J Med Dent Sci 2016; 63: 9−18

Original Article

Relationship between regional population and healthcare delivery in Japan

Takeo Niga[1)], Maiko Mori[2)] and Kazuo Kawahara[1)]

1) Department of Health Care Management and Planning, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University
2) School of Nursing and Health Studies, Georgetown University

In order to address regional inequality in healthcare delivery in Japan, healthcare districts were established in 1985. However, regional healthcare delivery has now become a national issue because of population migration and the aging population. In this study, the state of healthcare delivery at the district level is examined by analyzing population, the number of physicians, and the number of hospital beds. The results indicate a continuing disparity in healthcare delivery among districts. We find that the rate of change in population has a strong positive correlation with that in the number of physicians and a weak positive correlation with that in the number of hospital beds. In addition, principal component analysis is performed on three variables: the rate of change in population, the number of physicians per capita, and the number of hospital beds per capita. This analysis suggests that the two principal components contribute 90.1% of the information. The first principal component is thought to show the effect of the regulations on hospital beds. The second principal component is thought to show the capacity to recruit physicians. This study indicates that an adjustment to the regulations on hospital beds as well as physician allocation by public funds may be key to resolving the impending issue of regionally disproportionate healthcare delivery.

Corresponding Author: Takeo Niga, MMA
Department of Health Care Management and Planning, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo-ku, Tokyo 113-8510, Japan
Tel: +81-3-5803-4031 Fax: +81-3-5803-0358
E-mail: nigahcm@tmd.ac.jp, niga-takeo@umin.ac.jp
Received June 10; Accepted December 24, 2015

Key Words: Facility regulation and control, Health facility planning, Healthcare disparities, Principal component analysis, Public policy

Introduction

Since the 1950s in Japan, the population has increased and the economy has grown, and there has been a push to establish medical facilities and recruit medical practitioners in order to provide healthcare across the country. As a result, in the 1980s, a nationwide supply of hospital beds was almost obtained. However, because of the uneven disparity in bed distribution among regional areas, the government implemented policies under which prefectures could establish healthcare districts, created medical care plans for each district, and aimed to make the number of hospital beds close to the standard number in each district in 1985. The standard number of hospital beds in each district was calculated according to a nationally used algorithm. Specifically, the calculation was derived from four data sources: (i) population by sex and age group, (ii) the rate of hospital patients by sex and age group, (iii) the number of inflow hospital patients from other districts and outflow hospital inpatients to other districts, and (iv) the rate of bed occupation in the district. In healthcare districts that had more hospital beds than the standard number, it became difficult to establish new hospitals or to increase the number of hospital beds. Consequently, this policy was commonly called the regulations on hospital beds. However, there was no policy to increase hospital beds in those healthcare districts that had fewer hospital beds than the standard number. Because of the oversupply of physicians, during that period, the Ministry of Education requested a decrease in the fixed number of medical school students in 1987.

At the start of the 1990s, the population growth rate began to decrease and the population shift to urban areas did not slow, which led to a worsening of the finances of public hospitals and a decrease in the number of physicians in depopulated rural areas, creating the need to redevelop regional healthcare systems[1]. Moreover, in areas that had an increasing population, improvements in the healthcare delivery system were needed because of problems such as a lack of physicians and medical facilities. Against this background, there was a request to increase the fixed number of medical school students[2] and have prefectures verify the setting of healthcare districts[3].

In 2014, the Act Concerning the Comprehensive Promotion of the Securing of Health and Nursing Care in Regional Areas was amended, and a regional healthcare policy was included as part of the medical care plan. According to this regional healthcare policy, prefectures were to estimate the healthcare needs of each healthcare district and examine measures to implement the desired healthcare delivery system by 2025.

Because regional healthcare policies will be drawn up in every prefecture in the future, here we elucidate the relationship between regional populations and healthcare delivery in order to optimize regional healthcare delivery in an environment of continued population decline and uneven population distribution.

Materials and Methods

(1) Analysis of Current Healthcare Delivery

In order to display the status of healthcare delivery in each healthcare district, we drew a scatter plot. The number of physicians per capita and number of hospital beds per capita were used as indicators of healthcare delivery. The number of physicians per capita was calculated from 2010 data and number of hospital beds per capita was calculated using 2011 data on the number of hospital beds and 2010 data on population.

The data sources of this study were as follows. The data sources for the number of physicians were the 2000 and 2010 Surveys of Physicians, Dentists and Pharmacists, from which we used the number of physicians working in medical facilities. The number of hospital beds was calculated from the number of general beds and long-term care beds in the hospitals and clinics that were reported as active in the 2005 and 2011 Survey of Medical Institutions. We used the population data on the National Census of Japan (2000, 2005, and 2010) for all municipalities. Because the number and borders of healthcare districts have changed over time, we used the 2010 regional healthcare district divisions (349 districts) and adjusted the municipal data on the same areas for 2000, 2005, 2010, and 2011 to arrive at an equivalent district area to those from 2010. SPSS Statistics 23 (IBM) was used for the statistical analysis.

