Policy Forum

Equity Study in Health Workforce on Tuberculosis Control in China: a Nationwide Evaluation*

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We aimed to describe the distribution of tuberculosis (TB) health workers in China and provide evidences of potential inequity for policy development. We used Lorenz curves and Gini index to characterize the distribution of TB health workers by population size, geographical area and number of annual registered TB cases. An additional stratified analysis was done by three economic regions. The Gini index were 0.33 for population size, 0.62 for geographical area and 0.30 for number of registered tuberculosis cases that indicated an acceptable average, significant inequity and a relative average distribution nationwide respectively. All of these three measures indicated an acceptable or relative equity in the economic developed eastern region (G=0.31, G=0.30, G=0.34); a relative average on population distribution was seen in middle region (G=0.26, G=0.27, G=0.24); a polarization on both the population and geographical distribution was found in the poor and less developed western region although the distribution on case number was acceptable average (G=0.41, G=0.50, G=0.26). The equity of health workforce on TB control in China was considered fair except geographic distribution, a more equitable distribution can be seen after a stratify analysis in terms of regional economic status.

China is one of the 22 highest burden countries of tuberculosis (TB) and one of the 27 highest burden countries of multi-drug resistant tuberculosis (MDR-TB) in the world[1]. About 1.1-1.5 million new cases arise each year that accounts for 14% of the global new TB cases[2-3]. TB control in China has achieved Millennium Development Goals (MDG) in 2010 and the targets of STOP-TB Partnership regarding control of TB epidemic, case detection and treatment success under the National Plan (2001-2010)[4]. But the TB control achievements are challenged by the increasing burden of MDR-TB, TB/HIV co-infection, high prevalence in poor rural area and the domestic migrant population from rural villages to urban cities, as well as the sustainability of human resources.

Recently, much attention has been paid to the shortage and inequity of health workforce worldwide[5-6]. The estimated shortage is about 4.3 million doctors, nurses, midwives, and support workers globally and is considered as a global health crisis[7] that affects more severely in developing countries. It was found that health workforce is the key factor that constraints TB control after evaluating 17 of 22 TB high burden countries by WHO[8]. China, the lower-middle-income country, with an area of 9 600 000 km^2 and 1370 million people, is facing the same dilemma in TB control. A same conclusion was made from the results of the Report of evaluation on national TB control plan (2001-2010)[9] and the 4th national TB prevalence survey[10] in China. Following with the 2006 world health day, “human resource for health”, a “Human Resources for Health Action Framework” was published by WHO TB division. According to the Framework, the ultimate goal of Human Recourses Development (HRD)[11] for comprehensive TB control is to have the right number of health workforce, with the right skills, in the right place, at the right time, which are motivated and supported to provide the right services to the right TB patients.

The quality of service delivery depends to a large extent on performances of personnel that might be influenced by various factors such as motivation, training, supervision, salary, working condition, and so on. The premises of qualified services are the quantity and quality of workforce and its equity in distribution. However, little has been done to evaluate the status of TB health workforce distribution and its potential inequity in China. This study aimed to describe the distribution of TB health workers (HWs) in China and provide evidences of potential inequity for policy development.

The National TB control program (NTP) was launched in 1991, a vertical management system, consisting of central, province, prefecture and county TB control organizations that has been built under the NTP. TB medical care and management is

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available in several kinds of health facilities such as specialized TB hospitals, dispensaries, local centers for disease prevention and control (CDC), or TB clinics in general hospitals. TB health workforces (HWs) were defined as health workers who were working in the above TB facilities including clinic physicians, lab technicians, TB control personnel and support staff.

Data Resource The population size and geographical area at province level were retrieved from 2009 National Statistical Yearbook[12-13]. We subtracted the data of TB notification of 2009 from the China TB Recording & Reporting system[14]. TB HWs data was obtained from the evaluation on national TB control plan (2001-2010) carried out by the National Center for TB Prevention and Control in 2009. A uniformed questionnaire had been used in this evaluation, and was completed by TB institutions at all levels.

Data Analysis We used Lorenz curves and Gini index to analyze the inequity in distribution of human resources. The Lorenz curves refers to the cumulative share of HWs against the cumulative share of the population when the different locations are ranked from the lowest to the highest proportion of HWs, same as the cumulative share of HWs against the cumulative share of the geographical area and annual TB cases as an alternative measure of needs. The further the distance from diagonal line, indicates the greater degree of inequity.

The area between Lorenz curve and diagonal line presents a measure of aggregate level of inequity entitled Gini index. The Gini index ranges from 0 to 1, with higher values indicating the larger inequity. The currently accepted standard is following by: Gini≤0.2: indicates a perfect average; 0.2<Gini≤0.3: indicates a relative average; 0.3<Gini≤0.4: Indicates an acceptable average; Gini>0.4: means a resource polarization.

