Original Research

Spatial illustration of health-care workforce accessibility index in China: How far has our 2009 health-care reform brought us?

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Abstract

Objective: The objective of the study was to evaluate the effectiveness of China's health-care reform from 2009 to 2011 by examining China's annual health-care workforce statistics of 2008 and 2011.

Design: The design of the study was a secondary data analysis.

Main outcome measure: The main outcome measure used was the Primary Health Care Worker Accessibility Index (PHCWA).

Results: The statistics illustrated the impact health-care reform had on the provision of primary health care in rural areas. The results showed that the health-care reform of 2009 generally improved access to the primary health-care workforce in all 28 areas (range of increase: 13.18–324.0%). However, an increasing disparity in regional health care based on the increase of the standard deviations of PHCWA (range of increase: 36.44–77.10%) may be an issue that policy-makers and analysts will have to face.

Conclusions: Concerted policy efforts from both the provincial and central governments are needed to narrow the gaps. Regional development should not only focus on the economic aspect, but also account for the

fact that the adequate provision of primary health care is part of the infrastructure that makes development possible and sustainable.

KEY WORDS: accessibility, Chinese health-care reform, China, health-care workforce, primary health care.

Introduction

When the government of China was first formed in the late 1940s, there were barely any well-established health-care resources available throughout the country. In the early years, the health-care system was underdeveloped, and then World War II drained the national resources and wiped out existing health-care infrastructure. The situation improved significantly following the implementation of the 'barefoot doctors' policy in 1968. It was a low-level and wide-coverage model for rural primary health-care services that turned secondary school graduates into clinicians through basic medical and paramedical training.¹ It was so successful that it has become a role model for other developing countries.² With the economic reforms and developments in the 1980s, the model was gradually replaced by the 'village doctors' model, which was based on market orientation.¹ Unfortunately, the development of the rural health system has not been able to capitalize on the rapid economic growth that most urban areas underwent, resulting in a much slower pace of progress across rural China.³ Thus, modern health care has been mostly unavailable and inaccessible in these regions.

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What is already known on this subject:

- Traditional non-population density-based health-care workforce accessibility indices cannot be used for comparing data across regions with significant differences in area.
- The Primary Health Care Worker Accessibility Index was developed to compare data across regions with significant differences in area.

The 2009–2011 health-care reform aimed to solve the long-lasting problem of the ‘difficult and costly access to health-care services’ in China.³ Among the five major reform programmes, the third focused on ‘perfecting the system of healthcare services at grass-roots levels’, involving two items that are highly relevant to the accessibility of health care in rural China; the first is strengthening the establishment of grassroots health-care institutions, and the second is strengthening grassroots health-care workers. The former focuses on building more county-level hospitals, township health centres, and village clinics, while the latter is about training more general practitioners.³ Both can directly contribute to increasing the size of the rural health-care workforce and result in higher accessibility to health-care services. The other four major reforms are: (i) accelerating the establishment of the basic medical security system; (ii) preliminarily establishing the national essential medicines system; (iv) promoting the gradual equalization of basic public health services; and (v) push forward pilot projects for public hospital reform.³ They are not directly related to the accessibility of health care in rural China.

In 2011, scholars at Peking University developed the Primary Health Care Worker Accessibility Index (PHCWA) together with the World Health Organization.⁴ However, as only statistics from 2007 had been used to illustrate the validity and use of the index in their study, important changes that have taken place since 2008 were not accounted for by the index. In this context, this study proposed using the improved index (i.e. PHCWA) to examine the annual health-care workforce statistics from 2008 to 2011 to analyse the effect the health-care reform has had on the provision of primary health care in rural areas. The results from this analysis will help the Chinese government to gain a more precise overview of the current state of health-care provision and to improve the state further in the future. The rural health workforce was selected as the study objective not only because of Han’s successful experience,⁴ but also because accessing health-care service in rural areas is far more difficult than in cities due to different factors, such as transport.⁵ Moreover, as the

What this study adds:

