

Original Article

Anesthesia Workforce and Workload in China: A National Survey

Lei Yang^{1*}, Tao Zhu^{1*}, Jia-Jin Li², and Jin Liu¹

ABSTRACT

Background: With the economy growth and medical reform, anaesthesia workforce and workload, as well as for other medical specialties in China changed dramatically, but the detail information have not been presented. A national off-line survey was designed to learn the current status for anaesthesiology, to analyze the related issues for medicine and to make suggestions for government to improve equity and quality of healthcare in China.

Methods: From Mar 1 to Jun 30 in 2015, Chinese Society of Anaesthesiologists (CSA) released questionnaires containing hospital general information, anaesthesia-related information and surgical-related information to all the anaesthesiology departments in mainland China, except Hong Kong, Macao and Taiwan of China. Other relative data sources were searched from publications or website.

Results: A total of 16280 questionnaires were released and 14076 copies (86.5%) were retrieved. There were 13489 copies (82.9%) identified as anaesthesia related data copies (ARDC) and 7026 copies (43.2%) identified as surgical related data copies (SRDC). In 2014, there were 77926 anaesthesiologists and its density was 5.7 per 100,000 population, 27.66 million inside operating room (OR) anaesthesia cases and 11.47 million outside OR anaesthesia cases were done. GDP per capita in each province was positively correlated with densities of physicians, anaesthesiologists and anaesthesia cases. One attending anaesthesiologist covered 634 inside OR and 263 outside OR anaesthesia cases in 2014. In SRDC, attending surgeons to attending anaesthesiologists ratio was 7.5 to 1. Each attending surgeon had 0.93 operation day per week and performed 86 operations in 2014. Generally, the higher-level and larger-sized hospitals had higher surgeons to anaesthesiologists ratio, higher surgeons to ORs ratio, less operation day per week for one surgeon, more operations and anaesthesia cases done by one surgeon and one anaesthesiologist.

Conclusions: China has the biggest number of anaesthesiologists in the world, but is still in shortage of anaesthesiologists. Economic level was positively correlated with anaesthesia workforce and anaesthesia service for all provinces in China. Significant misdistribution and imbalance in different provinces, sized hospitals and medical specialties were found in this survey. A national needs-based resident recruitment system along with the set-up of compulsory standardized resident training system should be taken into consideration and action.

From ¹Department of Anesthesiology, West China Hospital, Sichuan University, Chengdu, China; ²Medical Insurance Office, West China Hospital, Sichuan University, Chengdu, China.

*Lei Yang and Tao Zhu contributed equally to this work.

Correspondence to Dr. Jin Liu at scujinliu@foxmail.com.

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From 2011, China has been classified by the World Bank into the upper middle income countries (1). As fast growth of China's economy over the last two decades, the public demand of health care increased rapidly either (2). In 2014, the density of physicians in China was increased to 14.9 per 10,000 population (3, 4), which was almost close to the average level of upper middle income countries (16.1 per 10,000 population), but was still significantly lower than those in developed countries, such as 28.1 per 10,000 population in the United Kingdom, 24.5 per 10,000 population in the United States and 21.4 per 10,000 population in Republic of Korea (4). Considering the equity of healthcare, the equilibrium of workforce and workload between different economic regions, different level and size hospitals, and different medical specialties should also be paid attention.

Shortages of anaesthesia workforce were reported in some high income countries (5-8) and also in the low and lower middle income countries, which impacts anaesthesia services qualitatively and quantitatively and contributes to unsafe practices (9-11). Chinese Society of Anaesthesiology (CSA) conducted this national off-line survey to learn the current status of anaesthesia workforce and workload in mainland China. The survey will also provide some basic data for making health policy to improve the public health service in China.

METHODS

CSA conducted this national off-line survey from Mar 1, 2015 to Jun 30, 2015. All anaesthesiology departments in mainland China, except those in Hong Kong, Macao and Taiwan of China, were involved. Special investigators from regional societies of anaesthesiology were responsible for releasing and retrieving the questionnaires. The questionnaire was designed by CSA and contained three parts as follows:

1) Hospital general information: hospital name, location and total number of beds in 2014.