The research ethics committee of Tokyo Medical and Dental University determined that an ethical review of the present study was unnecessary (December 27, 2013).

(2) Analysis of the Changes in Healthcare Delivery

In order to elucidate the changes in healthcare delivery in healthcare districts, we calculated the quartile values for the two indicators. We calculated the number of physicians per capita using 2000 and 2010 data and the number of hospital beds per capita using 2005 and 2011 data. The number of hospital beds per capita in 2011 was calculated as the number of hospital beds in 2011 divided by the 2010 population data.

(3) Analysis of the Correlation between the Changes in Population and Changes in Healthcare Delivery

In order to verify the strength of the relationship between the changes in population and changes in healthcare delivery, we examined the Spearman’s rank correlation coefficient between the rate of change in population from 2000 to 2010 in each healthcare district and the rate of change in the number of physicians during the same period. In addition, we measured the relationship between the rate of change in population from 2005 to 2010 in each healthcare district and the rate of change in the number of hospital beds from 2005 to 2011.

(4) Principal Component Analysis

In order to elucidate the relationship between the rate of change in population and healthcare delivery, we performed a principal component analysis in each healthcare district by using a correlation coefficient matrix with data on the rate of change in population from 2000 to 2010, the number of physicians per capita in 2010, and the number of hospital beds per capita in 2011, which was estimated based on the number of hospital beds in 2011 and the population in 2010.

Results

(1) Analysis of the Current State of Healthcare Delivery

The number of physicians per capita (100,000 people)

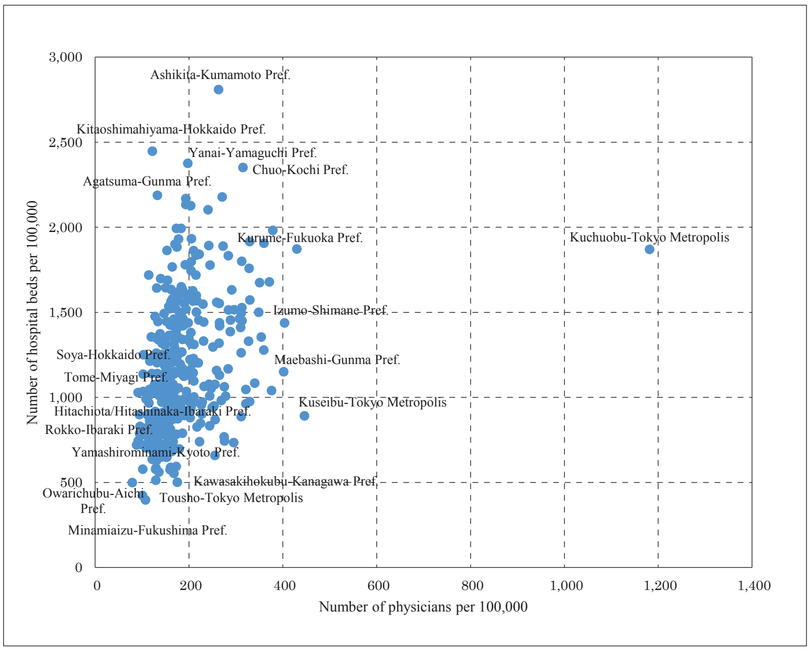

Figure 1. Distribution of the 349 healthcare districts by the per capita number of physicians and of hospital beds

Table 1. The rate of change in total population, number of physicians, and number of hospital beds

	2000	2005	2010[a] / 2011[b]	The rate of change	
				from 2000 to 2010	from 2005 to 2010[a]/ 2011[b]
Total population	126,925,843	127,767,994	128,057,352[a]	0.9%	0.2%[a]
Total number of physicians	243,201	—	280,431[a]	15.3%	—
Total number of hospital beds	—	1,430,429	1,358,918[b]	—	–5.0%[b]

is shown along the horizontal axis and the number of hospital beds per capita (100,000 people) is shown along the vertical axis of the scatter plot in Figure 1. A wide distribution was seen in healthcare delivery for each healthcare district. The mean value of the number of physicians per capita (100,000 people) was 219.0. The distribution of this index of healthcare districts ranged from 0.36 times to 5.39 times the mean value. In addition, the mean value of the number of hospital beds per capita (100,000 people) was 1061.0, while the distribution of this index of healthcare districts ranged from 0.38 times to 2.65 times the mean value.

(2) Analysis of the Changes in Healthcare Delivery

Nationwide, total population increased by 0.9% and the total number of physicians increased by 15.3% from 2000 to 2010, whereas the total number of hospital beds decreased by 5.0% from 2005 to 2011 (Table 1).

