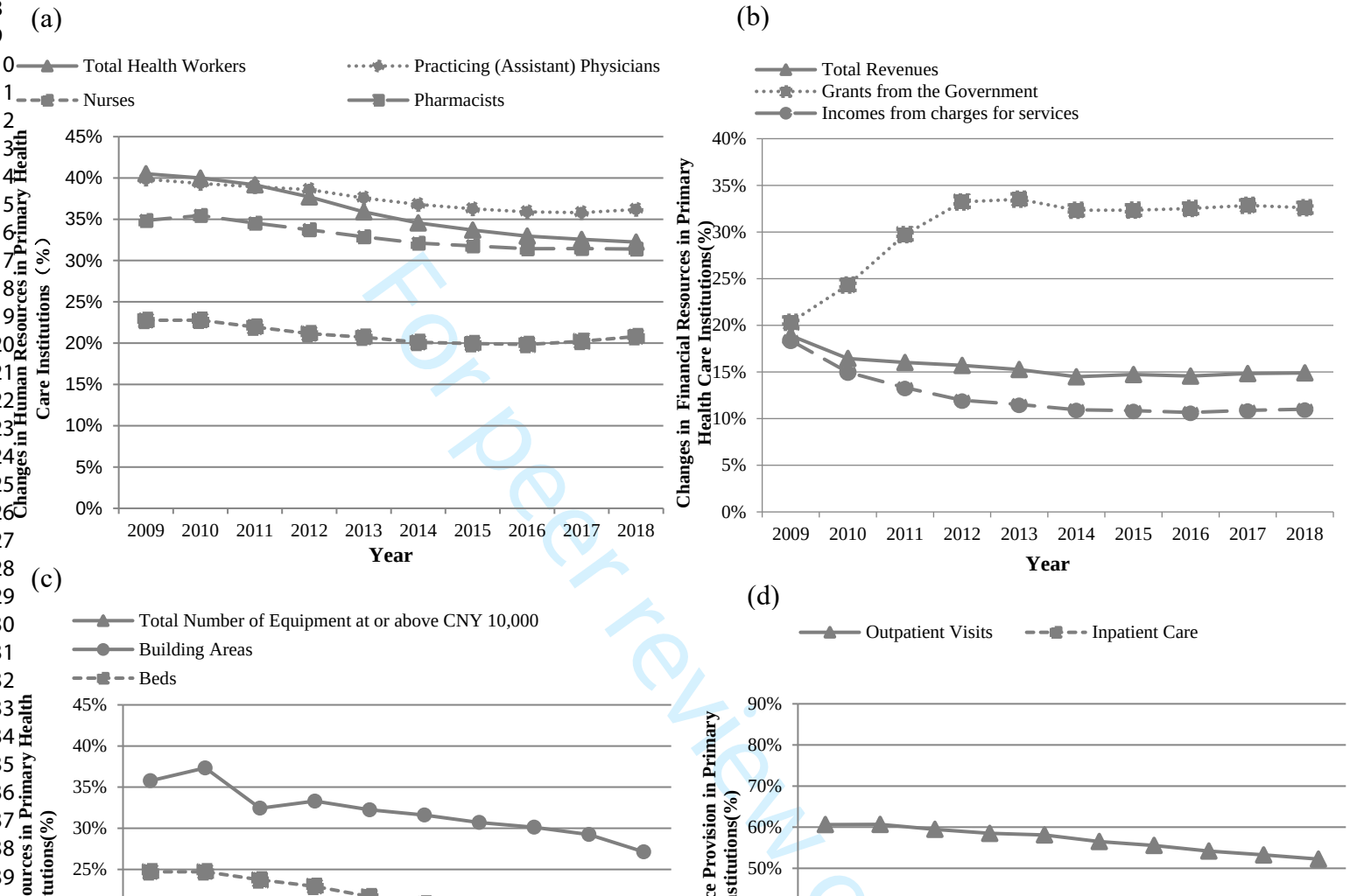

Figure1. (a) Changes in the percentage of human resources in primary healthcare institutions, 2009-2018. (b) Changes in the percentage of financial resources in primary healthcare institutions, 2009-2018. (c) Changes in the percentage of material resources in primary healthcare institutions, 2009-2018. (d) Changes in the percentage of health service provision in primary healthcare institutions, 2009-2018.