2) Anaesthesia-related information: total number of anaesthesiologists who were at work in 2014. Of total anaesthesiologists, number of under age 35, age 36 to 45, age 46 to 60 and over

age 60; number of attending anaesthesiologists, resident anaesthesiologists and anaesthesia nurses in 2014. Number of inside operating room (OR) and outside OR anaesthesia cases in 2012, 2013 and 2014.

3) Surgical-related information: total number of attending surgeons and ORs in 2014. The attending surgeons referred to all who can independently perform operations in OR, including ophthalmologists, otolaryngologists, obstetricians, etc.

International data about income groupings, gross national income per capita and physicians per 10,000 population were obtained from world health statistics (4, 12-14); density of anaesthesiologists per 100,000 population was obtained or calculated from published articles or website statista.com (Table 1) (4, 6, 8, 10, 15-17). Domestic data about population size, GDP per capita and density of physicians per 10,000 population in each province in China were obtained from China Health and Family Planning Statistics Yearbook 2015 (3).

Questionnaires were excluded if general information or total number of anaesthesiologists in 2014 was missing. The remaining copies were identified as anaesthesia related data copies (ARDC). Anaesthesia-related information were obtained from ARDC. Besides, density of anaesthesiologists per 100,000 population, density of anaesthesia cases per 100,000 population, number of anaesthesia cases done by one attending anaesthesiologist were also calculated by using the data in ARDC. In ARDC, the first 1000, 100 and 10 hospitals which had most inside OR anaesthesia cases in 2014 were ranked as the largest 1000, largest 100 and largest 10 hospitals in ARDC.

Correlation scatter diagram were performed between GDP per capita and density of physicians, density of anaesthesiologists and density of anaesthesia cases for all provinces in mainland China by software EXCEL 2010. We considered factors had linear relationship if $P < 0.05$.

The copies missing total number of attending surgeons or ORs were further excluded from above ARDC. The remaining copies were identified as surgical related data copies (SRDC). Surgical-related information was obtained from

SRDC. Besides, attending surgeons to attending anaesthesiologists ratio, number of operation done by one attending surgeon and operation days per week for one attending surgeon were calculated from the data in SRDC. Operation days per week for one attending surgeon was calculated as (number of ORs × 5) / number of attending surgeons. In SRDC, the first 1000, 100 and 10 hospitals which had most inside OR anaesthesia cases in 2014 were ranked as the largest 1000, largest 100 and largest 10 hospitals in SRDC.

RESULTS

A total of 16280 questionnaires were released and 14076 copies (86.5%) were retrieved. There were 13489 copies (82.9%) identified as ARDC and 7026 copies (43.2%) identified as SRDC (Figure 1).

Based on 13489 ARDC, there were 77926 anaesthesiologists including 43653 attendings and 34273 residents in 2014 (Table 2), indicating 5.7 anaesthesiologists per 100,000 population in China. In addition, there were 9147 anaesthesia nurses. Age distribution of anaesthesiologists was shown in figure 2. In 2012, 2013, 2014, China performed 22.37 million, 24.63 million, 27.66 million inside OR anaesthesia cases, respectively and 8.19 million, 9.43 million, 11.47 million outside OR anaesthesia cases, respectively. The largest 10 hospitals in ARDC experienced the highest growth rate of anaesthesia cases (Table 3). Average number of inside and outside OR cases by one attending anaesthesiologist was 634 and 263 in 2014, respectively. Attending anaesthesiologists in larger hospitals covered more anaesthesia cases (Table 2). Anaesthesiologists' workload in all provinces in mainland China, except Hong Kong, Macao and Taiwan of China, was represented as a heat map (Figure 3). The density of physicians per 10,000 population, the density of anaesthesiologists per 100,000 population and the density of anaesthesia cases per 100,000 population were all positively correlated with GDP per capita for all provinces in China (Figure 4).

In 7026 SRDC, there were a total number of 37543 ORs, 27056 attending anaesthesiologists and 201936 attending surgeons. The attending

Table 1. International Data of Economic, Density of Physicians and Anaesthesiologists.

