



Efficiency of community health centers in China during 2013–2015: A synchronic and diachronic study*

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Abstract

Objective: We aimed to explore the efficiency of community health centers (CHCs) in China from 2013 to 2015, providing policy suggestions for optimizing the allocation of health resources.

Methods: Data on the efficiency of CHCs in 30 provinces/autonomous regions/municipalities in mainland China (except Tibet) from 2013 to 2015 were collected from *China's Health and Family Planning Statistical Yearbook 2014*, *China's Health and Family Planning Statistical Yearbook 2015*, and *China's Health and Family Planning Statistical Yearbook 2016*. Data envelopment analysis and Malmquist index analysis were performed to investigate the efficiency of sampled CHCs during this period at the national level and the regional level. The applied input indicators include the numbers of CHCs, community health workers, and beds, and the output indicators consist of the numbers of visits and inpatients, the occupancy rate of beds, and the average length of stay.

Results: In 2015, the average annual overall technical efficiency, pure technical efficiency, and scale efficiency of CHCs in 30 regions at the national level were 0.715, 0.705, and 0.972, respectively. Eight regions (Guangdong, Guizhou, Hainan, Ningxia, Qinghai, Shanghai, Zhejiang, and Chongqing, accounting for 26.7% of the total) had efficient CHCs with overall technical efficiency of 1.000, and the other 22 regions had surpluses of 131 CHCs, 5573 community health workers, and 2086 beds on average. In 2015, the average annual technical change index, pure technical efficiency change index, total factor productivity, technical efficiency change index, and scale efficiency change index of CHCs at the national level were 1.034, 1.002, 1.024, 0.990, and 0.988, respectively. Compared with 2013, the former three increased by 3.4%, 0.2%, and 2.4%, respectively, while the latter two decreased by 1.0% and 1.2%, respectively.

Conclusion: On the whole, efficiency improvements of CHCs were achieved at the national level from 2013 to 2015, but with obvious interregional differences. In regions with inefficient CHCs identified by data envelopment analysis, there was a problem of coexistence of shortage and wastage of community health resources. In view of this, targeted measures should be taken to optimize the allocation of community health resources, and the management of CHCs should be strengthened to improve the efficiency of these institutions.

Keywords: Community health center; data envelopment analysis; efficiency; total factor productivity

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Introduction

The *Opinions of the Central Committee of the CPC and the State Council on Deepening the*

Reform of the Pharmaceutical and Healthcare System promulgated in 2009 put forward that, to achieve the goals of the deepening the



reform of the pharmaceutical and healthcare system, the principle of the unity of fairness and efficiency should be adhered to; in particular, importance should be attached to the development and efficiency evaluation of community health services during improvement of the grassroots healthcare delivery system and promotion of the equalization of the basic public health services. In this way, a long-term mechanism ensuring equity and efficiency in healthcare will be formed, and the health service sector will gradually fulfill the responsibilities and duties of the “gatekeeper” for residents’ health [1, 2]. Moreover, the *Guiding Opinions of the General Office of the State Council on Pushing Forward the Building of the Hierarchical Medical System* promulgated in 2015 proposed that, by 2017, a comparatively complete system of supportive policies for the implementation of the hierarchical medical system will have been developed gradually, mechanisms for separation of duties and cooperation of medical institutions will have been developed basically, high-quality medical resources will have been orderly and efficiently allocated to grassroots medical institutions, the building of the primary care workforce, consisting mainly of general practitioners, will have been strengthened, and the utilization efficiency and overall benefits of medical resources will have been further enhanced. In addition, by 2020, the capabilities of medical institutions delivering hierarchical medical services will have increased comprehensively, the medical insurance system will have gradually improved, a healthcare delivery system characterized by reasonable distribution, appropriate size, optimized hierarchy, clearly defined responsibilities, fully functioning, and high efficiency will have been constructed basically, a hierarchical diagnosis and treatment pattern characterized by initial diagnosis and treatment in grassroots medical institutions, bidirectional referral, treatment of acute and chronic diseases separately, and cooperation between upper-level and lower-level medical institutions will have been formed in a step-by-step approach, and the construction of the hierarchical medical system based on national conditions will have been completed basically [3]. Therefore, evaluating the efficiency of community health organizations (CHOs) in China contributes to promoting the effective running of the community healthcare delivery system, facilitating the implementation of the hierarchical medical system, and remarkably relieving the problem of “difficult and costly access to healthcare services.” To provide evidence-based

policy recommendations for optimizing the allocation of health resources, we conducted a synchronic and diachronic study of the efficiency of community health centers (CHCs) in mainland China (except Tibet) by using data envelopment analysis (DEA) and DEA-based Malmquist index models.