Online supplemental appendix 1

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:

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

In the formula, $\hat{\mathbf{Y}}$ 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:

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

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); **ri** 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); **ni** is the total of various indicators in year **i** (e.g.: The total number of health workers in all medical institutions in 2009); **xi** 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 2. 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*[α]
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
Business Incomes (%)	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

[α] The Cochran–Armitage trend test was used to calculate *P* values.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Not Applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	7-8
Bias	9	Describe any efforts to address potential sources of bias	Not Applicable
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7-8
		(*b*) Describe any methods used to examine subgroups and interactions	Not Applicable
		(*c*) Explain how missing data were addressed	Not Applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not Applicable
		(*e*) Describe any sensitivity analyses	Not Applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8-11
		(b) Give reasons for non-participation at each stage	Not Applicable
		(c) Consider use of a flow diagram	Not Applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic,	8-11

		clinical, social) and information on exposures and potential confounders	
		(b) Indicate number of participants with missing data for each variable of interest	Not Applicable
Outcome data	15*	Report numbers of outcome events or summary measures	8-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Not Applicable
		(*b*) Report category boundaries when continuous variables were categorized	8-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not Applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	12-14
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12-15
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	16

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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The Development Trend of Primary Healthcare after Health Reform in China: a longitudinal observational study

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Title Page

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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 4.04% for practicing (assistant) physicians, by 2.55% for nurses, by 4.06% for total revenues, by 5.54% for beds, by 7.37% 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.

Keywords: primary healthcare, health reform, development

Strengths and limitations of this study:

1. 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.
2. This study was the first to use the Cochran-Armitage trend test and linear trend test to examine trends in health resource allocation and health service provision, which somewhat increased the statistical validity of the results.
3. Due to the limited data provided by the Yearbook, we could not analyze the development of PHIs before 2009. Secondly, due to the limited data provided by the Yearbooks, we could only analyze the development of PHC based on health resource 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 analyzed, which could limit the overall understanding of primary healthcare development in China.
4. 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.

Main Manuscript Text:

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 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 realization of the goal of "health care 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 resource 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 optimizing 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 realizing the reform goal. In the first three 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, standardizing service programs including 17 basic public health services, promoting family doctor contracting services, improving the multi-level 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. Firstly, the evaluation perspective is relatively single, most researchers evaluate from a single aspect of health resource allocation or service provision,[22] lacking a combination of the two aspects. Secondly, 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's 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 is the crucial basis for the normal operation of the whole health system.[26]Therefore, analyzing PHC's constituent ratio of health resources allocation and health service provision in the whole health system is the main approach to analyzing 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 analyze the changing tendency of various indicators of PHC system construction since the health reform. This study evaluated the development of the PHC system via analyzing the changing trend of health resources and health service quantities and evaluated the role of primary healthcare in the whole health system by analyzing 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 summarize the construction

experience and existing problems, adjusting the relevant policies and measures of health reform, promoting high-quality development of medical care, accelerating the realization of the goal of reconstructing the PHC system.

METHODS

Ethical 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.

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 toward primary healthcare institutions and whether the service quantity of primary healthcare services has been increased, we analyzed the dynamic changes in the absolute value and the constituent ratio of health resource allocation and health service provision in primary healthcare institutions from 2009 to 2018.

Indicators and definitions

In this study, the definition of primary healthcare institutions refers to the statistical caliber of the China Health Statistics Yearbook. In China, PHIs include community health service centers (stations), township health centers, village clinics, outpatient departments, clinics, infirmaries, and nursing stations. The main indicators of this study are health resource 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 were 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 were shown in online supplemental appendix 2.). We used the absolute value of each indicator to analyze the development of primary healthcare institutions 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 version 9.2 (SAS Inc., Cary, NC, USA). All statistical tests were two-tailed, and a *P-value* <0.05 was considered to be statistically significant.