- The progress of the health-care reform in China from 2009 to 2011 was evaluated using the newly developed the Primary Health Care Worker Accessibility Index.
- The results provided a direction for policy-makers to formulate future health-care reform.

new index is more suitable to apply to the regions covering large areas, this is particularly suitable for rural health-care workforce studies.⁴

Data and methods

The PHCWA is a spatial index of the availability of primary health-care manpower based on the composite population density. The lowest value of the index is zero, and a higher index value means greater accessibility to primary health care. It is believed to be a more valid indicator for measuring the state of primary health-care provision in rural China, as population density has been considered. For example, one physician per 1000 residents in a small province is better than a large province because patients are more concentrated. Moreover, the index was validated using the child mortality and maternal mortality rate (MMR), which is an important indicator of health status. The $\log(\text{PHCWA} \times 1000)$ was found to have a stronger correlation with the $\log(\text{MMR})$ over the traditional primary health-care work density index, with correlations of -0.683 and -0.447 , respectively.⁴ The magnitude of the -0.683 correlation can be considered as large.⁶ Mathematically, the PHCWA can be written as:

Rural PHCWA index of province X

$$= \left(\frac{\text{primary health-care worker density per 1000 farming population index of province X}}{\text{population density index of province X}} \right) = \left(\frac{\text{province X primary health-care worker density per 1000 farming population actual value} - \text{the minimum}}{\text{the maximum} - \text{the minimum}} \right) \left(\frac{\text{province X population density actual value} - \text{population density minimum}}{\text{population density maximum} - \text{population density minimum}} \right)$$

The traditional non-population density-based indices cannot be used for comparing data across different regions,⁷ but the PHCWA index makes comparisons feasible and meaningful.⁴ This is due to the fact that the traditional indices do not consider the fact that health-care teams have to cover significantly larger areas in regions with extremely low population density.

The PHCWA index was used to assess how the accessibility of the rural primary health-care workforce changed in each province between 2008 and 2011. As the index values have to be comparable between the two years, the normalization parameters (i.e. the min and max values in the earlier equation) that were used for the 2008 data to represent the situation in 2008 were applied to the 2011 data. In this way, an improvement can be observed over the 3-year period. On the other hand, the three municipalities – Beijing, Shanghai and Tianjin – and the special administrative regions – Hong Kong and Macau – were excluded in the analysis because of their relatively small areas (some of them are just a point on the map of China) and their high degree of urbanization (proportions of rural area were too small).⁸ The detailed algorithm that was used to calculate the PHCWA index can be found in the paper by Han et al.⁴

The provincial-level statistics that were used to calculate PHCWA values included the total population, total area and number of health personnel in township hospitals and village clinics per 1000 people in the rural population.^{8,9} In this study, a rural area includes county/county-level city township health centres and village clinics, which is consistent with the year book of health in the People's Republic of China.⁸ Data were obtained from the Chinese Internet Information Center⁹ and the National Health and Family Planning Commission website.⁸ In addition, the ranking of PHCWA values among the provinces were compared with the percentage change of PHCWA values between 2008 and 2011. Finally, the overall PHCWA values and their variations within different regions of China were compared using the Wilcoxon signed ranks test and Levene's test for equality of variances. Throughout the study, the Statistical Package for the Social Sciences (SPSS) 20 (SPSS, Inc., Chicago, IL, USA) was used for all statistical calculations. The thematic maps were created using ArcGIS 9.0 (ESRI, Redlands, CA, USA), and the statistical significance was set at 0.05.

Results

Table 1 shows a comparison of the PHCWA index before and after the health-care reform. About half (15) of the provinces showed no change in their PHCWA ranking. Six provinces ranked lower in 2011, and all but Yunnan were located in the relatively well-developed

areas of Eastern and Central China. In contrast, four provinces in Western China ranked higher in 2011. Chongqing, in Western China, showed the greatest improvement; it moved from rank 11 to rank 6. Zhejiang, a province in Eastern China, experienced the greatest loss in rank and moved from rank 9 to rank 13.