Although a general increase was noted for the number of physicians per capita, the median increase per 100,000 persons was 13.7 people, lower than the national mean of 27.4 persons. Furthermore, while a general decrease in the number of hospital beds per capita was noted, the median decrease per 100,000 persons was 65.3 beds, higher than the national mean of 58.3 beds (Tables 2 and 3).

(3) Analysis of the Correlation between the Changes in Population and Changes in Healthcare Delivery

The number of physicians per capita in the Kuchuobu-Tokyo Metropolis was greater than the mean value by 11.7 times the standard deviation; therefore, we excluded the data on this healthcare district from the statistical analysis. The calculation of the correlation coefficients for the 348 healthcare districts revealed a significant and strong positive correlation between the changes in population and changes in the number of physicians (r=0.772, p<0.001) and a weak positive correlation between the changes in population and changes in the

Table 2. Quartiles and the mean number of physicians per 100,000

	2000		2010		Difference from 2010 to 2000
	Number of physicians	Compared with the mean value	Number of physicians	Compared with the mean value	
Maximum	1,197.9	625.1%	1,181.3	539.4%	–16.6
Third quartile	192.7	100.6%	210.6	96.2%	17.8
Median	155.8	81.3%	169.4	77.4%	13.7
First quartile	130.5	68.1%	142.4	65.0%	11.9
Minimum	56.0	29.2%	79.1	36.1%	23.1
The mean value	191.6	100.0%	219.0	100.0%	27.4

Table 3. Quartiles and the mean number of hospital beds per 100,000

	2005		2011		Difference from 2011 to 2005
	Number of hospital beds	Compared with the mean value	Number of hospital beds	Compared with the mean value	
Maximum	2,543.2	227.2%	2,809.8	264.8%	266.6
Third quartile	1,547.2	138.2%	1,450.7	136.7%	–96.4
Median	1,190.4	106.3%	1,125.1	106.0%	–65.3
First quartile	946.8	84.6%	894.4	84.3%	–52.4
Minimum	364.1	32.5%	398.1	37.5%	34.0
The mean value	1,119.4	100.0%	1,061.0	100.0%	–58.3

Table 4. Correlation coefficient between the rate of change in population and change in healthcare delivery

	Rate of change in population from 2000 to 2010 for physicians/ Rate of change in population from 2005 to 2010 for hospital beds			
	Total population	Population by age		
		Age 0–14	Age 15–64	Age 65 and over
Rate of change of the number of physicians from 2000 to 2010	0.772**	0.726**	0.705**	0.714**
Rate of change of the number of hospital beds from 2005 to 2011	0.308**	0.290**	0.276**	0.258**

**: Significant at 0.1%

number of hospital beds (r=0.308, p<0.001). The analysis by age for both items revealed that in comparison with the younger, working-age, and elderly populations, the strongest correlation was observed for the rate of change in the total population (Table 4).

(4) Principal Component Analysis

Through a principal component analysis of the rate of change in population, number of physicians per capita, and number of hospital beds per capita in the 348 healthcare districts, we confirmed the eigenvectors of the two principal components and that the proportion of variance was 90.1%. The eigenvector of principal component 1 (PC1 hereafter) was (–0.662, 0.368, 0.932) for the rate of change in population, number of hospital beds per capita, and number of physicians per capita, respectively, while the proportion of variance was 48.1%. That of principal component 2 (PC2 hereafter) was (0.681, 0.882, 0.135) for the rate of change in population, number of physicians per capita, and number of hospital beds per capita, respectively, while the proportion of variance was 42.0% (Tables 5 and 6).

By using the principal component loading for each principal component, the principal component scores were then calculated from the following formulas and organized on a scatter plot (Figure 2). For data on the i healthcare district, z_{i1}, z_{i2}, and z_{i3} represented the standardized datum of the rate of change in population in i, standardized datum of the number of physicians per capita in i, and standardized datum of the number of hospital beds per capita in i.

Scoring of PC1

$$f_{i1}=-0.662z_{i1}+0.368z_{i2}+0.932z_{i3}$$

Scoring of PC2

$$f_{i2}=0.681z_{i1}+0.882z_{i3}+0.135z_{i3}$$

Table 5. Proportion of variance of the principal components

	Variance	Proportion of variance (%)	Cumulative variance (%)
Principal component 1	1.44	48.1	48.1
Principal component 2	1.26	42.0	90.1
Principal component 3	0.30	9.9	100.0

Table 6. Eigenvectors of the princilpal components

	PC1	PC2
Rate of change in population from 2000 to 2010	–0.662	0.681
Per capita physician populaton in 2010	0.368	0.882
Per capita number of hospital beds in 2011	0.932	0.135