Income groupings*	Nation	Gross national income per capita (US dollars)	Physicians per 10,000 population	Anesthesiologists per 100,000 population#
High income	USA	53960 (4)	24.5 (4)	12.7 (4, 17)
	UK	35760 (3)	28.0 (3)	11.5 (4, 15)
	Korea	33440 (3)	21.0 (3)	9.2 (4, 16)
	France	26380 (12)	33.5 (13)	14.8 (8)
	Israel	25280 (13)	38.2 (13)	10.8 (6)
Upper middle income	Average	13402 (4)	16.1 (4)	NA
	China	11850 (4)	14.9 (4)	5.7
Lower middle income	Bolivia	5750 (14)	4.7 (14)	5.0 (10)
	India	2960 (12)	6.0 (12)	1.1 (10)
Low income	Bangladesh	2030 (14)	3.6 (14)	0.56 (10)
	Tanzania	1750 (14)	0.3 (14)	0.059 (10)

*Income groupings were obtained from World Health Statistics 2015 (4). #density of anaesthesiologists were directly obtained from published articles or calculated by the total anaesthesiologists and total population.

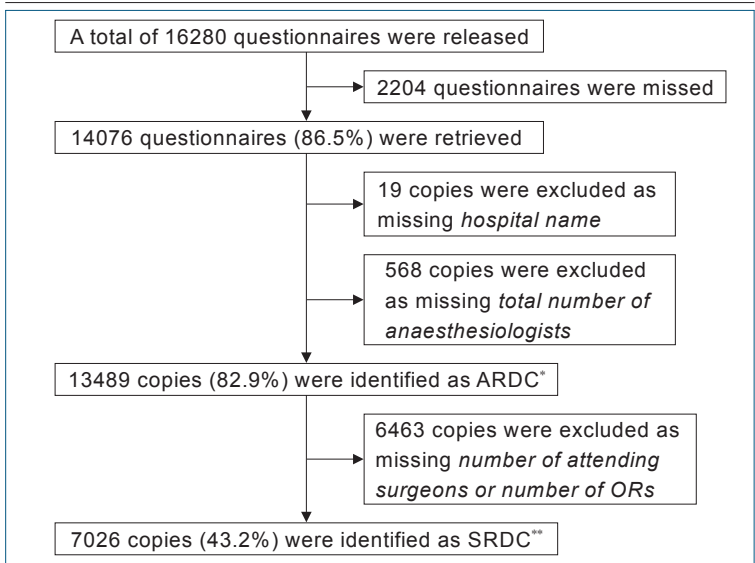


Figure 1. Flow chart.
 *ARDC were presented or calculated as follows: total number of anaesthesiologists, resident anaesthesiologists and attending anaesthesiologists, age distribution of anaesthesiologists, number of anaesthesia cases inside or outside OR, number of anaesthesia cases inside or outside OR done by one attending anaesthesiologist, anaesthesiologists per 100,000 population. **SRDC were presented or calculated as follows: total number of ORs, total number of attending surgeons, total number of attending anaesthesiologists, operation days per week for one attending surgeon, attending surgeons / attending anaesthesiologists ratio, number of operation done by one attending surgeon.

surgeons to attending anaesthesiologists ratio was 7.5 to 1 in these 7026 hospitals. In the largest 1000, largest 100 and largest 10 hospitals in SRDC, the ratio was 8.4 to 1, 8.7 to 1 and 9.8 to

Table 2. Composition and Workload of Anaesthesiologists in China in 2014. (From ARDC, N=13489)

	Total anaesthesiologists	Total attending anaesthesiologists	Total resident anaesthesiologists	Total anaesthesia cases done by one anaesthesiologist	Inside OR anaesthesia cases done by one anaesthesiologist	Outside OR anaesthesia cases done by one anaesthesiologist
National	77926	43653	34273	897	634	263
Largest 1000 in ARDC*	27188	15639	11549	1145	830	315
Largest 100 in ARDC*	6730	3795	2935	1247	902	345
Largest 10 in ARDC*	1299	585	714	1433	1060	373

*Hospitals in ARDC were ranked by number of inside OR anaesthesia cases in 2014.

