

ORIGINAL RESEARCH

Does the insufficient supply of physicians worsen their urban-rural distribution? A Hiroshima-Nagasaki comparison

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ABSTRACT

Introduction: Studies have suggested that a rapid increase in physicians does not necessarily change an urban-rural inequity in their distribution. However, it is unknown whether an insufficient supply of physicians worsens an inequity. Spatial competition and attraction-repulsion hypotheses were applied to the geographic distribution of physicians during a time of insufficient physician supply in Japan.

Methods: Trends of physician distribution as well as urban-rural physician flow were compared using Hiroshima Prefecture which had the lowest increase in physician-to-population ratios between 2002 and 2008 (2.7%), and Nagasaki Prefecture where the increase was one of the highest (12.0%) among the 47 Japanese prefectures.

Results: The Gini coefficient of physicians compared with population in Hiroshima increased by 4.1%. Movement toward inequity was greater in Hiroshima compared with Nagasaki where the increase was 2.5%. Approximately 245 physicians or 18.8% moved



from rural to urban locations in Hiroshima compared with 143 (14.6%) for Nagasaki ($p=0.01$). In contrast, 228 (7.6%) urban physicians moved to rural areas in Hiroshima compared with 175 (11.6%) in Nagasaki ($p<0.001$).

Conclusions: In a time of insufficient supply of physicians, a region with a smaller increase in physicians may experience worsening of the urban–rural distribution of physicians compared with a region where there is a more rapid increase in physicians. One strategy for achieving a more equitable distribution of physicians is to increase in the physician supply relative to demand in order to stimulate competition among urban physicians and maintain the power equilibrium between attraction-to and repulsion-from urban areas.

Key words: geography, Japan, manpower, medically underserved area, physicians, rural health, supply and distribution.

Introduction

Maldistribution of physicians is an issue of concern worldwide¹, and in Japan many political interventions have been applied^{2,3}. For example, between 2007 and 2011 the Japanese government increased the number of medical school entrants by 17% (from 7625 to 8923)⁴.

Physicians gravitate toward urban locations, especially when they and their spouse are born, raised, and educated in cities^{5,6}. The training location effect is often urban, and more physicians enter specialties that require the advanced technologies of large hospitals^{7,8}. Physicians who wish to give their children a high quality education likewise tend to live in urban areas⁹. All of these factors combine to 'pull' physicians to serve in urban areas to the detriment of rural locations.

At the same time, there is also a market-derived force that 'pushes' physicians out of urban areas. Physicians are impacted by the maximization of profit and an increase in physician density will increase competition for profit in urban areas. This can move physicians towards service in rural areas with the result of improved equity of physician distribution (the spatial competition effect: Fig1)¹⁰⁻¹³. The effect of market-derived repulsion is particularly visible in countries such as Japan where there is no regulation (eg regional caps of physicians) on physicians' choice of practice location.

It is thus hypothesised that an urban–rural distribution of physicians is determined by a power balance between attraction and repulsion. However, past studies have not succeeded in showing the repulsion effect of the implementation of policies aimed to increase the supply of physicians^{12,14-16}. For example, between 1980 and 1990 Japan experienced a 30% increase in the number of physicians per unit population, but the equity of their distribution between urban and rural areas did not improve^{12,14,16}. These statistics, however, do not deny the possibility that competition-based repulsion was influential in that period. Increasing overall demand for physician services can work against the rural distribution of physicians. The period 1980–1990 was a time of increasing physician demand as a result of economic expansion, demographic changes and the implementation of new technologies and services. If the increase in the supply of physicians matched the increase in demand, the two-force equilibrium would be unchanged and the equity of distribution would be constant. However, with physician supply falling behind increasing demand, the equity of physician distribution would worsen.

The attraction–repulsion balance, and the expected effect of an insufficient supply of physicians, may be shown by a comparison between two regions with different rates of physician increase. In a region with a lower rate of physician increase, the spatial competition among physicians in urban communities would be weaker, and repulsion would be less dominant. This would lead to a greater movement of physicians from rural to urban communities, and a more skewed overall distribution to urban areas.



Total Population 555,000	Community A 500,000		Community B 50,000		Community C 5,000		Equity
Physicians	Physicians	PPP*	Physicians	PPP*	Physicians	PPP*	
5	5	100,000	0		0		
11	10	50,000	1	50,000	0		
22	20	25,000	2	25,000	0		
111	100	5,000	10	5,000	1	5,000	

* PPP: population per physician

Figure 1: Simplified model of spatial competition.