Materials and methods

Data sources

Data concerning the efficiency of CHCs in 30 provinces/autonomous regions/municipalities in mainland China (Tibet was excluded because of partial data loss) during 2013–2015 were obtained from *China’s Health and Family Planning Statistical Yearbook 2014*, *China’s Health and Family Planning Statistical Yearbook 2015*, and *China’s Health and Family Planning Statistical Yearbook 2016* [4–6].

Methods

DEA is a mathematical programming–based method that is used to systematically compare the relative productive efficiency of different units of the same type by dealing with multiple inputs and outputs. It is considered to be the most mature and advanced approach for measuring the performance of health institutions. By use of the Banker-Charnes-Cooper (BCC) model, a type of DEA model allowing variable returns to scale, scores of pure technical efficiency (PTE) and scale efficiency (SE) were obtained; these were then multiplied to obtain the overall technical efficiency (OTE). If a decision-making unit (DMU) achieves an OTE of 1, then it is considered efficient; otherwise it is inefficient. For an inefficient DMU, the target output value was obtained by subtraction of the excess input value from the initial input value; namely, the optimal outputs were achieved by our taking full advantage of the inputs via improvements [7]. By use of a DEA-based Malmquist index model, the dynamic efficiency of the DMU was derived. Efficiency changes were studied by use of the total factor productivity (TFP), an efficiency function–based Malmquist index, which was transformed from the distance function–based Malmquist index by use of the reciprocal relationship between the efficiency function and the distance function. The efficiency change index (ECI) was defined as the product of the technical change index (TCI) and the technical efficiency change index (TECI; which could be decomposed



into the pure technical efficiency change index [PTECI] and the scale efficiency change index [SECI]). If a DMU achieves an ECI greater than 1, less than 1, or equal to 1, this indicates that it has increasing, decreasing, or constant returns to scale compared with the prior period [8].

Evaluation parameters

As DEA-based efficiency assessment of health institutions is based on input and output data and a specified minimum number of inputs and outputs [9], reasonable choice of these indicators is of great significance. Currently, a widely adopted minimum sample for DEA should be equal to or greater than $2nm$, where n and m represent the number of inputs and outputs, respectively. In a systematic review of studies concerning DEA-based assessment of the efficiency of medical institutions in China, Wang and Xing [9] put forward suggestions for effectively selecting the input and output indicators. On the basis of the suggestions, the aim of our study, and the conditions of domestic CHCs, we developed an assessment system consisting of three input indicators (number of CHCs, number of community health workers, and number of beds) and four output indicators (number of visits, number of inpatients, occupancy rate of beds, and average length of stay). Moreover, we chose 30 Chinese provinces/autonomous regions/municipalities as the DMUs, exceeding the minimum sample size ($2nm=24$; $n=3$, $m=4$) required for DEA.

Statistical analysis

Data were stored in a database built with Excel 2010 and were analyzed descriptively. DEA-based empirical analysis of the performance of CHCs was conducted with MaxDEA 5.0.

Results

DEA-based efficiency assessment of the CHCs in China from a synchronic perspective

Input-output indicator values for CHCs in 30 Chinese provinces/autonomous regions/municipalities in 2015: As shown in Table 1, the top three regions with the largest number of CHCs were Guangdong (1078), Jiangsu (548), and Shandong (513), and the three regions with the least number of CHCs were Ningxia (16), Hainan (22), and Qinghai (29). The number of community health workers was greatest in Guangdong (42,837), Jiangsu (37,589), and Zhejiang (33,982),