Table 3. Number of anaesthesia cases from 2012 to 2014 in different hospitals in China. (From ARDC, N=13489)

	Inside OR anaesthesia cases (million)			Outside OR anaesthesia cases (million)		
	2012	2013	2014	2012	2013	2014
National	22.37	24.63 (10.1%)	27.66 (23.6%)	8.19	9.43 (15.1%)	11.47 (40.0%)
Largest 1000 in ARDC*	10.51	11.60 (10.4%)	13.00 (23.7%)	3.50	4.01 (14.6%)	4.92 (40.6%)
Largest 100 in ARDC*	2.67	3.02 (13.1%)	3.42 (28.1%)	0.91	1.04 (14.3%)	1.31 (44.0%)
Largest 10 in ARDC*	0.47	0.55 (17.0%)	0.62 (31.9%)	0.14	0.18 (25.6%)	0.22 (57.1%)

*Hospitals in ARDC were ranked by number of inside OR anaesthesia cases in 2014. (%) was growth percentage of anaesthesia cases compared to 2012.

Table 4. Surgical-related information. (From SRDC, N=7026)

	Total ORs	Total attending surgeons	Total attending anaesthesiologists	Total cases inside OR (million)	Operation days per week for one attending surgeon [†]	attending surgeons/ attending anaesthesiologists	Operation/ one attending surgeon
National	37543	201936	27056	17.34	0.93	7.5 : 1	86
Largest 1000 in SRDC*	15255	111117	13177	10.69	0.69	8.4 : 1	96
Largest 100 in SRDC*	3976	31004	3569	3.12	0.64	8.7 : 1	101
Largest 10 in SRDC*	608	5221	533	0.55	0.58	9.8 : 1	106

*Hospitals in SRDC were ranked by number of inside OR anaesthesia cases in 2014. [†]Operation days per week for one attending surgeon = number of ORs × 5 / number of attending surgeons.

1, respectively. Each attending surgeon had 0.93 operation day in each week and performed 86 operations in 2014. But one attending surgeon in the largest 10 hospitals in SRDC had less operation days per week as 0.58, but performed more operations as 106 in 2014 (Table 4).

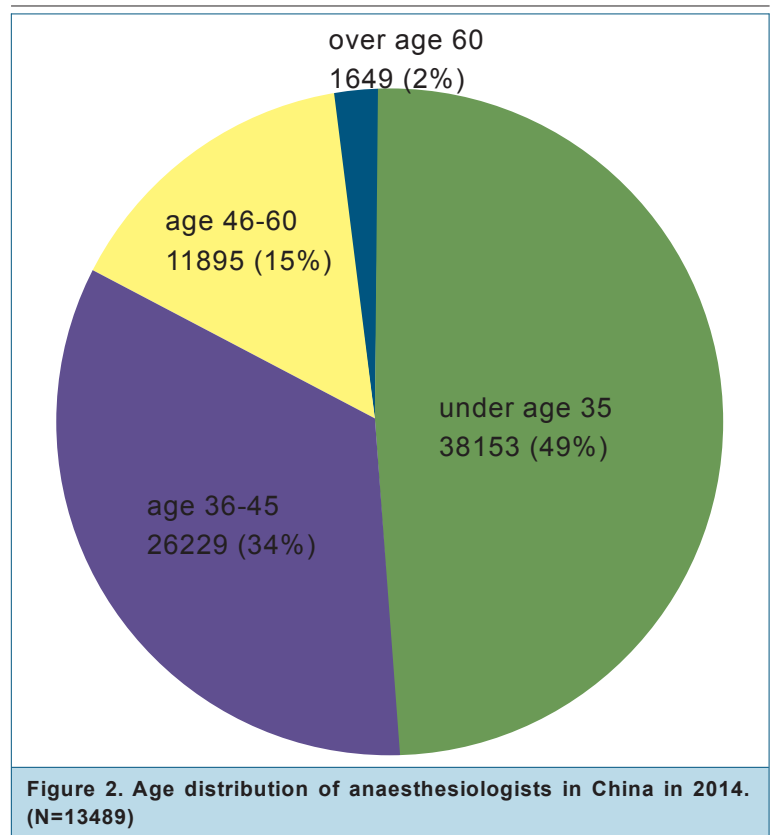
DISCUSSION

Economic level is one of the most important factors for national health-care workforce and service distribution. China has been ranked as an upper middle income country by the World Bank since 2011. With the economy growth,