The measurement of health inequity by means of the Lorenz curve and the Gini coefficient was first used by Le Grand and Rabin[15], whereas most of current studies[16-18] used a formula provided by Brown, M.C (1994). In this study we used a more mathematically tractable and computationally convenient formula[19-20]:

$$G = -[1 + \sum Y_i P_i - 2\sum P_c Y_i]$$

Where G is the Gini index, Y_i is the proportion of TB HWs in i^{th} group among total TB HWs, P_i is the proportion of population in i^{th} group among total population, P_c is proportion of population of cumulative population from group 1 to group i among total population.

Administratively, China is consisting of 31 provinces with imbalances on population size, geographical area and economic development. An additional stratified analysis was conducted by regions with various economic levels, which is defined by the National People's Congress mostly depending on provincial economic circumstances. As a result, the country was divided into eastern, central and western regions, in which each of them respectively represents the higher, middle and lower economic level and consist of 11, 8, and 12 provinces (Table 1).

Table 1. Demographic and Economic Distribution by Administrative Divisions in East, Middle, and West Region

East Region			Middle Region			West Region		
Administrative Divisions	Population (X100 000)	Average DP(USD)	Province	Population (X100 000)	Average GDP(USD)	Province	Population (100 000)	Average GDP(USD)
BEIJING	1 755	10 298.3	ANHUI	6 131	2 442.55	CHONGQING	2 859	2 964.6
FUJIAN	3 627	4 854.2	HEILONGJIANG	3 826	3 166.16	GANSU	2 635	1 888.9
GUANGDONG	9 638	5 861.9	HENAN	9 487	3 089.95	GUANGXI	4 856	2 430.5
HAINAN	864	2 750.7	HUBEI	5 720	3 233.07	GUIZHOU	3 798	1 351.0
HEBEI	7 034	3 604.6	HUNAN	6 406	2 837.92	INNER MONGOLIA	2 422	5 467.3
JIANGSU	7 725	6 437.9	JIANGXI	4 432	2 334.40	NINGXIA	625	2 880.0
LIAONING	4 319	5 013.7	JILIN	2 740	3 798.49	QINGHAI	557	2 690.0
SHANDONG	9 470	5 263.0	SHANXI	3 427	3 046.80	SHAANXI	3 772	3 005.4
SHANGHAI	1 921	11 320.4				SICHUANG	8 185	2 535.1
TIANJIN	1 228	9 295.5				TABIT	290	2 342.5
ZHEJIANG	5 180	6 582.9				XINJIANG	2 159	2 803.4
						YUNAN	4 571	2 006.9
Total	52 761	6 480.3	Total	42 169	2 993.70	Total	36 729	2 697.1

There was a total of 27 855 TB HWs by the end of 2009. A total of 27 724 HWs was included in analysis with an exclusion of HWs employed in national level.

On average, there were 2.1 TB workers per 100 000 populations nationwide. Number of TB HWs per capita varied greatly among provinces, from the highest 19.1 (Tibet autonomous region) to the lowest 0.35 per 100 000 (Yunnan province). Geographically, there was an average of 28.7 TB HWs per 10 000 km^2 from a highest 369 per 10 000 km^2 in the developed eastern region (Tianjin municipality) to the lowest 2.76 per 10 000 km^2 in the developing western region (Qinghai province). With regard to workload, the mean of TB HWs was 28.7 per 1000 registered TB cases, with a range from 10.7 to 135 (ZheJiang Province and TianJin municipalities) (Table 2).