Overall, the PHCWA values increased in all provinces, ranging from a 13.18% increase in Anhui to a 324.32% increase in Tibet. The PHCWA value of four provinces in Western China doubled. Table 2 shows that the mean PHCWA values of Eastern, Central, Western and all of China as a whole had statistically significant improvements ($P < 0.05$). However, the differences in the within-group variation of PHCWA between 2008 and 2011 were not large enough to be statistically significant. The spatial visualization of the PHCWA ranking and values are shown in Figures 1 and 2, respectively.

Discussion

The results mentioned earlier show that the health-care reform of 2009 had a measurable impact. The index shows that the accessibility to the primary health-care workforce has improved in all provinces, and the improvement was statistically significant ($P < 0.001$). The exceptionally positive improvement in Chongqing could be due to the city launching a programme to promote becoming a National Central City in early 2010.¹⁰ Even though Zhejiang's ranking appears to have dropped significantly, there was still an increase of 26.34% in the index value; this increase was larger than that of five other provinces. Nevertheless, the province losing ranks could suggest that the primary health care there did not advance at a similar pace as it did in other provinces. To further improve the situation, both the provincial and central governments need to address problems such as insufficient health-care investments, coordination issues, misallocation, the lack of provincial incentives to retain qualified manpower and the lack of accessibility.

The massive improvements in the PHCWA values of Tibet and four other provinces in Western China could be attributed to the impact of the Eleventh Five-Year Plan on Western Development; one of its goals was to improve the provision of health care in the rural areas of these regions.¹¹ However, irrespective of its index value improvement, Tibet remains the lowest-ranking province. This could be due to a number of factors; the extremely low population density in the province could mean that health-care teams have to cover larger areas, and there is also a poorer standard of living for health-care professionals, making it harder to attract and retain new and qualified staff. In addition, there are more

TABLE 1: *Comparison of Primary Health Care Worker Accessibility Index among different provinces before and after the health reform*

	2008†	2011†	Percentage change (%)‡	Rank in 2008	Rank in 2011	Change of ranking
Eastern						
Hebei	0.2712	0.4558	68.06	6	5	1
Liaoning	0.2119	0.2908	37.24	8	8	0
Jiangsu	0.9587	1.1858	23.69	1	2	-1
Zhejiang	0.2042	0.2579	26.34	9	13	-4
Fujian	0.1954	0.2794	42.95	10	10	0
Shandong	0.8136	1.2592	54.77	2	1	1
Guangdong	0.4968	0.6355	27.92	3	3	0
Hainan	0.1509	0.1818	20.48	15	17	-2
Central						
Heilongjiang	0.0535	0.0804	50.35	20	20	0
Jilin	0.1270	0.1847	45.47	16	16	0
Shanxi	0.1839	0.2780	51.16	13	11	2
Anhui	0.2507	0.2838	13.18	7	9	-2
Jiangxi	0.1904	0.2708	42.20	12	12	0
Henan	0.4379	0.6264	43.04	4	4	0
Hubei	0.2913	0.3356	15.22	5	7	-2
Hunan	0.1610	0.2539	57.73	14	14	0
Western						
Inner Mongolia	0.0143	0.0233	62.29	25	25	0
Guangxi	0.0846	0.1374	62.44	19	19	0
Chongqing	0.1929	0.3772	95.56	11	6	5
Sichuan	0.1020	0.1622	58.98	18	18	0
Guizhou	0.0381	0.0791	107.54	21	21	0
Yunnan	0.0359	0.0449	25.18	22	24	-2
Tibet	0.0012	0.0052	324.32	28	28	0
Shaanxi	0.1228	0.2134	73.74	17	15	2
Gansu	0.0211	0.0467	121.74	24	23	1
Qinghai	0.0049	0.0103	109.50	27	27	0
Ningxia	0.0341	0.0552	62.16	23	22	1
Xinjiang	0.0075	0.0129	72.07	26	26	0

†The min and max values for calculating the population density index were set at 756.53 and 0, respectively. The min and max values for calculating the primary health-care worker density per 1000 rural population index were set at 3.42 and 1.0, respectively. ‡The change was statistical significant based on the result of Wilcoxon's signed ranks test ($P < 0.001$).

substantial travelling costs, both in terms of required time and money, connected to people having access to health-care services.