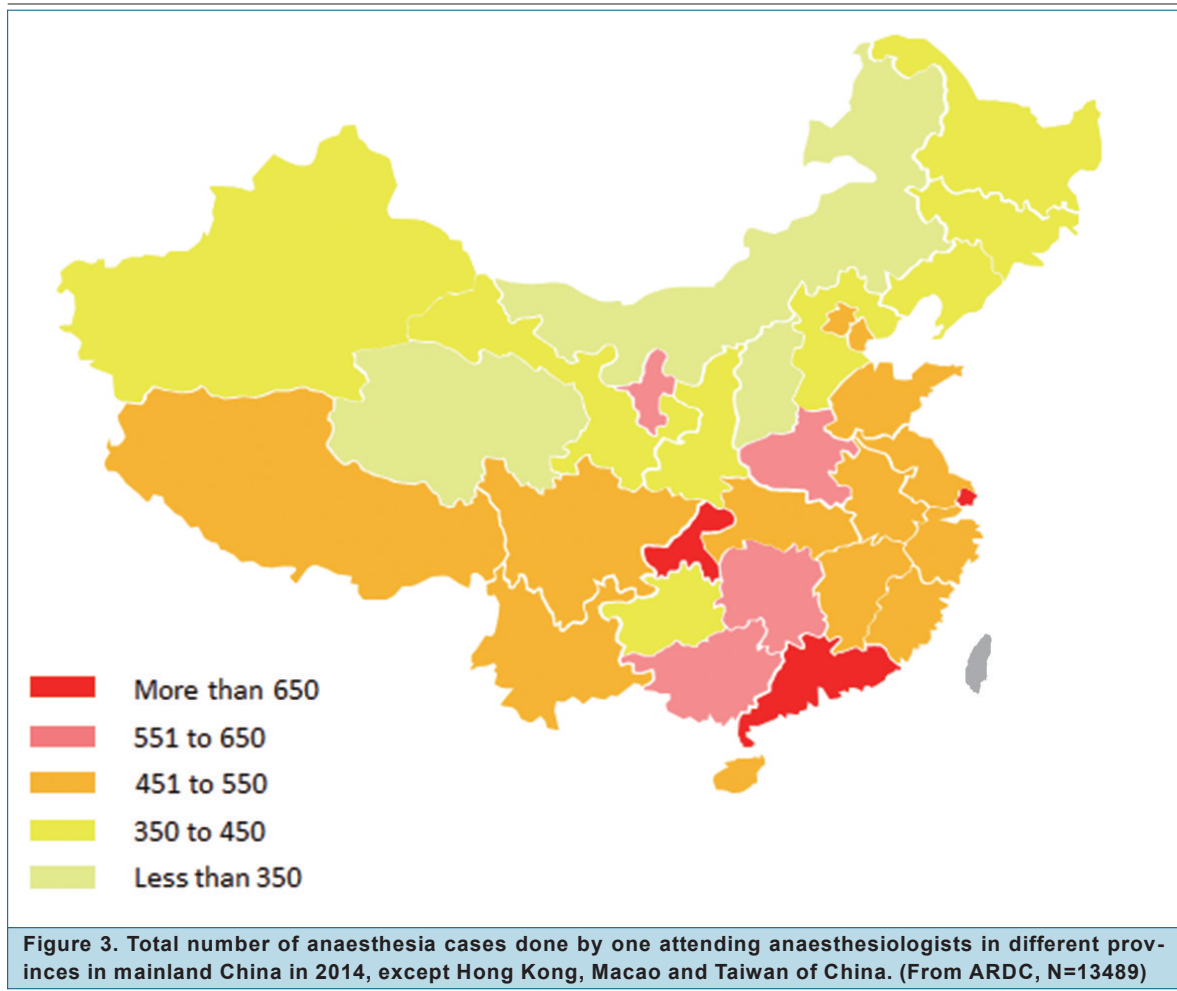
China's health workforce (including anaesthesiologist) has been expanded (Figure 2). From 2012 to 2014, the GDP per capita in China increased about 18.0% and the density of physicians increased about 9.3% (3). The slower growth in density of physicians than in economy may explain why China's density of total physicians (14.9 per 10,000) is close to, but still lower than the average level (16.1 per 10,000) of upper middle income countries in the world. The global density of anaesthesiologists, obstetricians and surgeons was reported significantly correlated with the country's economic level (10). This survey found that the density of anaesthesiologists