Table 2. Distribution of TB HWs by Administrative Divisions

Administrative Divisions	TB HW	Population (100 000)	Area (10 000 km^2)	TB case IN 2009	TB HW/ Population	TB HW / Area	TB HW /TB Case (1000)
SHANGHAI	112	1 921	0.634	6 784	0.6	176.7	16.5
NINGXIA	147	625	6.64	3 317	2.4	22.1	44.3
YUNAN	160	4 571	39.4	3 434	0.4	4.1	46.6
QINGHAI	199	557	72	3 803	3.6	2.8	52.3
HAINAN	267	864	3.392	8 800	3.1	78.7	30.3
ZHEJIANG	373	5 180	10.18	34 913	0.7	36.6	10.7
TIANJIN	417	1 228	1.13	3 089	3.4	369.0	135.0
BEIJING	420	1 755	1.6807	4 556	2.4	249.9	92.2
JIANGSU	505	7 725	10.26	43 789	0.7	49.2	11.5
SICHUANG	520	8 185	48.5	45 760	0.6	10.7	11.4
FUJIAN	527	3 627	12.14	23 123	1.5	43.4	22.8
TABIT	554	290	122.84	25 010	19.1	4.5	22.2
ANHUI	577	6 131	13.96	41 558	0.9	41.3	13.9
SHANXI	631	3 427	15.6	23 719	1.8	40.4	26.6
SHANXI	638	3 772	20.58	21 934	1.7	31.0	29.1
GANSU	640	2 635	45.5	23 720	2.4	14.1	27.0
XINJIANG	660	2 159	166.49	25 065	3.1	4.0	26.3
GUIZHOU	746	3 798	17.62	22 264	2.0	42.3	33.5
JIANGXI	749	4 432	16.69	38 453	1.7	44.9	19.5
GUANGXI	819	4 856	23.63	41 447	1.7	34.7	19.8
HUNAN	995	6 406	21.18	54 345	1.6	47.0	18.3
CHONGQING	1 060	2 859	8.3	68 847	3.7	127.7	15.4
HEBEI	1 120	7 034	19	41 305	1.6	58.9	27.1
INNNER MONGOLIA	1 160	2 422	118.3	19 339	4.8	9.8	60.0
HUBEI	1 400	5 720	18.59	48 911	2.4	75.3	28.6
JILIN	1 496	2 740	18.74	21 914	5.5	79.8	68.3
HEILONGJIANG	1 614	3 826	47.3	37 172	4.2	34.1	43.4
LIAONING	1 922	4 319	14.57	23 865	4.5	131.9	80.5
SHANDONG	2 049	9 470	15.7	41 287	2.2	130.5	49.6
HENAN	2 425	9 487	16.7	73 679	2.6	145.2	32.9
GUANGDONG	2 822	9 638	17.98	72 932	2.9	157.0	38.7
TOTAL	27 724	131 659	965.2267	948 134	2.9	74.1	37.2

Figure 1A showed the Lorenz curve for the distribution of TB HWs by population size across provinces. The value of Gini index was 0.33. We calculated the Gini index for each region from high to low GDP and found it was highest in west region (Gini=0.41) despite western regions had a higher density of TB HWs regarding the population than that in eastern and middle region (3.8 and 2.1 *vs.* 2.6) (Table 3).

One alternative to population size for measuring needs is the area of geography. Figure 1B showed the Lorenz curve for distribution of TB HWs by geographical area across provinces. The value of Gini index was 0.62. We calculated the Gini index for each region, which displayed that the Gini index for each region were all lower than the national total. On average, eastern region had the highest density of TB HWs per 10 000 km^2, whereas both of the middle and western regions were less than the national average. The most significant inequity was found in the western region (Table 3).

Another alternative for measuring needs is the number of registered TB cases. Again; Figure 1C showed the Lorenz curve for the distribution of TB HWs by the number of registered TB cases across provinces. The value of Gini index was 0.30 in total. Middle region had the lowest Gini index but the average workload (reverse of TB HWs per 1000 TB cases) was higher than that of eastern and western region. In general the distributions of TB workforce in these regions were all in equity measured by workload (Table 3).

In general, due to the long history of TB control in China and the rapid development in recent years, the current TB HWs (27 724) is larger than those in other communicable disease fields. In some provinces the special TB hospitals and TB dispensaries play an important supplement role in TB control to the CDC system. However, current TB HWs are still not enough compared with the high TB prevalence, especially in the face of the emerging of MDR-TB and TB/HIV co-infection.

The Gini coefficient, one of the most commonly used indicators of inequity[21], has been widely applied in a number of studies in USA[22], UK[23-24], Sweden[25], Japan[26], Iran[27], Albania[28], Tanzania[29] and Thailand[30]. Based on Gini index criterion, the calculation on population, geographical area and registered TB cases in China indicated an acceptable equity (G=0.33), a significant inequity (G=0.62), and a relative equity (G=0.30) distribution respectively, which suggested a better status of equity in TB HWs distribution in China compared with above studies.

When region stratified Gini index and average resource were calculated, from low to high economic status, regions in western, middle and eastern presented a quite different picture. Western region was with the highest TB HWs per capita but a fairly

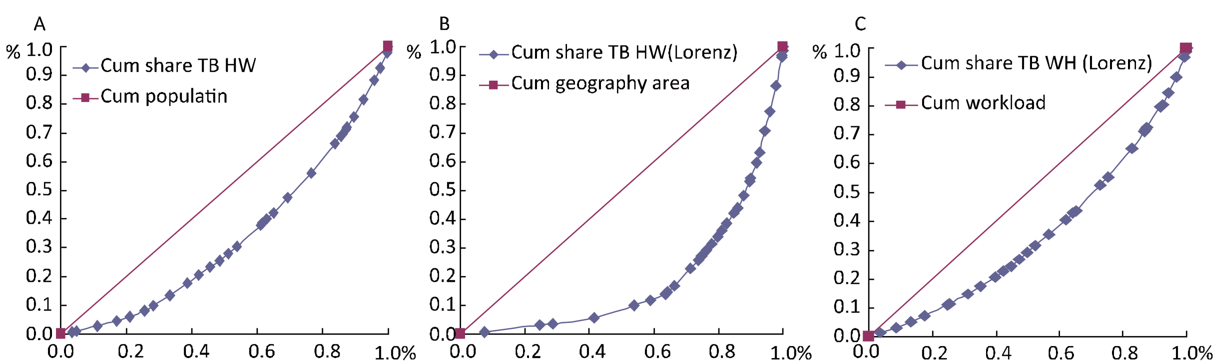

Figure 1. Lorenz curve for the distribution by different indicators.