RESULTS

The dynamics changes of the health resources allocation and health service provision' quantities 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. (Table 1 and Table 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' rate of increases were slower than in all medical institutions, for total revenues (173.26% VS 246.56%) and for grants from the government (93.70% VS 223.39%). (Table 1 and Table 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%).

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 to the rate of increases with all medical institutions, PHIs has grown more slowly, whose growth rate was 32.52% and 6.44%.

Table 1. Health Resources Allocation and Health Service Provision of Medical Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	increase[a]	%[b]	β	SE	*P*[c]
Human Resources															
Total Health Workers / person	7,781,448	8,207,502	8,616,040	9,115,705	9,790,483	10,234,213	10,693,881	11,172,945	11,748,972	12,300,325	4,518,877	58.07	505594	7612.33	<0.001
Practicing (Assistant) Physicians / person	2,329,206	2,413,259	2,466,094	2,616,064	2,794,754	2,892,518	3,039,135	3,191,005	3,390,034	3,607,156	1,277,950	54.87	141397	6827.13	<0.001
Nurses / person	1,854,818	2,048,071	2,244,020	2,496,599	2,783,121	3,004,144	3,241,469	3,507,166	3,804,021	4,098,630	2,243,812	120.97	250044	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	14262	244.40	<0.001
Financial Resources[d]															
Total Revenues / million yuan	1,186,291.18	1,372,627.83	1,647,299.36	1,998,578.88	2,314,754.80	2,643,488.53	2,953,787.71	3,316,611.68	3,697,532.03	4,111,172.38	2,924,881.2	246.56	328116	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	606485.23	472,951.44	354.18	52679	1613.26	<0.001
Incomes from charges for services / million yuan	1,034,124.24	1,184,722.31	1,392,683.83	1,653,952.71	1,914,745.48	2,197,213.63	2,414,403.39	2,709,985.97	3,015,316.40	3,344,278.71	2,310,154.47	223.39	259127	6995.94	<0.001
Material Resources															
Total Number of Equipment at or above CNY 10,000 / set[e]	2,528,796	2,824,445	3,176,357	3,586,935	4,172,171	4,833,818	5,290,731	5,924,738	6,578,025	7315901	4,787,105	189.30	538630	21795.00	<0.001
Building Areas / million square meters[f]	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	4,416,612	4,786,831	5,159,889	5,724,775	6,181,891	6,601,214	7,015,214	7,410,453	7,940,252	8404078	3,987,466	90.28	445482	5618.70	<0.001
Service Provision															
Outpatient Visits / million	5,187.41	5,521.32	5,944.81	6,529.94	6,960.52	7,258.64	7,366.24	7,600.34	7,847.83	7978.16	2,790.75	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

a: the change in the absolute value of each indicator in 2018 compared with the value in 2009. b:"%" was the value's growth rate in 2018 compared with the value in 2009. c:*P* values were associated with linear regression analysis. d: This study did not correct for the effect of inflation on the financial resources indicators. e and f: 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 dynamics 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.

Table 2. Health Resources Allocation and Health Service Provision of Primary Healthcare Institutions in China, 2009-2018

Indicators	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	increase[a]	%[b]	β	SE	*P*[c]
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	79889	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	39176	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	44780	2647.31	<0.001
Pharmacists / person	119,166	125,467	125,698	127,262	130,039	131,493	134,495	138,060	142482	146,827	27,661	23.21	2745.56	2647.31	<0.001
Financial Resources[d]															
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	43891	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	18826	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	20538	2294.59	<0.001
Material Resources															
Total Number of Equipment at or above CNY 10,000 / set[e]	354,402	405,494	435,463	439,640	482,336	532,575	579,740	640,344	719,543	816,199	462,524	140.30	49674	2708.58	<0.001
Building Areas / million square meters[f]	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	49523	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	0.423	0.18	=0.051

a: the change in the absolute value of each indicator in 2018 compared with the value in 2009. b:"%" was the value's growth rate in 2018 compared with the value in 2009. c:*P* values were associated with linear regression analysis. d: This study did not correct for the effect of inflation on the financial resources indicators. e and f: 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 dynamics 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.