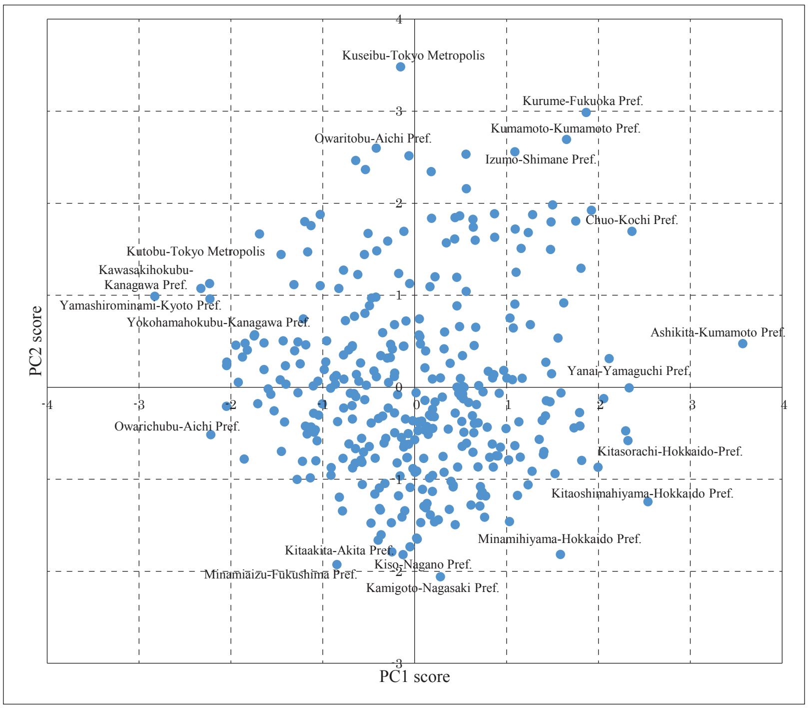

Figure 2. Distribution of the 348 healthcare districts by PC1 and PC2 scores

The healthcare districts with high PC1 scores were the Kyushu region and the Hokkaido, Kochi, and Yamaguchi Prefectures; these regions were characterized by high decreases in the population growth rate and high numbers of hospital beds. Further, in some healthcare districts, the rate of change in the number of hospital beds increased even though population decreased (Table 7).

The healthcare districts with low PC1 scores were the Tokyo, Nagoya, and Kyoto regions; these regions were characterized by high increases in the population growth rate and low numbers of physicians and hospital beds. The reason for the extremely high rate of change in the number of hospital beds in the Yamashirominami-Kyoto Prefecture was the establishment of a hospital in 2006 in addition to the existing two hospitals (Table 8).

Furthermore, healthcare districts with a high PC2 score were characterized by high numbers of physicians per capita and high rates of increase in the number of physicians. Moreover, the top 10 healthcare districts had at least one medical school and medical school hospital (Table 9).

As some physicians do not work only in clinical action such as education physicians, medical interns in medical school hospitals, the healthcare delivery in the healthcare districts is shown as being larger than the real delivery level. Therefore, we examined the healthcare districts with a high PC2 score except those healthcare districts that had at least one medical school. We found that these healthcare districts were also characterized by high rates of increase in the number of physicians (Table 10).

Table 7. Data on the top 10 healthcare districts based on PC1 score

The name of healthcare district	PC1 score	PC2 score	The rate of change in population from 2000 to 2010	Number of physicians per 100,000 in 2010	Number of hospital beds per 100,000 in 2011	The rate of change in the number of hospital beds from 2005 to 2011	Total population in 2010	Medical school
Ashikita-Kumamoto Pref.	3.57	0.47	–13.3%	262.9	2,809.8	8.2%	51,356	—
Kitaoshimahiyama-Hokkaido Pref.	2.54	–1.24	–14.8%	121.8	2,447.8	6.1%	41,058	—
Chuo-Kochi Pref.	2.36	1.69	–3.4%	315.1	2,351.8	–3.5%	555,072	✓
Yanai-Yamaguchi Pref.	2.33	–0.01	–9.2%	197.4	2,377.0	–1.9%	86,623	—
Kitasorachi-Hokkaido Pref.	2.32	–0.58	–15.0%	193.2	2,134.1	–10.2%	35,706	—
Amakusa-Kumamoto Pref.	2.30	–0.47	–13.8%	193.3	2,169.2	–1.7%	127,281	—
Ariake-Fukuoka Pref.	2.12	0.31	–10.0%	240.5	2,103.5	–0.2%	235,745	—
Nansatsu-Kagoshima Pref.	2.06	–0.12	–10.7%	203.7	2,128.2	–1.2%	145,803	—
Seibu2-Tokushima Pref.	1.99	–0.87	–15.9%	177.8	1,931.3	0.0%	44,995	—
Ube / Onoda-Yamaguchi Pref.	1.92	1.92	–5.0%	359.6	1,906.3	–4.7%	266,952	✓