Table 3. Regional Distribution of TB HWs by population, geographic area, TB cases

Region	TB HWs per Capital (100 000)				TB HWs per Area (10 000 km^2)				TB HWs per TB Case (1000)			
	Mean	Range	Median	Gini	Mean	Range	Median	Gini	Mean	Range	Median	Gini
Eastern	2.1	0.6-4.4	2.1	0.31	134.7	36.6-369.0	130.5	0.3	46.8	10.7-135.0	30.3	0.34
Middle	2.6	0.9-5.4	2.1	0.26	63.5	34.1-145.2	45.9	0.27	31.4	13.9-68.3	27.6	0.24
Western	3.8	0.4-19.1	2.4	0.41	25.6	2.8-127.7	12.4	0.50	32.3	11.4-60.0	28.0	0.26
Total	2.9	0.4-19.1	2.4	0.33	74.1	2.8-339.0	43.4	0.62	37.2	10.7-135.0	28.6	0.30

high inequity compared with the national average (3.8/100 000 *vs.* 2.9/100 000). Geographically, despite the difference in density of HWs in the 3 regions (Gini=0.62), the distribution was fairly equity inter-regions (Gini<0.30) except western region; middle region had the highest workload (31.4/1000 TB cases) while with the lowest Gini index (0.24) in workload distribution compared with other regions. In practice, population density in eastern region (Beijing and Shanghai, for example) was particularly higher than that of middle and western regions, which might have led to a higher workforce density and lower HWs per capita. However a relatively high population density may improve the access to TB care that might explain the lower HWs per capita in eastern region. In addition, middle and western regions had a relatively higher TB burden than eastern region which partly explained that these regions had a relative high workload in spite of western region with the highest average HWs per capita. However, it’s hard to distinguish temporal relationship between case findings and HWs, fewer HWs may lead to a low case detection, and then fewer cases need fewer HWs for case management.

Inequity can be partly explained by imbalanced economic development but it has been shown that economy was just one factor affecting a health professional's decision that where to locate his/her practice[31]. Professional, personal, educational and social/lifestyle-related factors can greatly influence job-related decisions; therefore management on workforce is another key element.

If we combine the human resources data with actual TB control practice together, a question on absolute equity or relative equity, which acts the main role in TB human resource, will arise. For instance, Zhe Jiang and Jiang Su province in the better development eastern region both had a minimum human resource per capita per km^2 and a maximum workload but achieved national TB control goals in advance; in contrast, some provinces were equipped with a high level human resources but their work did not sound good[9]. On the other hand, we can find in the practice not only a same TB control effect with a significant difference in human resource but also a different effect with the same level of HWs equipment at different regions. Numbers of previous studies showed that absolute increasing of human resource did not necessarily lead to decline of mal distribution or improving health outcomes[16,21-22,24]. Based on pilot program in part of eastern region of China, a new TB control model, “Hospital, CDC & Community Integrated TB Control” has been promoted by Chinese government nationwide which may improve TB management and minimize the inequity on workforce.

In addition to population size we used alternative measures in calculating Gini index by geographical area and TB workload in this study. Implications for the degree of inequity were different, however depending on which alternative measure was used. Higher inequity in the distribution will therefore became more pronounced by using geographical area measure, hence much relevant information may be left out when population size was used as the only measure variable. Apart from the limitation of the Gini calculate measures, the other limitation in this study was that we didn’t calculate the distributions of education level and academic title of TB HWs across provinces because of limited data. Based on the fifth national census reports[32] we had an assumption that the distributions of education background and professions should be inequity nationwide that eastern region have a higher education level and professions proportion than middle and western regions caused by imbalanced economic development. Finally, we only evaluate the equity of TB HWs rather than estimate the quantity due to the method limitation. A more comprehensive study which includes quantity, quality and equity is needed in the future for an integrate description of TB control human resource.

Other measures of health care needs than population, geography and workload may have to be developed in order to ensure a more meaningful measurement of inequity of health workforce distribution. One way to solve it is to build a systematic indicator including weighted measures to evaluate inequity comprehensively. This requires a multidisciplinary teamwork involving economists, epidemiologists, clinicians, and human resource management specialists and a series of cost-effectiveness analyses.

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