and was least in Ningxia (1229), Qinghai (1937), and Hainan (2490). Jiangsu (19,019), Shanghai (17,099), and Hubei (13,349) were the top three regions having the largest number of beds in CHCs, and Ningxia (94), Qinghai (568), and Hainan (720) were the bottom three. The number of visits in CHCs was greatest in Guangdong (99,604,961), Shanghai (86,740,055), and Zhejiang (84,484,539), and was least in Ningxia (254,589), Qinghai (716,853), and Hainan (1,042,836). In terms of the number of inpatients in CHCs, the three top-ranked regions were Jiangsu (333,650), Hubei (309,576), and Hunan (274,093), and the three bottom-ranked regions were Ningxia (190), Qinghai (8724), and Tianjin (11,852). With regard to the occupancy rate of beds in CHCs, Shanghai (86.0%), Chongqing (74.6%), and Hunan (69.9%) ranked in the top three, while Tianjin (20.6%), Ningxia (22.7%), and Jilin (26.8%) ranked in the bottom three. With regard to the average length of stay in CHCs, the three highest-ranked regions were Shanghai (60.5 days), Beijing (20.7 days), and Ningxia (20.3 days), and the three lowest-ranked regions were Guizhou (4.7 days), Gansu (5.7 days), and Qinghai (6.0 days).

Efficiency of CHCs in 30 Chinese provinces/autonomous regions/municipalities in 2015:

The average annual OTE, PTE, and SE for the CHCs in the 30 Chinese provinces/autonomous regions/municipalities in 2015 were 0.715, 0.705, and 0.972, respectively. The CHCs in eight regions (Guangdong, Guizhou, Hainan, Ningxia, Qinghai, Shanghai, Zhejiang, and Chongqing) scored 1.000 in terms of the average annual OTE, PTE, and SE, indicating their performances were efficient (Table 2).

Improvement measures based on input indicators for inefficient CHCs at the regional level:

Twenty-two regions were found to have inefficient CHCs: Anhui, Beijing, Fujian, Gansu, Guangxi, Hebei, Henan, Heilongjiang, Hubei, Hunan, Jilin, Jiangsu, Jiangxi, Liaoning, Inner Mongolia, Shandong, Shanxi, Shaanxi, Sichuan, Xinjiang, Yunnan, and Tianjin. To improve the efficiency of inefficient CHCs at the regional level under the premise of keeping the outputs constant, there is a need to reduce the input quantity in each of these regions: the numbers of CHCs, community health workers, and beds in these regions need to be reduced by 131, 5573, and 2086, respectively, on average (Table 3).



Efficiency of community health centers in China during 2013–2015

Table 1. Input-output indicator values for community health centers in 30 Chinese provinces/autonomous regions/municipalities in 2015

Province/ autonomous region/ municipality	Input indicators			Output indicators			
	Number of community health centers	Number of community health workers	Number of beds	Number of visits	Number of inpatients	Occupancy rate of beds (%)	Average length of stay (days)
Beijing	322	26,193	4412	43,590,747	21,737	32.2	20.7
Tianjin	115	6735	2806	15,486,321	11,852	20.6	13.1
Hebei	279	13,836	5568	6,752,172	59,655	43.4	8.6
Shanxi	219	10,244	3124	3,383,979	33,370	47.6	11.2
Inner Mongolia	308	10,474	3528	3,821,280	40,938	43.7	9.5
Liaoning	368	13,304	5378	9,753,855	71,970	44.2	9.4
Jilin	203	7176	2887	3,768,108	24,193	26.8	9.7
Heilongjiang	439	12,810	6121	5,953,041	71,599	42.8	10.7
Shanghai	306	28,498	17,099	86,740,055	83,814	86.0	60.5
Jiangsu	548	37,589	19,019	64,626,065	333,650	50.3	9.3
Zhejiang	467	33,982	7379	84,484,539	63,035	40.1	15.0
Anhui	407	16,211	7348	10,377,235	126,854	43.3	8.2
Fujian	219	9959	3201	12,288,163	62,447	36.1	6.2
Jiangxi	170	7607	2876	3,539,747	52,958	51.5	7.6
Shandong	513	29,534	12,505	17,410,433	215,380	48.8	7.7
Henan	420	18,211	10,201	11,842,094	180,849	51.3	9.3
Hubei	342	19,214	13,349	14,799,261	309,576	61.6	7.9
Hunan	296	13,010	9000	7,998,071	274,093	69.9	7.3
Guangdong	1078	42,837	8114	99,604,961	177,570	55.4	8.3
Guangxi	144	6188	1408	7,338,741	30,693	53.9	7.8
Hainan	22	2490	720	1,042,836	22,661	68.5	6.7
Chongqing	203	8780	7859	6,650,589	257,368	74.6	7.8
Sichuan	397	16,330	8995	17,939,299	211,276	61.0	8.0
Guizhou	166	6340	2923	1,979,899	98,479	51.8	4.7
Yunnan	171	5783	3599	4,010,043	78,278	55.7	7.4
Shaanxi	242	9719	3211	4,677,682	50,041	39.1	8.8
Gansu	205	7024	2452	3,386,841	38,092	53.3	5.7
Qinghai	29	1937	568	716,853	8724	53.6	6.0
Ningxia	16	1229	94	254,589	190	22.7	20.3
Xinjiang	185	7744	2605	4,765,056	44,157	48.7	8.7