Proportions of health resources allocation and service provision by primary healthcare institutions

Figure 1a showed 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 was 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 were 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 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 analyze the development of PHC in China from two interrelated aspects: health resource allocation and health service provision. With the rapid development of China's health system in the past 10 years, the absolute value of health resource allocation and health service provision of the PHIs has increased significantly, but the rate of increases of PHIs were 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, the total amount of health resource 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[31] and Zhang[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 resource 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.

Firstly, 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. Secondly, 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 primary healthcare institutions in the same region. Thirdly, 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. Fourthly, compared with hospitals, primary healthcare institutions 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 standardization 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 outpatients and outpatient visits 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 resource allocation and health service provision, which somewhat increased the statistical validity of the results. Secondly, the existing studies'

evaluation perspective was scattered, analyzing the effectiveness of the health reform more at a micro level, 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 macro level, 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- and middle-income countries, particularly those with social systems compatible with China, strengthening their decision-making on PHC planning, health resource allocation, and health service provision.

This study also had some limitations. Firstly, 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 analyze the development of PHIs before 2009. Secondly, due to the limited data provided by the Yearbooks, we could only analyze the development of PHC based on health resource 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 analyzed, 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 analyze 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 resource 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 has 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, mobilize their enthusiasm, and strengthen their responsibility to optimize health resources' allocation. Secondly, 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.

Figure legend:

Figure1. (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.

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Contributors: J. Feng conceived the study and analyzed the data. Data collection was performed by J.X. Wu. J. Feng and Y.H. Gong wrote the draft of the paper. H. Li, G.P. Zhang and Z.X. Lu gave advice on statistical methodology. JF, XZ and X.X. Yin brought up connected suggestions for revise the manuscript and checked the revised manuscript. X.X. Yin and XZ provided the critical revision of the manuscript for important intellectual content and supervision of the work. X.X Yin obtained funding. All authors read and approved the final manuscript.

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Competing interests: None declared.

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.

Patient consent for publication: Not required.

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

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Figure 1. Changes in the percentage of health resources allocation and health service provision of primary healthcare institutions in China, 2009-2018