Note: Assuming that physicians rationally choose their practice location so that they can maximize client numbers, the first nine physicians who entered this three-community market chose Community A. The tenth or eleventh physician chose Community B where the physician can expect a larger patient load. Community C obtains its first physician when the overall number of physicians reaches 109–111, with the result that physician-to-population ratios among all communities reach the most equitable status^{10,12,13}.

Japan is well suited to testing this hypothesis because physicians can freely choose their practice locations, unlike those in some European countries. Although the entire population is covered by public health insurance, most medical institutions operate on a for-profit basis¹⁷. In Japan, unlike countries such as the USA, only physicians can be the employers at medical institutions, as is prescribed in the *Medical Service Act of 1948* (revised 2011). These conditions are necessary for the creation of market-based repulsion. In addition, in 2004 a new regional variation emerged in the rate of increase of physicians among Japanese prefectures as the result of a new government postgraduate clinical training scheme^{18,19}. This intervention produced the conditions for a natural experiment by allowing observations of physician increases and their impacts on the urban–rural flow of physicians.

This study compared trends in physician distribution and the urban–rural flow of physicians between Hiroshima Prefecture, which has the lowest rate of increase in the number of physicians in Japan, and Nagasaki Prefecture, which has the highest. The aim was to show that an insufficient supply of physicians breaks the two-force equilibrium of attraction and repulsion and exacerbates an uneven urban–rural distribution of physicians.

Methods

Physician data were derived from the *Physician Census* compiled by the Ministry of Health, Labour and Welfare in 2002, 2004, 2006, and 2008 (with the permission of The Ministry to use the data for research purposes). In Japan, all those who hold a physician license are obliged to register for the census. For the purposes of the study, among all registered license holders, only those whose main employment was recorded as 'practice' in 'clinics' or 'hospitals' (including university hospitals) were recognised as 'physicians'. In short, all medical doctors in clinical institutions in Hiroshima and Nagasaki Prefectures were included in this study.

Population data were derived from 'Population and Population Dynamics Based on a National Census: National Basic Resident Register 2002-2008'²⁰. Japan has three levels of government: municipal, prefectural and national. Data on municipal-level (city, town and village) populations in Hiroshima and Nagasaki prefectures were extracted from the whole data.



In Japan, the annual production of physicians has been almost constant (approximately 7700). The increase in the number of physicians per 100 000 population (physician-to-population ratio) during the study period in Hiroshima was the lowest among all 47 of Japan's prefectures. It is noteworthy that Hiroshima's physician-to-population ratio decreased for the first time between 2004 and 2006²¹. Among the five prefectures with the highest rate of physician increase, Okinawa, Saitama, Chiba, and Ibaraki were excluded, either because of their isolation from the mainland or because of their proximity to Tokyo, leaving Nagasaki as the control for Hiroshima²¹. Neither Hiroshima nor Nagasaki is adjacent to metropolitan areas such as Tokyo and Osaka. In 2010, Hiroshima's population was 2 861 000 (12th among the 47 prefectures) and that of Nagasaki was 1 427 000 (27th)²². In 2008, the average annual income per person in Hiroshima was 2,834,000 yen (14th) and that in Nagasaki was 2,157,000 yen (44th)²³.

The Gini coefficient was calculated for each prefecture based on the number of physicians and the population size. All municipalities were ranked according to physician-to-population ratio, and the cumulative proportion of physicians and population in each municipality was plotted in a plane of coordinates. The plotted line is the Lorenz curve, and the Gini coefficient is the area between the Lorenz curve and the 45° line, divided by the triangle under the 45° line. The Gini coefficient varies between 0 (complete equity) and 1 (complete inequity) according to the degree of variation in physician-to-population ratio^{12,14,24}.

All municipalities were then categorised as urban or rural and the flow of physicians between urban and rural areas was examined for each prefecture. Municipalities with a population greater than 200 000 or a population density of more than 4000 per km² were defined as urban, and the others were defined rural. Among the 23 municipalities in Hiroshima prefecture, Hiroshima, Fukuyama and Kure cities, as well as Fuchu and Kaita towns were considered urban. Of the 23 municipalities in Nagasaki prefecture, Nagasaki and Sasebo cities were considered urban. Because many municipalities in both prefectures were merged during the study period, the geographic border of municipalities in 2008 was accepted as representative of earlier years.