Table 8. Data on the bottom 10 healthcare districts based on PC1 score

The name of healthcare district	PC1 score	PC2 score	The rate of change in population from 2000 to 2010	Number of physicians per 100,000 in 2010	Number of hospital beds per 100,000 in 2011	The rate of change in the number of hospital beds from 2005 to 2011	Total population in 2010	Medical school
Yamashirominami-Kyoto Pref.	–2.83	0.99	18.8%	129.2	513.2	55.4%	114,577	—
Kawasakihokubu-Kanagawa Pref.	–2.33	1.07	13.7%	175.1	501.7	5.9%	820,047	✓
Kutobu-Tokyo Metropolice	–2.23	1.13	14.4%	172.8	594.5	2.7%	1,387,392	—
Yokohamahokubu-Kanagawa Pref.	–2.23	0.96	13.1%	167.9	553.8	4.6%	1,518,277	—
Owarichubu-Aichi Pref.	–2.22	–0.52	6.6%	79.1	500.2	6.8%	161,733	—
Nanseibu-Saitama Pref.	–2.05	–0.21	7.2%	101.5	578.4	–5.0%	689,961	—
Nanbu-Saitama Pref.	–2.05	0.24	9.0%	129.6	586.2	–3.6%	756,087	—
Nishimikawahokubu-Aichi Pref.	–2.05	0.27	8.7%	135.8	561.9	–2.2%	481,585	—
Toukatsunanbu-Chiba Pref.	–1.95	0.46	9.8%	142.6	651.2	7.2%	1,710,000	—
Chitahanto-Aichi Pref.	–1.92	0.06	6.9%	128.7	578.2	–4.1%	614,794	—

Table 9. Data on the top 10 healthcare districts based on PC2 score

The name of healthcare district	PC1 score	PC2 score	The rate of change in population from 2000 to 2010	Number of physicians per 100,000 in 2010	Number of hospital beds per 100,000 in 2011	The rate of change in the number of physicians from 2000 to 2010	Total population in 2010	Medical school
Kuseibu-Tokyo Metropolis	–0.15	3.48	6.5%	446.1	892.0	12.1%	1,190,628	✓
Kurume-Fukuoka Pref.	1.87	2.99	–0.9%	429.9	1,873.1	20.6%	459,623	✓
Kumamoto-Kumamoto Pref.	1.65	2.69	1.9%	378.5	1,982.0	14.5%	734,474	✓
Owaritobu-Aichi Pref.	–0.42	2.60	8.9%	340.0	1,084.3	27.5%	461,219	✓
Izumo-Shimane Pref.	1.09	2.56	–1.3%	403.5	1,438.6	14.8%	171,485	✓
Maebashi-Gunma Pref.	0.56	2.53	–0.4%	401.7	1,151.4	15.6%	340,291	✓
Fukuoka / Itoshima-Fukuoka Pref.	–0.06	2.52	8.7%	327.0	1,330.9	22.8%	1,562,178	✓
Otsu-Shiga Pref.	–0.64	2.46	9.0%	329.4	975.6	21.1%	337,634	✓
Tsukuba-Ibaraki Pref.	–0.54	2.37	8.6%	320.9	1,046.6	33.3%	324,371	✓
Kennan-Tochigi Pref.	0.18	2.34	1.0%	375.6	1,041.0	20.0%	478,386	✓

Table 10. Data on the top 10 healthcare districts based on PC2 scores excluding the healthcare districts that have one or more medical schools

Total rank	The name of healthcare district	PC1 score	PC2 score	The rate of change in population from 2000 to 2010	Number of physicians per 100,000 in 2010	Number of hospital beds per 100,000 in 2011	The rate of change in the number of physicians from 2000 to 2010	Total population in 2010	Medical school
15	Kuseinanbu-Tokyo Metropolis	–1.03	1.88	7.0%	295.3	734.8	18.2%	1,349,960	—
21	Awa-Chiba Pref.	1.75	1.81	–7.2%	371.0	1,679.5	54.9%	136,110	—
31	Kawasakinanbu-Kanagawa Pref.	–1.69	1.67	14.5%	217.0	827.1	9.1%	605,465	—
37	Kenou-Nagasaki Pref.	1.16	1.51	0.2%	283.7	1,833.4	24.1%	270,050	—
42	Konan-Shiga Pref.	–1.46	1.44	13.0%	204.3	940.1	46.1%	321,044	—
43	Tobu-Oita Pref.	1.81	1.29	–1.9%	270.6	2,178.5	–1.3%	219,880	—
50	Kutobu-Tokyo Metropolis	–2.23	1.13	14.4%	172.8	594.5	66.5%	1,387,392	—
54	Kikuchi-Kumamoto Pref.	0.17	1.09	9.9%	170.0	1,899.9	3.5%	174,164	—
58	Yamashirominami-Kyoto Pref.	–2.83	0.99	18.8%	129.2	513.2	51.0%	114,577	—
60	Chuwa-Nara Pref.	–0.47	0.97	1.0%	249.5	940.5	15.9%	382,012	—