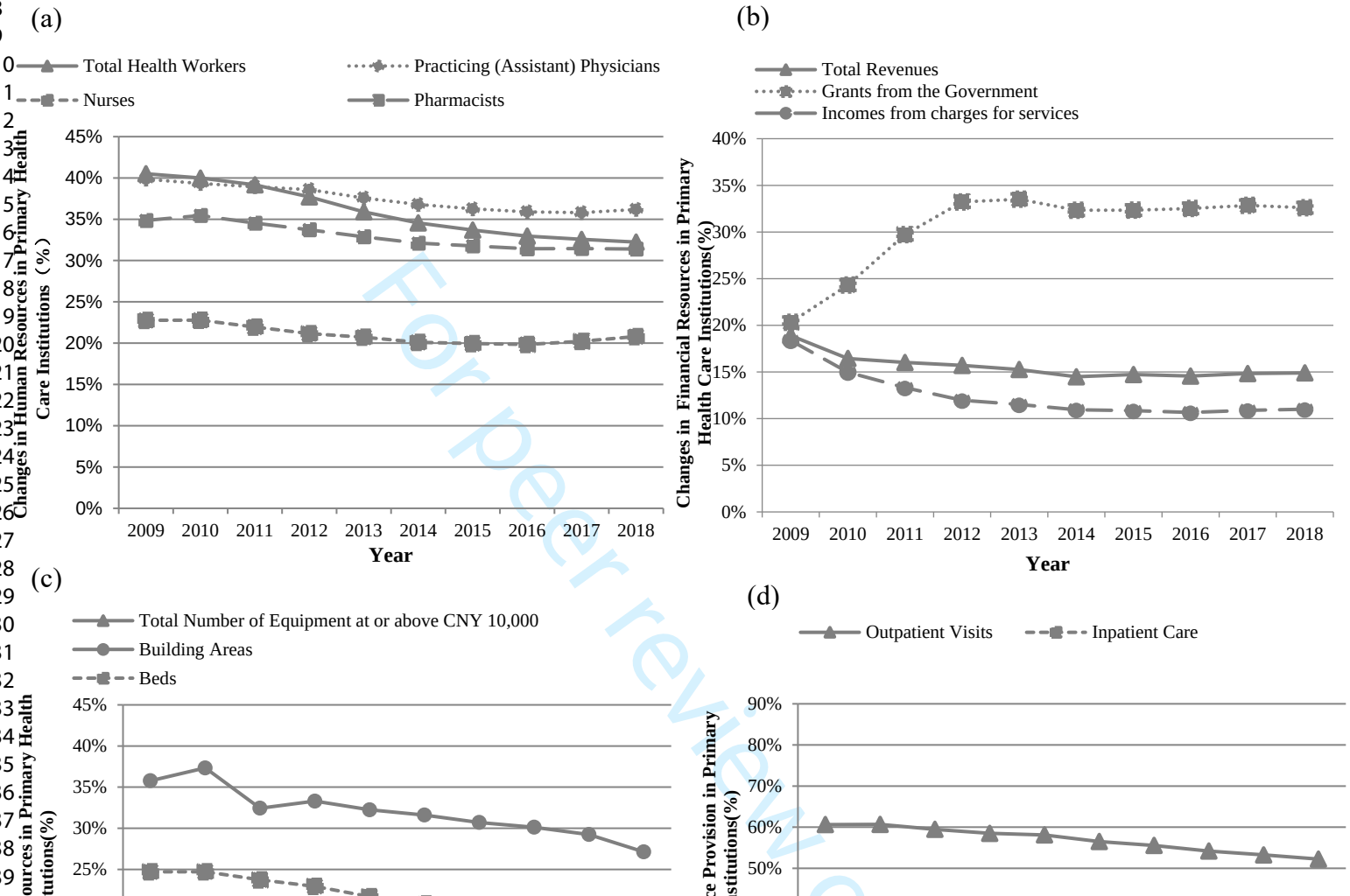

Figure1. (a) Changes in the percentage of human resources in primary healthcare institutions, 2009-2018. (b) Changes in the percentage of financial resources in primary healthcare institutions, 2009-2018. (c) Changes in the percentage of material resources in primary healthcare institutions, 2009-2018. (d) Changes in the percentage of health service provision in primary healthcare institutions, 2009-2018.

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:

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

In the formula, $\hat{\mathbf{Y}}$ 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:

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

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); **ri** 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); **ni** is the total of various indicators in year **i** (e.g.: The total number of health workers in all medical institutions in 2009); **xi** 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^{α}
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

[α] The Cochran–Armitage trend test was used to calculate *P* values.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-5
Objectives	3	State specific objectives, including any prespecified hypotheses	5-6
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Not Applicable
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-7
Bias	9	Describe any efforts to address potential sources of bias	Not Applicable
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	7
		(*b*) Describe any methods used to examine subgroups and interactions	Not Applicable
		(*c*) Explain how missing data were addressed	Not Applicable
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Not Applicable
		(*e*) Describe any sensitivity analyses	Not Applicable
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7-12
		(b) Give reasons for non-participation at each stage	Not Applicable
		(c) Consider use of a flow diagram	Not Applicable
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic,	7-11

		clinical, social) and information on exposures and potential confounders	
		(b) Indicate number of participants with missing data for each variable of interest	Not Applicable
Outcome data	15*	Report numbers of outcome events or summary measures	7-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Not Applicable
		(*b*) Report category boundaries when continuous variables were categorized	7-11
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	Not Applicable
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Not Applicable
Discussion			
Key results	18	Summarise key results with reference to study objectives	11-12
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	15

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.