Next a cohort of physicians (identified by their unique registration number) who worked in the same prefecture in 2002 and 2008 was created and the result was 4288 in Hiroshima, and 2483 in Nagasaki. Cross-table analysis was conducted comparing the numbers of physicians classified according to rural/urban and 2002/2008 categories in each prefecture. Differences in average career length, cross-tabulated by place and year, were also examined. A similar cross-table comparison was performed using the data of a cohort of young physicians with no more than 5 years career experience (who were registered in the 2008 census but not in 2002). The size of the young physician cohort was 802 in Hiroshima and 486 in Nagasaki.

Statistical analyses were performed using SPSS for Windows v18.0 (www.spss.com). In the cross-table analysis, the proportion of the number of physicians in each cell was compared between Hiroshima and Nagasaki using the χ^2 test. The average career length was compared using a two-sample *t*-test. *P*-values of less than 0.05 were considered statistically significant.

This study was approved by the Ethics Committee of Epidemiological Studies, Hiroshima University in 2010 (#Epidemiology-332).

Results

Physicians, population and Gini coefficients are shown (Table 1). The physician-to-population ratio was larger in Nagasaki than in Hiroshima. The increase of physician-to-population ratio in Nagasaki between 2002 and 2008 (12.0%) was greater than that in Hiroshima (2.7%). The increase of physician-to-population ratio in urban Nagasaki (10.9%) was greater than that in urban Hiroshima (2.6%). The increase in rural Nagasaki (12.9%) was greater than that in rural Hiroshima (2.4%). During the period, the Gini coefficient in Hiroshima Prefecture increased toward greater inequity (from 0 toward 1) by 4.1% while the increase for Nagasaki was 2.5%. This indicates that the geographic equity of physicians has worsened in Hiroshima compared with that observed for Nagasaki.