It has been noted that some of the lowest-ranking provinces, such as Yunan, Qinghai and Xinjiang, also have a large population of ethnic groups.¹² There are situations, such as low income and affordability issues, geographical accessibility by those in remote rural areas, and the cost and profit-making concern of health-care services, where some people may be denied proper health-care services. It is questionable whether health-care plans that rely heavily on market forces can meet the needs of primary health care in provinces with

extremely low index values. Thus, provinces deserve policy support to prevent regional disparities in health care from widening rather than narrowing. Further research is also needed to analyse potential contextual situations in specific provinces so that more focused policies can be formulated to improve their health-care status.

It might be worth noting that the improved public health care is a result of many factors, although health-care reform appears to set the infrastructure for such improvements. The strict surveillance and penalty requirement imposed by provincial and local governments as well as the enhanced health-care efficiency by

TABLE 2: Comparison of Primary Health Care Worker Accessibility Index among the Eastern, Central and Western regions before and after the health reform

	2008		2011		Percentage increase (%)	
	Mean	SD	Mean	SD	Mean†	SD‡
Eastern	0.4128	0.3129	0.5683	0.4280	37.65*	36.76
Central	0.2120	0.1165	0.2892	0.1568	36.44*	34.59
Western	0.0550	0.0590	0.0973	0.1102	77.10**	86.96
Whole China	0.2021	0.2305	0.2867	0.3134	41.89***	35.97

* $P < 0.05$; ** $P < 0.01$; *** $P < 0.001$. †Tested by Wilcoxon's signed ranks test. ‡Tested by Levene's test for equality of variances. SD, standard deviation.

FIGURE 1: Spatial pattern of the change of Primary Health Care Worker Accessibility Index (PHCWA) ranking. (■) < -2 ; (■) -2 to -1 ; (□) 0 ; (▨) $1-2$; (▩) > 2 . Excluded areas were set at 0 for completeness. Source: Boundary map from GADM database of Global Administrative Areas

township and village doctors are crucial factors to bring about these changes.¹³ Above all, the tremendous economic developments in major cities in the 3-year period have made it possible for local governments to invest more in health-care services, and retain fewer money, which is supposed to be passed down from the central government to towns and village health care. Whether

these favourable factors will continue to shape a favourable improvement remains to be seen.

Limitation

One of the major limitations of this study is the validity of the index used. Although the validity was assessed

FIGURE 2: Spatial pattern of Primary Health Care Worker Accessibility Index (PHCWA) value percentage change. (□) <25%; (■) 25–50%; (■) 50–75%; (■) 75–100%; (■) >100%. Excluded areas were set at 0 for completeness. Source: Boundary map from GADM database of Global Administrative Areas

using child mortality and maternal mortality rate in Han's study,⁴ the assessment is limited in scope and may be only indirectly related to the PHCWA index. As this study is not in itself a validation study of the index, it is ideal to further assess the index validity in the future, using multiple methods and data. Moreover, the index can also be enriched by incorporating more geographically related factors other than population density, such as road network density.

Conclusion

The health-care reform of 2009 has had a tangible impact, which is reflected in the new index. Without going into the debate of which index works best to calculate the index, the idea of approximating the provision of primary health care using the accessibility of the health-care workforce as a proxy is worth consideration. Although all provinces showed a certain degree of improvement between 2008 and 2011, the increasing trend of within-region dispersion suggests that regional health-care disparities may be an issue that policy-makers and analysts will have to face. Perhaps a longer period needs to be examined to ascertain this trend.

Some districts/provinces managed to develop significantly more than others and widened the regional disparity over time, making it even harder to attract health professionals to come to work in the least-developed districts/provinces. This will result in a vicious cycle, making it difficult for certain districts/provinces to improve their health care. Concerted policy efforts from both the provincial and central governments are needed to narrow currently existing gaps. Regional development should not only focus on the economic aspect, but also account for the fact that an adequate provision of primary health care is part of the infrastructure that makes the development possible and sustainable.

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