Table 11. Data on the bottom 10 healthcare districts based on PC2 score

The name of healthcare district	PC1 score	PC2 score	The rate of change in population from 2000 to 2010	Number of physicians per 100,000 in 2010	Number of hospital beds per 100,000 in 2011	The rate of change in the number of physicians from 2000 to 2010	Total population in 2010	Medical school
Kamigoto-Nagasaki Pref.	0.28	–2.06	–20.4%	128.4	798.5	–5.9%	24,923	—
Minamiaizu-Fukushima Pref.	–0.85	–1.93	–14.6%	107.0	398.1	–8.6%	29,893	—
Kiso-Nagano Pref.	–0.13	–1.82	–15.0%	109.5	821.5	–29.2%	31,042	—
Minamihiyama-Hokkaido Pref.	1.59	–1.82	–18.6%	114.1	1,719.8	–16.7%	26,282	—
Kitaakita-Akita Pref.	–0.25	–1.79	–13.9%	104.8	802.8	–26.8%	39,114	—
Soya-Hokkaido Pref.	–0.05	–1.73	–12.1%	91.2	1,029.3	–19.3%	73,447	—
Miyako-Iwate Pref.	–0.40	–1.66	–12.2%	104.6	781.1	–23.6%	92,694	—
Kyonan-Yamanashi Pref.	0.03	–1.65	–13.3%	108.4	990.8	–18.2%	58,137	—
Hidaka-Hokkaido Pref.	0.02	–1.64	–12.4%	102.2	1,035.6	–17.2%	75,321	—
Tome-Miyagi Pref.	–0.37	–1.60	–10.5%	94.1	899.1	–18.6%	83,969	—

Finally, healthcare districts with a low PC2 score were underpopulated regions characterized by high decreases in the population growth rate and in the number of physicians (Table 11).

Discussion

(1) Analysis of Healthcare Delivery

Since 1985, there has been an effort to establish healthcare districts and manage hospital beds; however, the analysis of healthcare delivery conditions in each healthcare district revealed that a wide distribution in both the number of physicians per capita and the number of hospital beds per capita remains. This uneven distribution in regional healthcare delivery systems has thus been insufficiently resolved, not only among prefectures[4] but also among healthcare districts.

Furthermore, the changes in the number of physicians per capita showed that the increase in the median was smaller than that of the nationwide average. This result showed that relatively more physicians were located in healthcare districts with a high number of physicians per capita. In comparison with the mean number of physicians per capita of OECD nations (308 physicians / 100,000 people, 2010 data, 29 nations), the number in Japan is low, suggesting that the recruitment of physicians in healthcare districts with a small number of physicians per capita is an urgent task.

The results of the present study also revealed that for the changes in the number of hospital beds per capita, the decrease in the median was greater than that of the national average. Thus, in healthcare districts with relatively high numbers of hospital beds per capita, there were large decreases in the number of hospital beds. However, in light of the fact that the number of hospital beds per capita in Japan is overwhelmingly high in comparison with the average of OECD nations (506 beds / 100,000 people, 2011 data, 29 nations), a nationwide surplus of hospital beds seems to be evident.

Moreover, the finding of the strong positive correlation between the rate of change in population and rate of change in the number of physicians indicated the possibility of the migration of physicians being a response to changes in healthcare demand, or the possibility of the migration of population being a response to changes in the number of physicians. By contrast, the weak positive correlation between the rate of change in population and rate of change in the number of hospital beds is thought to be caused by the sufficient number of hospital beds in many healthcare districts.

(2) Principal Component Analysis

Because the two principal components (PC1 and PC2) contributed 90.1% of the data related to the rate of change in population, number of physicians per capita, and number of hospital beds per capita, we focused on the healthcare districts that had high or low PC1 and PC2 scores to elucidate their content. First, PC1 scores increased when the rate of change in population was low, the number of physicians per capita was high, and the number of hospital beds per capita was high. In other words, PC1 scores were higher when the population reduced greatly and healthcare delivery (in particular, the number of hospitals per capita) was sufficient. On the contrary, PC2 scores increased when the rate of change in population was high, number of physicians per capita was high, and number of hospital beds per capita was high. PC2 scores were higher when the population increased greatly and healthcare delivery (in particular, the number of physicians per capita) was sufficient.