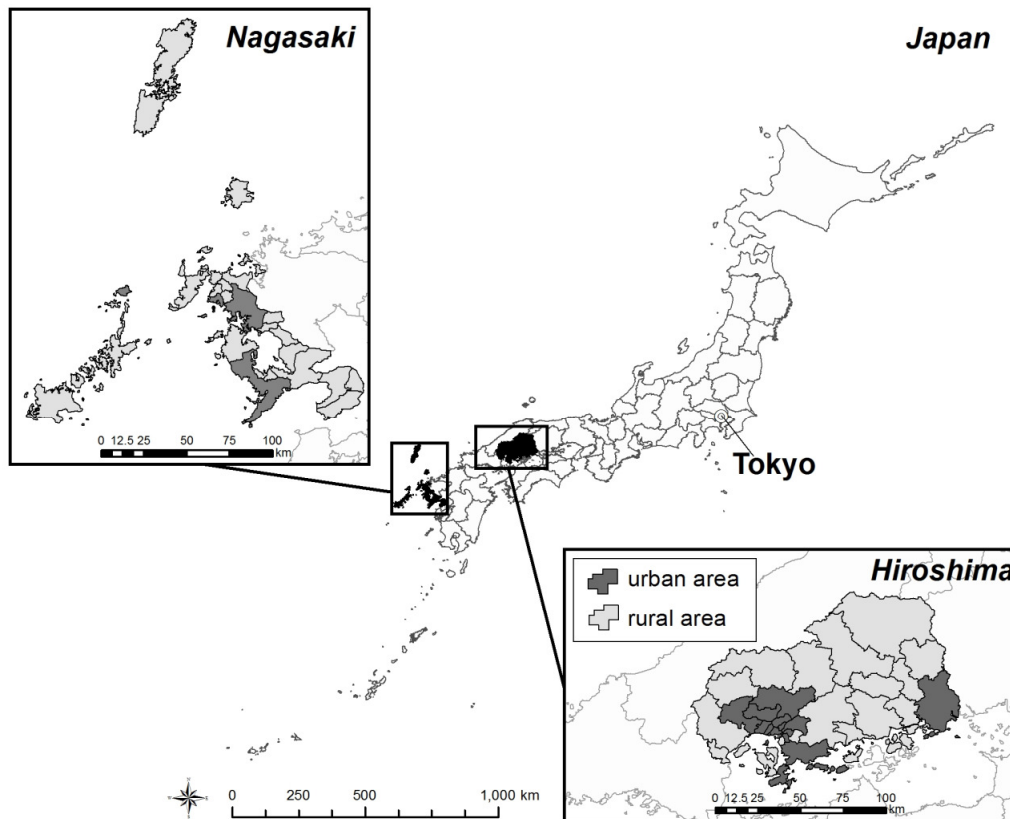


Figure 2: Map of Hiroshima and Nagasaki Prefectures, Japan

Flows of physicians between urban and rural areas for each prefecture are shown (Table 2). In Hiroshima, 18.8% of rural physicians moved to urban areas, while the proportion was 14.6% in Nagasaki ($p=0.01$). In contrast, 7.6% of urban physicians moved to rural areas in Hiroshima, compared with 11.6% in Nagasaki ($p<0.001$). The net flow of physicians was from rural to urban in Hiroshima (17 physicians). The reverse was true for Nagasaki where net flow was 32 physicians from urban to rural areas.

The average career length of physicians moving from urban to rural areas was longer than that of physicians moving in the opposite direction in Hiroshima although this did not reach statistical significance (19.1 [standard deviation 10.3] vs 17.6 [8.8] years; $p=0.067$). The career length for Nagasaki was not significantly different (17.9 [10.1] vs 18.7 [9.8] years;

$p=0.442$). Of the young physicians with no more than 5 years career experience, 18.3% worked in rural areas in 2008, which was 34% less than the proportion of physicians of all ages (27.7%) in Hiroshima. In Nagasaki, 30.2% of the early-career physicians worked in rural areas, which was 22% less than that of all physicians (38.8%).

Discussion

In Hiroshima Prefecture, which had a smaller increase in physicians, the equity of geographic distribution of physicians deteriorated, the flow of physicians from rural to urban areas was more pronounced, and the career length of physicians going from rural to urban areas tended to be shorter than in Nagasaki Prefecture where the physician increase was more rapid.



Table 1: Transition of population, number of physicians and Gini coefficient

Prefecture	Item	Year				2002–2008 Change %
		2002	2004	2006	2008	
Hiroshima	Population	2 869 011	2 869 555	2 870 907	2 864 167	-0.2
	Urban	1 921 316	1 927 444	1 936 287	1 940 959	1.0
	Rural	947 695	942 111	934 620	923 208	-2.6
	Physicians	6074	6163	6121	6226	2.5
	Urban	4346	4379	4364	4503	3.6
	Rural	1728	1784	1757	1723	-0.3
	Physicians/ 100 000 pop.	212	215	213	217	2.7
	Urban	226	227	225	232	2.6
	Rural	182	189	188	187	2.4
Gini coefficient	0.272	0.278	0.279	0.283	4.1	
Nagasaki	Population	1 522 140	1 511 064	1 494 879	1 469 197	-3.5
	Urban	724 030	723 319	715 558	705 704	-2.5
	Rural	798 110	787 745	779 321	763 493	-4.3
	Physicians	3342	3515	3563	3612	8.1
	Urban	2046	2155	2181	2212	8.1
	Rural	1296	1360	1382	1400	8.0
	Physicians/ 100 000 pop.	220	233	238	246	12.0
	Urban	283	298	305	313	10.9
	Rural	162	173	177	183	12.9
Gini coefficient	0.210	0.212	0.214	0.215	2.5	

Pop. Population.

Table 2: Flow of physicians between urban and rural areas

Year	Location	2008 n (%)					
		Hiroshima			Nagasaki		
		Rural	Urban	Total	Rural	Urban	Total
2002	Rural	1061 (81.2)	245 (18.8)**	1306 (100)	836 (85.4)	143 (14.6)**	979 (100)
	Urban	228 (7.6)***	2754 (92.4)	2982 (100)	175 (11.6)***	1329 (88.4)	1504 (100)

P-values for difference: **0.01 ***<0.001.

The attraction–repulsion hypothesis predicts that regions with smaller increases in physicians will have less spatial competition in urban areas, and thus repulsion would be less dominant in the attraction–repulsion equilibrium compared with regions of larger increases. The net flow of physicians from rural to urban areas in such regions would be more obvious. The results of this study support this prediction. Flow from rural to urban areas in Hiroshima was 1.3 times larger than that in Nagasaki, and the flow in the opposite direction in Hiroshima was 0.7 times that of Nagasaki. The

inequity of physician distribution deteriorated in Hiroshima compared with Nagasaki.