in China was 5.7 per 100,000 population in 2014, higher than those in lower middle income and low income countries, but much lower than those in high income countries, such as France (14.8), USA (12.7), UK (11.5), Israel (10.8) and Korea (9.2, Table 1). Economy influence on the distribution of health-care workforce and service was also found within China. GDP per capita in different provinces is positively correlated with the densities of physicians, anaesthesiologists and anaesthesia cases. The differences in the densities of physicians (highest in Beijing as 35.0/10,000 population vs. lowest in Tibet as 12.5/10,000 population) and anaesthesiologists (highest in Beijing as 12.6/100,000 population vs. lowest in Tibet as 2.9/100,000 population), as well as anaesthesia cases (highest in Beijing as 5788/100,000 population vs. lowest in Shanxi 1393/100,000 population) between different provinces varied by factors of 2.8 or higher, revealing severe unjust distribution of medical resources and anaesthesia service in China. Low density of health workers was associated with low medical coverage and high medical mortality in the world (18). Such huge un-equity distributions, consistent with previously reported for China (19), strongly suggested that China's central government should take some action to achieve fairness in health-care workforce and service distribution for the people living in different areas, but within the same country. Indeed, the health-care reform pushed by the National Health and Family Planning Commission will help China to improve such within-country equity (18).

Workload disparity of anaesthesiologists and surgeons among different sized hospitals in China was found in this survey. Anaesthesia workload among different provinces varied by a factor of 2.2 (Figure 3). In higher-level and larger-size hospitals, both inside and outside OR anaesthesia cases increased faster from 2012 to 2014, one attending anaesthesiologist did more anaesthesia cases and one attending surgeon operated on more patients a year (Table 2-4). These findings indicated that patients in China were more intended to visit doctors in larger hospitals, which led to the doctors' higher workload. Taken anaesthesiologists as an example, one attending in largest 10 hospitals in ARDC did 1433 an-



aesthesia cases in 2014 (1060 inside OR plus 373 outside OR), which was 67% more inside OR anaesthesia cases and 42% more outside OR anaesthesia cases than the national average level (Table 2). Chinese patients and the public trust in physicians in larger hospitals, rather than smaller hospitals, even for common and frequently-occurring diseases. This may be mainly due to the absent of nationwide standardised resident training (SRT) and hierarchical medical system in China's history. Training and quality of doctors in China is highly variable. As we found in this survey, 11549 of 34273 anaesthesia residents (only 33.7%, Table 2) were taking clinical training in the largest 1000 hospitals, the other 2/3 anaesthesia residents were doing their residency in smaller-size and lower-level hospitals. Actually, same situation exists for all other medical specialties in China. Right after medical school, most medical graduates were permanently employed by lower-level and smaller-size hospitals, such as township, county or small prefectural hospitals, and worked in the same hospital for entire career life in a way similar to civil servants. Even though called as residents in the