The healthcare districts with high PC1 scores were those that had a high number of beds per capita despite decreasing medical demand owing to the declining population. When the regulations on hospital beds were implemented, beds became entitlements that could be traded between medical facilities[5]. This added-value to hospital beds made it difficult to incentivize the adjustment of hospital bed numbers[6]. The healthcare districts with a high number of hospital beds per capita are thought to be those that have been heavily influenced by the regulations on hospital beds. By contrast, healthcare districts with low PC1 scores such as the surrounding areas of Tokyo, Nagoya, and Kyoto had a large population influx, with which the healthcare delivery system was unable to keep up. In November 2011, the senior officials of the local governments that had these healthcare districts (e.g., the governors of Saitama, Chiba, Tokyo, and Kanagawa Prefectures and the mayors of Yokohama, Kawasaki, Chiba, Saitama, and Sagamihara Cities) requested the Minister of Health, Labour and Welfare relax the regulations on hospital beds because of the strain on regional healthcare delivery systems[7]. In particular, these local government officials found that the regulations on hospital beds were obstructing the establishment of proper healthcare delivery.

Based on the above points, PC1 seems to be the effect of the regulations on hospital beds. There is a high likelihood that healthcare districts with high PC1 scores maintained a number of hospital beds over the amount necessary because of the regulations on hospital beds. Hence, the surplus of hospital beds may have been a factor in the increase in healthcare costs due to the increase in the average length of a hospital stay[8, 9]. Furthermore, medical facilities in regions that have a surplus of hospital beds tend to keep the status quo because they want to maintain the vested interests. Therefore, it is difficult to implement effective incentives that reduce hospital beds to improve the efficiency of medical facilities or promote increases in the number of hospital beds and replace equipment for the modernization of the medical facilities in regions that have a surplus of hospital beds[10]. The adverse effect of regulations on the development of the healthcare delivery was large in these healthcare districts. It is thus necessary to create measures to repeal the regulations in order to eliminate vested interests.

It was calculated that the prefectures of healthcare districts that had low PC1 scores also showed an increase in the number of needed hospital beds due to a population influx[11]; thus, increasing the number of hospital beds may also be necessary in these areas. Furthermore, the increases in the number of beds suggested that the current regulations on hospital beds are suppressing the market entry of new medical facilities and facility investment to increase the number of beds. Because competition among medical facilities is limited and medical services are slow to improve[12], a revision of the regulations to promote competition among medical facilities is needed.

The healthcare districts with high PC2 scores were those that had not only a high number of physicians but also a high rate of change in the number of physicians. All of the top ten and most of the healthcare districts with high PC2 scores had at least one medical school and medical school hospital. For this reason, it appears as though obtaining physicians in these districts has been relatively easy, suggesting that healthcare delivery has been able to respond flexibly to changes in population. Moreover, many of the healthcare districts that had no medical school with high PC2 scores were those that also had a high rate of change in the number of physicians. They seemed to have the capacity to recruit physicians. On the contrary, healthcare districts with low PC2 scores were underpopulated regions with marked decreases in population. At the same time, the number of physicians in these regions has been decreasing, resulting in an extremely small number of physicians per 100,000 people (approximately 100 physicians). Because of the strong positive correlation between changes in population and the rate of change in the number of physicians, it seems as though the decrease in the population has caused a decrease in the number of physicians, which has subsequently caused a decrease in the population and so on in a vicious cycle.

From the above points, PC2 seems to show the capacity to recruit physicians. Healthcare districts with high PC2 scores can be expected to have ample healthcare delivery in the future. In the United States, the economic effects of medical facilities on regional economies have been researched. Studies supported by simulation models in regions such as Northeast Minnesota[13], New York[14], Oklahoma[15], and Nebraska[16, 17] have shown the important role of healthcare sectors in regional economies. In particular, the economic effects on the regional economies of medical schools and teaching hospitals in the United States have been expanding[18]. Therefore, healthcare districts with high PC2 scores are expected to grow economically. Because it is easy for the industry–academic cooperation necessary for medical research to progress in healthcare districts where medical educators and researchers are concentrated and companies are active[19], in order to promote industry development, research investment may be effective in these healthcare districts.

Since the healthcare districts with low PC2 scores were underpopulated, it is estimated that the population outflow will continue[20], and it can thus be surmised that the number of physicians and medical facilities will continue to decrease along with the population. The worsening of the healthcare delivery system and closure of hospitals have led to a decline in regional economies[21]. In these healthcare districts, it is essential to revise the settings of healthcare districts or take measures such as using public funds to recruit physicians because it is impossible for individual hospitals to recruit physicians by themselves.

When the above observations are addressed, the optimal size for healthcare delivery in each region can be realized by implementing policy changes in consideration of the two principal components. Specifically, the following policy changes are needed for each healthcare district. For healthcare districts that had high PC1 scores, the repealing of the regulations on hospital beds in order to eliminate vested interests is important. For healthcare districts that had low PC1 scores, these regulations should be relaxed in order to increase healthcare delivery. For healthcare districts that had high PC2 scores, R&D investment must be promoted in order to encourage economic development. Finally, for healthcare districts that had low PC2 scores, public funds should be used to recruit physicians in order to maintain the healthcare delivery system.