The attraction–repulsion hypothesis also predicts that physicians who move from urban to rural areas tend to be younger than those who move from rural to urban areas. This can be explained in terms of barriers to entry into job markets²⁵. New physicians in locations where the job market is saturated have difficulty finding employment. In addition, a longer career may add value in attributes such as experience, board certifications, or advanced degrees. Repulsion from



urban areas, therefore, would affect younger physicians more strongly than older physicians. Attraction to urban areas would affect physicians of all ages.

In a region with an adequate supply of physicians, younger physicians would be more likely to move from urban to rural areas. A greater number of new physicians who have just entered the job market would start their careers in rural areas, but this would not be true in a region with an insufficient physician supply. This was supported by the results of the present study. In Nagasaki, physicians who moved from urban to rural areas were younger than those who moved in the opposite direction in the same prefecture, and younger than those who moved in the same direction in Hiroshima. A higher proportion of new physicians started their careers in rural areas in Nagasaki compared with Hiroshima.

Despite a rapid increase in physicians in Japan since 1980, the equity of physician distribution has not improved^{12,14,16,19,26}. This seems to contradict the attraction–repulsion hypothesis. The findings of this study, however, suggest that even with attempts to increase the supply of physicians dramatically, the rate at which physicians have graduated since 1980 did not exceed the increase in demand. Based on the two-force hypothesis, if the supply exceeded the demand, the urban–rural distribution of physicians would have improved, just as an insufficient supply would have worsened the distribution, as was shown in this study.

Limitations

Because the findings are embedded in Japan's unique healthcare system, they should be applied to the healthcare systems of other countries only with the greatest caution. Japan's entire population is covered by social health insurance. The fee for each health service is strictly regulated by the government and is uniform throughout the country. In this sense the Japanese health system is different from that of the free market. However, patients can choose the medical institution for their health care. Physicians, too, can choose their practice locations without any legal or economic

regulations. Most of the medical institutions in Japan are private and operated for profit. It is expected, therefore, that the spatial competition shown in Figure 1 would reasonably affect the geographic distribution of physicians in Japan.

The Japanese situation can be contrasted with that of countries such as the UK where the both patients' and physicians' choices are much more regulated. Patients are limited to the medical institutions with which they are registered, and there is a regional cap on the number of physicians in each area that would increase repulsion. Not surprisingly the geographic distribution of GPs per population in the UK is twice as equitable as that of primary care physicians in Japan²⁴. Even so, an insufficient supply relative to demand in such nations could still result in physician movement from rural to urban areas.

The study areas were only two of Japan's 47 prefectures and there is no indication that the movement pattern of physicians in these two prefectures can be generalized to the other prefectures. The results could be due to policies, geography and culture unique to Hiroshima and Nagasaki. The influence of geography may also be a consideration, because Nagasaki's rural areas include more isolated islands and less mountainous areas than the rural areas of Hiroshima.

The definition of 'rural' has always been an issue in physicians distribution studies²⁷, and changing the rural definition may change the urban–rural flow. However, use of the Gini coefficient of physician-to-population ratio is not limited by an arbitrary rural definition.

Finally, the cohort of physicians created to measure urban–rural flow in this study did not account for physicians who relocated to or from other prefectures and so the movements of these physicians are unknown.

Conclusion

To achieve a fair distribution of physicians across locations, the production of physicians needs to keep pace with an



increase in demand for their services. A rapid increase of physicians, however, incurs a substantial social cost and is not feasible in countries with struggling or stagnant economies (this includes Japan, among many other nations). Interventions that strengthen 'repulsion' can improve the cost-effectiveness of physician expansion. For example, regulations that set an upper limit or cap on the number of physicians in each area would lead to a more equitable distribution of physicians²⁴. Such an intervention has never been attempted in Japan. In terms of weakening urban attraction, increasing the number of rural-origin students admitted to medical schools would be an effective strategy⁶. Changes to Japan's health insurance design that increase remuneration to rural medical facilities are likely to positively influence distribution. However, improved equity in the physician distribution in Japan is unlikely without attention to a number of these important strategies.

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