Efficiency assessment of the CHCs in China during 2013–2015 from a diachronic perspective by use of DEA-based Malmquist index models: In 2015, the average annual TCI, PTECI, TFP, TECI, and SECI of CHCs at the national level were 1.034, 1.002, 1.024, 0.990, and 0.988, respectively. Compared with 2013, the former three grew by 3.4%, 0.2%, and 2.4%, respectively, whereas the latter two declined by 1.0% and 1.2%, respectively. From a regional

perspective, compared with 2013, in 2015, the average annual TECI, TCI, PTECI, SECI, and TFP of CHCs increased the most in Tianjin, Qinghai, Shanxi, Jilin, and Qinghai, respectively, increasing by 7.0%, 31.1%, 19.0%, and 4.5%, and 31.1%, respectively, whereas they declined most in Anhui, Beijing, Anhui, Shanxi, and Heilongjiang, respectively, decreasing by 12.8%, 6.2%, 6.4%, 15.9%, and 7.3%, respectively (Table 4).



Table 2. Efficiency of community health centers in 30 Chinese provinces/autonomous regions/municipalities in 2015

Province/autonomous region/municipality	Overall technical efficiency	Pure technical efficiency	Scale efficiency	Returns to scale
Anhui	0.551	0.551	1.000	Decreasing
Beijing	0.867	1.000	0.867	Decreasing
Fujian	0.699	0.718	0.975	Increasing
Gansu	0.504	0.511	0.987	Increasing
Guangdong	1.000	1.000	1.000	Constant
Guangxi	0.810	0.811	0.998	Increasing
Guizhou	1.000	1.000	1.000	Constant
Hainan	1.000	1.000	1.000	Constant
Hebei	0.359	0.365	0.983	Increasing
Henan	0.561	0.561	0.999	Decreasing
Heilongjiang	0.381	0.384	0.992	Increasing
Hubei	0.782	1.000	0.782	Decreasing
Hunan	0.929	1.000	0.929	Decreasing
Jilin	0.361	0.403	0.898	Increasing
Jiangsu	0.884	1.000	0.884	Decreasing
Jiangxi	0.583	0.584	0.998	Increasing
Liaoning	0.465	0.475	0.978	Increasing
Inner Mongolia	0.380	0.382	0.996	Increasing
Ningxia	1.000	1.000	1.000	Constant
Qinghai	1.000	1.000	1.000	Constant
Shandong	0.554	0.554	1.000	Increasing
Shanxi	0.357	0.357	0.999	Increasing
Shaanxi	0.505	0.506	0.997	Increasing
Shanghai	1.000	1.000	1.000	Constant
Sichuan	0.756	0.756	1.000	Increasing
Tianjin	0.873	0.940	0.929	Increasing
Xinjiang	0.562	0.564	0.997	Increasing
Yunnan	0.725	0.743	0.975	Increasing
Zhejiang	1.000	1.000	1.000	Constant
Chongqing	1.000	1.000	1.000	Constant
Average	0.715	0.705	0.972	–

Some values for the overall technical efficiency may not be completely equal to the products of the corresponding pure technical efficiency and scale efficiency because of different numbers of decimal places preserved in the initial data and during the calculation and the values presented in the final data being rounded.

Discussion

Static analysis of the efficiency of CHCs in 30 Chinese provinces/autonomous regions/municipalities

We found that the distribution of community health resources is unbalanced and the workload of CHCs is different across the regions of China. The input/output levels of CHCs were high

mainly in Guangdong, Jiangsu, and Shanghai, but were low mainly in Ningxia and Qinghai, which may be due to regional disparities in economic levels and community-based care development. Moreover, the efficiency of CHCs at the national level is relatively low: only eight regions (26.7% of the total) with efficient CHCs scored 1 in terms of OTE, PTE, and SE.