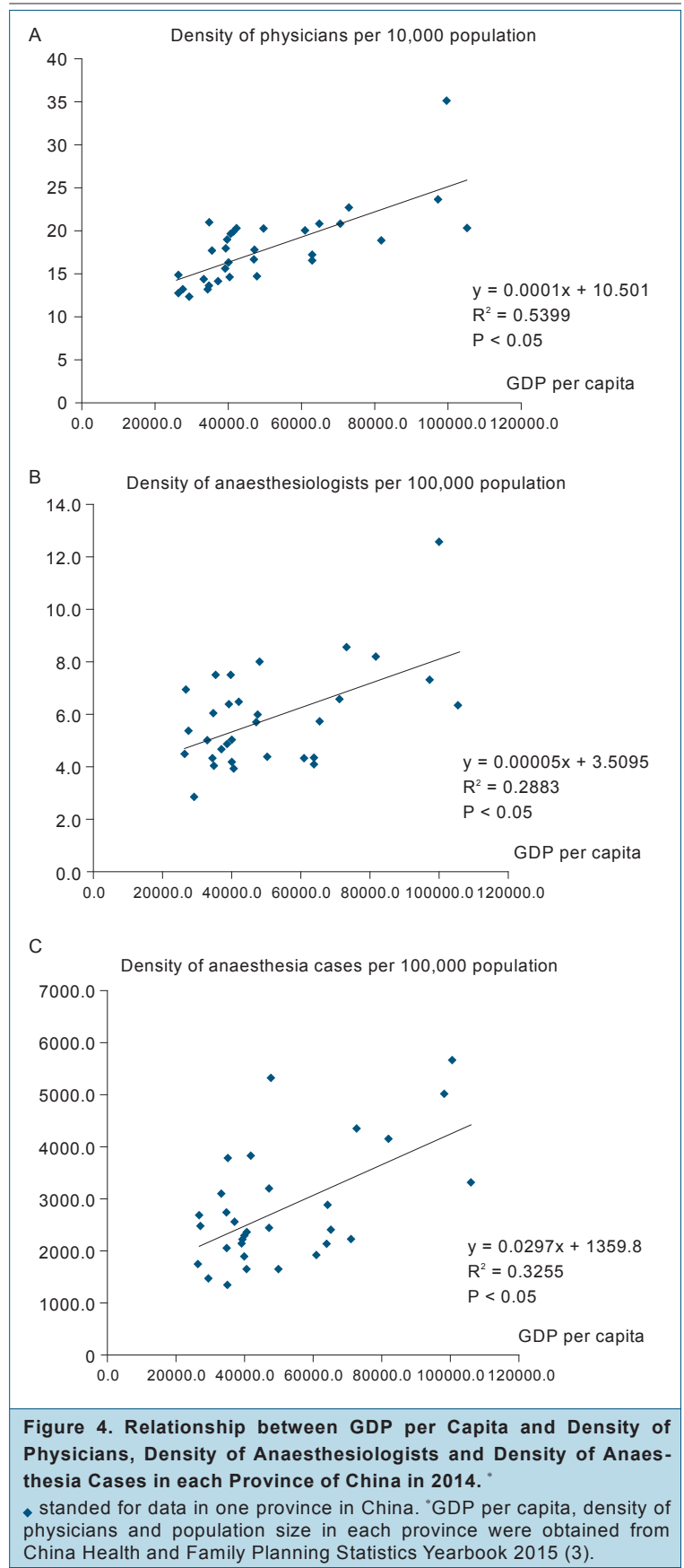
first 5 years, they were not well trained during their residency in those hospitals to have necessary medical knowledge, clinical skills, ethical and humanistic professional competencies. Therefore, they are not able to provide same quality medical care for common and frequently-occurring diseases and to have patients' or public trust as who worked in higher-level and larger-size hospitals. Besides, health referral system was also weak in China, patients seeking high-quality primary health-care flooded directly into large hospitals, resulting much heavier workload for the physicians there.

Medical reform and education transformation in China have been aimed to meet the needs from Chinese people (20, 21). One of priorities in China's medical reform is to establish a nationwide SRT system. At the end of 2013, seven ministries of the central government jointly launched the SRT for all medical specialties in-

cluding family medicine as a national strategy (22, 23). This SRT started in 2015 and will become compulsory by 2020. To produce competent doctors, all medical graduates are required to be trained in one of medical specialties including family medicine for three years in qualified training bases, most of which are large prefectural, provincial, and national hospitals. Nowadays, 559 training bases have been accredited across China by Chinese Medical Doctor Association and accredited bases will be expanded to about 1000, mainly match with the largest 1000 hospitals in ARDC in this survey. Since almost all residents will be trained in these largest 1000 hospitals, faculty size should have to keep the pace for resident growth in future. Considering more teaching, more complex and difficult cases, and more academic research conducted by attending faculties in training bases, the largest 1000 hospitals in ARDC should strengthen their

faculties (number and quality) rapidly during the establishment phase of SRT from 2015 to 2020. The attending to resident ratio in the largest 1000 hospitals should reach 2-3 to 1, rather than 1.35 to 1 (15639 to 11549) for anaesthesiology in the largest 1000 hospitals found in ARDC of this survey. Standardised training during residency is fundamental for standardised practice for a physician at any level and sized hospital, and standardise practice is essential prerequisite and foundation for hierarchical medical system. Only when health-care provided for common and frequently- occurring diseases in primary hospitals were similar as larger hospitals, hierarchical medical system could be promoted and accepted well by patients and public. Another challenge that China has to overcome is to find a sustainable way in the near future to motivate these better-trained doctors to work at the grassroots level hospitals in rural and remote areas, and to reduce the brain drain from undeveloped regions.