Limitations and Future Prospects

Some limitations exist in this study. Firstly, the numbers of educational physicians and medical interns in medical school hospitals were included in the number of physicians, when these physicians were not the physicians only for healthcare delivery. Secondly, the number of hospital beds used was the total number of general beds and long-term care beds, when each type of bed was prepared for different type of healthcare demands. Thirdly, this study was designed as a cross-sectional study only around 2010. Studies that differentiate the types of physicians and hospital beds and that reflect other time periods are needed for policy adaption. Moreover, a comparative study of the medical costs per inhabitant between healthcare districts with high PC1 scores and the national average would be worthwhile.

Acknowledgments

The work was supported by a grant from the Ministry of Health, Labour and Welfare in Japan (grant number, H25-Iryo-Shitei-006, Health Labour Sciences Research Grant).

References

1. Planning conference report on fiscal measures related to public hospitals (in Japanese). Tokyo: Ministry of Internal Affairs and Communications, 2008.
2. Planning conference report on the supply and demand of doctors (in Japanese). Tokyo: Ministry of Health, Labour and Welfare, 2006.
3. Planning conference report on the reconsideration of the national medical care plan (in Japanese). Tokyo: Ministry of Health, Labour and Welfare, 2011.
4. Fukuda Y, Hasegawa T. Analysis of the factors causing inter-prefectural difference in hospital beds in Japan (in Japanese). Journal of the Japan Society for Healthcare Administration 1999; **36(2)**: 31–36.
5. Takagi Y. The changes and issues caused by the medical supply system under the national medical care plan (in Japanese). Social Security Survey 1996; **31(4)**: 388–399.
6. Inoue Y. Today's meaning of the regulations of hospital beds (in Japanese). The Journal of Yokohama 2000; **18(3)**: 1–26.
7. Governors of Saitama, Chiba, Tokyo, and Kanagawa, and Mayors of Saitama, Chiba, Yokohama, Kawasaki, and Sagamihara. Flexibility of the regulations of hospital beds (in Japanese). Tokyo: 2011.
8. Izumida N. Realities of the regional distribution and effects of regulations of hospital beds (in Japanese). Social Security Survey 2003; **39(2)**: 164–173.
9. Kawanobe H, Metatsu Y. A quantitative analysis of the difference of medical treatment expenses between 47 prefectures in Japan. Public Choice Studies 1999; **33**: 29–44.
10. Inoue Y. Today's meaning of the regulations of hospital beds (in Japanese). The Journal of Yokohama 2000; **18(3)**: 1–26.
11. Komatsu S, Watanabe M, Kameda S. Transition estimation of future hospital bed demand using the projected future population by prefecture and the calculation formula of the hospital beds under the national medical care plan. Journal of Health and Welfare Statistics 2012; **1**: 7–13.
12. Takagi Y. The changes and issues caused by the medical supply system under the national medical care plan (in Japanese). Social Security Survey 1996; **31(4)**: 388–399.
13. Lichty RW, Jesswein WA, McMillan DJ. Estimating medical industry impacts on a regional economy. Medical Care 1986; **24(4)**: 350–362.
14. Lowenstein R. The health sector's role in New York's regional economy. Current Issues in Economics and Finance 1995; **1(5)**: 1–6.
15. Doeksen GA, Johnson T, Biard-Holmes D, Schott V. A healthy health sector is crucial for community economic development. The Journal of Rural Health 1998; **14(1)**: 66–72.
16. Cordes S, Sluis EV, Lamphear C, Hoffman J. Rural hospitals and the local economy: A needed extension and refinement of existing empirical research. The Journal of Remote Health 1999; **15(2)**: 189–201.
17. Doeksen GA, Schott V. Economic importance of the health-care sector in a rural economy. Rural and Remote Health **3:135**. (Online) 2003. Available: http://www.rrh.org.au (Accessed 23 October 2014)
18. Association of American Medical Colleges. The economic impact of AAMC-member medical schools and teaching hospitals. Washington, DC: Association of American Medical Colleges, 2007, 2009, 2012.
19. Melese T, Lin SM, Chang JL, Cohen NH. Open innovation networks between academia and industry: An imperative for breakthrough therapies. Nature Medicine 2009; **15(5)**: 502–507.
20. National Institute of Population and Social Security Research. Projection of the future population of Japan by region (March 2013 estimate) (in Japanese). Tokyo: National Institute of Population and Social Security Research, 2013.
21. Holmes GM, Slifkin RT, Randolph RK, Poley S. The effect of rural hospital closures on community economic health. Health Services Research 2006; **41(2)**: 467–485.