Table 3. Target input quantity and input reductions needed to make inefficient community health centers efficient in 22 Chinese provinces/autonomous regions/municipalities

Province/ autonomous region/municipality	Community health centers		Community health workers		Beds	
	Number needed to be reduced	Target number	Number needed to be reduced	Target number	Number needed to be reduced	Target number
Anhui	185	222	7212	8999	3296	4052
Beijing	43	279	7761	18,432	589	3823
Fujian	66	153	2993	6966	962	2239
Gansu	102	103	3482	3542	1216	1236
Guangxi	50	94	1313	4875	268	1140
Hebei	179	100	8872	4964	3570	1998
Henan	184	236	7999	10,212	4481	5720
Heilongjiang	333	106	7931	4879	3790	2331
Hubei	75	267	6449	12,765	2914	10,435
Hunan	21	275	1612	11,398	640	8360
Jilin	158	45	4582	2594	1844	1043
Jiangsu	64	484	6932	30,657	2209	16,810
Jiangxi	76	94	3175	4432	1200	1676
Liaoning	233	135	7118	6186	2877	2501
Inner Mongolia	224	84	6490	3984	2186	1342
Shandong	229	284	17,411	12,123	5572	6933
Shanxi	149	70	6586	3658	2008	1116
Shaanxi	127	115	4865	4854	1590	1621
Sichuan	99	298	3978	12,352	2191	6804
Tianjin	45	70	852	5883	355	2451
Xinjiang	96	89	3393	4351	1141	1464
Yunnan	96	75	1593	4190	991	2608
Average	131	164	5573	8286	2086	3986

The CHCs in six regions (Anhui, Beijing, Henan, Hubei, Hunan, and Jiangsu) exhibited decreasing returns to scale, suggesting that health resources in these institutions were wasted during running, while 16 regions (Fujian, Gansu, Guangxi, Hebei, Heilongjiang, Jilin, Jiangxi, Liaoning, Inner Mongolia, Shandong, Shanxi, Shaanxi, Sichuan, Tianjin, Xinjiang, and Yunnan) exhibited increasing returns to scale, indicating that health resources in these institutions became insufficient because of changes in scale.

In addition, average surpluses of 131 CHCs, 5573 community health workers, and 2086 beds were found in the 22 regions with inefficient CHCs, demonstrating that the inputs for the CHCs in these regions were wasted to various degrees or were used insufficiently. Thus it can be seen that health resources at

the national level are manifested by the coexistence of shortage and wastage besides insufficient amount and imbalanced distribution. In view of this, we suggest that the investment for the construction of public health hardware should be strengthened and equipment available in CHCs should be improved. Moreover, good management and reasonable use of equipment are needed [8, 10]. Furthermore, to reduce wastage of health resources, measures for improving the use of the surplus and idle health resources, such as increasing equipment sharing between departments of the CHCs, and loaning equipment to other institutions with payment of a fee, should be taken on the basis of local conditions. In this way, a community-based service delivery system characterized by reasonable distribution, good support, and standardized management will be established.



Table 4. Average annual dynamic changes in the efficiency of community health centers in 30 Chinese provinces/autonomous regions/municipalities from 2013 to 2015