To assess a nation's physician supply should not only assess the overall density of physicians, but also the infrastructure and distribution among different specialties. Disparity between surgeons and anaesthesiologists in China was found from this survey. Anaesthesiologists' shortage and surgeons' surplus were severer in higher-level and larger-size hospitals. According to a recent survey from 167 countries (including China) representing 92% of the global population, there were 1,112,727 surgeons, 483,357 obstetricians, and 550,134 anaesthesiologists (24). The ratio of surgeons plus obstetricians to anaesthesiologists was 2.9 to 1. Compared with this global ratio, China had a much higher ratio as 7.5 to 1 in 2014 (Table 4). In China, the larger the hospital was, the larger the ratio was. Attending surgeons to attending anaesthesiologists ratio in the largest 10 hospitals in SRDC was almost 10 to 1. Such relative surplus of surgeons was mirrored by that one attending surgeon in China had less than 1 operation day per week and performed only 86 operations in 2014. Again, the larger the hospital was, the less the operation days per week for one attending surgeon. In the largest 1000, 100 or 10 hospitals in SRDC, one attending surgeon had only 0.69, 0.64 or 0.58 operation days per week, respec-



tively. The disparity of surgeons to anaesthesiologists ratio restricts multidisciplinary teamwork for surgical operations.

Actually, severe misdistribution does not exist only between surgeons and anaesthesiologists, but also exists in other specialties in China, such as family doctors, paediatricians and psychiatrists (25-28). Historically, China did not have a national needs-based resident recruitment system to keep a reasonable balance between different specialties. Except for personal willingness, due to unequal working condition, unbalanced payment and uneven social recognition, the number of medical graduates to apply residency in different specialties varies considerably. Adding to the lack of needs-based resident recruitment system, the current phenomena for application and recruitment in different specialties in China could be described as "more applied, more recruited, less applied, less recruited". In some places, even "no applied, no recruited" for paediatricians occurred (29). Since SRT will become compulsory, the preexisting imbalance between different specialties is possible to be exacerbated without a paralleling establishment of needs-based resident recruitment system. China's government is very strong and will be the leverage point for solving these problems. Set-up phase of compulsory SRT from 2015 to 2020 will be a good opportunity for government to set up a national needs-based resident recruitment system for optimizing residents allocation today and health-care workforce allocation in the future. The infrastructure of this system should include continued data collection and comprehensive assessment about the current shortage and surplus for all medical specialties, dynamic healthcare needs and demand-

based analyses and projection of the future medical service needs and supply (30), allowing medical graduates to do multiple applications for different specialties, an effective recruitment match system for different economical regions, sized hospitals and medical specialties. China, the most populous country with about 20% of doctors in the world (27), recently completed a rapid transition from a low income country to an upper middle income country. China's experiences in medical reform, lessons on maldistribution and imbalance of healthcare workforce and workload should be, to some degree, valuable references for other developing countries those are making the transition from low or lower middle income countries to lower middle or upper middle income countries.

This was the first time to collect national data in mainland China, so we cannot compare the current situation to the past situation. We therefore cannot accurately describe the development condition of anesthesia workforce in mainland China in recent years.

In summary, mainland China had at least 77926 anaesthesiologists who covered 39.13 million anaesthesia cases in 2014. China has the biggest number of anaesthesiologists in the world, but is still in shortage of anaesthesia workforce. Significant maldistribution and imbalance in different provinces, sized hospitals and medical specialties were found in mainland China from this survey. We strongly suggest China's government to establish a nationwide needs-based resident recruitment system along with the set-up of compulsory SRT system.

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