Province/ autonomous region/municipality	Technical efficiency change index	Technical change index	Pure technical efficiency change index	Scale efficiency change index	Total factor productivity
Beijing	1.037	0.938	1.000	1.037	0.973
Tianjin	1.070	0.979	1.031	1.038	1.047
Hebei	1.058	1.000	1.050	1.008	1.058
Shanxi	1.000	1.042	1.190	0.841	1.042
Inner Mongolia	0.967	1.042	0.967	1.000	1.008
Liaoning	1.054	1.015	1.049	1.005	1.070
Jilin	1.018	1.001	0.973	1.045	1.018
Heilongjiang	0.917	1.011	1.043	0.880	0.927
Shanghai	1.000	0.978	1.000	1.000	0.978
Jiangsu	0.980	0.973	1.000	0.980	0.954
Zhejiang	1.000	0.940	1.000	1.000	0.940
Anhui	0.872	1.095	0.936	0.932	0.955
Fujian	1.019	1.033	1.006	1.012	1.052
Jiangxi	0.955	1.082	0.955	1.000	1.033
Shandong	0.992	1.011	1.033	0.961	1.002
Henan	0.956	1.026	0.962	0.994	0.981
Hubei	1.019	0.979	1.000	1.019	0.998
Hunan	0.953	1.052	0.940	1.013	1.002
Guangdong	1.000	0.988	1.000	1.000	0.988
Guangxi	0.952	1.085	0.960	0.992	1.033
Hainan	1.000	1.138	1.000	1.000	1.138
Chongqing	1.000	0.989	1.000	1.000	0.989
Sichuan	1.028	1.014	1.087	0.945	1.042
Guizhou	1.000	1.126	1.000	1.000	1.126
Yunnan	0.999	1.046	0.995	1.004	1.045
Shaanxi	0.999	1.093	1.031	0.969	1.092
Gansu	0.934	1.052	0.938	0.995	0.982
Qinghai	1.000	1.311	1.000	1.000	1.311
Ningxia	1.000	0.995	1.000	1.000	0.995
Xinjiang	0.956	1.053	0.958	0.999	1.007
Average	0.990	1.034	1.002	0.988	1.024

The technical efficiency change index, technical change index, pure technical efficiency change index, scale efficiency change index, and total factor productivity are geometric mean values. Because of different numbers of decimal places preserved in the initial data and during the calculation and the values presented in the final data being rounded, the values of the technical efficiency change index are not completely equal to the products of corresponding pure technical efficiency change index and scale efficiency change index, and the values of the total factor productivity are not completely equal to the products of the corresponding technical change index and technical efficiency change index.



Dynamic analysis of the efficiency of CHCs in 30 Chinese provinces/autonomous regions/municipalities by Use of DEA-based Malmquist index models

This study revealed that during 2013–2015, the CHCs at the national level achieved a TECI of about 1 (0.990) and a TCI of 1.034, suggesting that the improvement of overall production efficiency in this period was mainly derived from technical innovation. However, since increased PTE and decreased SE are the major driving force of OTE, the low management level of CHCs was mainly caused by decreased scale economies. During the period, the TFP of CHCs across the regions had an average growth rate of 2.4%, which is much lower than that (13.9%) found by Zhao [11] concerning the assessment of relative productive efficiency of medical institutions in 31 regions of China during 2007–2011. Nevertheless, Zhao proposed that technical innovation rather than an enhanced management level generated the increased efficiency of medical institutions, which is similar to our findings.

The TFP of the CHCs in 18 regions (60.0% of the total) improved during 2013–2015, but there were regional differences. Moreover, the differences were more significant between regions with the greatest improvement of TFP of the CHCs and those with the least. Hence, in regions with less improved or decreased TFP of CHCs, reasonable establishment and scientific management of CHCs should be strengthened, the integration of the network of CHCs should be achieved as early as possible, registration of general practitioners should be promoted, and the service quality of CHOs should be improved [12].

Moreover, governments at the regional level should strongly support social forces to run CHOs to provide diversified health services for residents, and in a unified way construct the information management system for CHOs to achieve integrated sharing of internal information and big data in healthcare between CHOs as soon as possible. In this way, the diagnostic and therapeutic process (including appointment, registration, diagnosis, treatment, referral, use of public services, payment of medical costs, reimbursement of medical costs through medical insurance, and drug inspection and management) for residents will be more efficient and convenient, exchange of information between CHOs and physician-patient interaction will be strengthened, the experience of residents in seeking

healthcare will be improved, and the overall efficiency of CHOs will be improved.

Conflict of interest

The authors declare that they have no conflict of interest.

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Author contributions

Lin Zhao and Guiming Yan designed and conducted the study, wrote the paper, and are responsible for the content of the paper. Yao Zhang and Yabing Hou helped collect data, perform the study, and interpret the results. Lin Zhao performed quality control and revised the paper.

Significance statement

- Evaluation of the efficiency of CHCs in China at the national level and regional level from synchronic and diachronic perspectives.
- Use of data collected from *China's Health and Family Planning Statistical Yearbook 2014*, *China's Health and Family Planning Statistical Yearbook 2015*, and *China's Health and Family Planning Statistical Yearbook 2016*.
- Use of data envelopment analysis and Malmquist index analysis to analyze the efficiency of CHCs.

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