Original Article

Increase in the number of physicians and mortality/life expectancy in Japan

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Abstract

Background

The distribution of physicians varies over area and time, and increases or decreases in their number are an important issue for the healthcare system. This study aimed to examine the association of an increase or decrease in the number of physicians with the mortality and life expectancy in a given population.

Methods

This was a cross-sectional ecological study of a population that comprised the inhabitants of a unit district of the healthcare system. The independent variable was the number of physicians per 10,000 population in that district in 2006 divided by the corresponding number in 1996. The dependent variables were life expectancy and standardized mortality ratios (SMRs) for all causes, neoplasms, heart disease, and cerebrovascular disease.

Results

Life expectancy in men was significantly correlated with an increase in the total number of physicians ($p = 0.003$). Supplementary analysis showed a relationship between the increase in the number of physicians in clinics and life expectancy ($\beta = 0.859$) in men.

Conclusion

A relationship was observed between particular SMRs/life expectancy and an increase in the number of physicians, and it was suggested that the increase of physicians could affect regional healthcare planning.

(**Keywords**: standardized mortality ratio, healthcare resources, socioeconomic resources, ecological study)

I. Background

Ideally, access to healthcare should be equitable over a given area; however, the distribution of physicians in any vicinity is not even. A relationship between the volume of physicians and mortality rate has been reported previously[1-6]. Although the number of physicians in Japan is constantly increasing, there is no public system to control their allocation, and each local government and hospital therefore tackles the recruitment of physicians from its own perspective; this uneven distribution has been signaled[7]. In general, developed communities tend to attract more physicians[8] than their undeveloped counterparts, which also leads to an unequal distribution. An important issue for the healthcare system is not only the number of physicians available in a particular area in any given year, but also any increase or decrease in their number in that year. A balanced relationship between the increase or decrease in the number of healthcare providers and the lifespan of the population in a given area is a central problem for healthcare planners. This study aimed to examine the association between the lifespan and the increase or decrease in the number of physicians per 10,000 inhabitants of a particular population with regard to mortality and life expectancy.

II. Methods

We performed a cross-sectional ecological study using national statistics that are available to the public. The subject population comprised all 358 healthcare districts (Ni-ji-iryoken in Japanese). The Japanese healthcare system is based on three district levels: the primary level is the

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municipal district (n=1743); the second level is healthcare districts, which comprise one or more municipalities (n=358); and the third level is the prefecture (n=55), which comprises several healthcare districts. Of these, a wider range of medical care is expected to be available in a healthcare district.

Empirical Bayes estimates of the standardized mortality ratios (SMRs) for all cause and major diseases that occurred between 2003 and 2007 were calculated using data collected from the National Vital Statistics[9]. We selected three major causes of death : neoplasms, heart disease, and cerebrovascular disease. Life expectancy data were obtained from the municipal life table of 2005[10]. The dependent variables of SMR and life expectancy were obtained by averaging the values reported for the municipalities that constituted the district.

The numbers of total physicians, physicians in hospitals, and physicians in clinics was extracted from the national statistics of 2006 and 1996[11,12], and demographic data were extracted from the national census of 2005 and 1995[13,14]. We considered the demographics for 2005 and 1995 as data for 2006 and 1996. The numbers of physicians per 10,000 inhabitants in 2006 and 1996 were then calculated. The increase or decrease was calculated as the number of physicians per 10,000 inhabitants in 2006 divided by that in 1996, which constituted the independent variable.

Modulating variables were healthcare and socioeconomic resources. Healthcare resources were the total numbers of physicians in 2006 and the number of hospitals, emergency centers, hospital beds, and clinics per 10,000 inhabitants in 2005[15]. Socioeconomic resources were the total number of inhabitants in 2005 and the number of live births per 1,000 inhabitants, old households per 1,000 households, marriages per 1,000 inhabitants, divorces per 1,000 inhabitants, totally unemployed per 1,000 members of the labor force, secondary industry workers per 1,000 members of the labor force, and tertiary industry workers per 1,000 members of the labor force[9)13)]. To obtain an index for regionality, we also considered habitable area size and prefecture (47 prefectures in Japan). As a result, 46 dummy variables were added to multivariate analysis.

The main outcome was relationship between an increase in the number of physicians and the SMRs for all causes or life expectancy. We also analyzed the workplaces of physicians and the SMRs for major diseases as a secondary outcome.

For SMR and life expectancy, the relationship between the variables was analyzed using Spearman's rank test and multiple regression analysis. A p value of 0.05 was considered to be statistically significant. The Bonferroni correction was used to counteract the problem of multiple comparisons. Stata/SE 11.2 for Mac (Stata Corp, College Station, Texas, USA) was used for all analyses.

III. Results

A. Mortality/life expectancy

The basic statistics of SMRs and life expectancy are shown in Table 1. The median life expectancy was 78.5 years for men and 85.7 years for women. The maximum difference in life expectancy between various healthcare districts was 5.1 years for men and 2.9 years for women. The SMR for all causes demonstrated a 1.5-fold difference between the districts.

B. Increase/decrease in the number of physicians

The increase/decrease in the number of physicians from 1996 to 2006 is shown in Table 2. In 2006, the numbers of total physicians, physicians in hospitals, and physicians in clinics were 162.8, 98.7, and 66.0 per 10,000 inhabitants, respectively, and the average increase in the total number of physicians was 1.1 (range, 0.8–1.8) over a period of 10 years.

C. Relationship between the increase/decrease in the number of physicians and SMRs/life expectancy

Our analysis revealed a correlation between the increase in the total number of physicians and SMRs for all causes ($r = -0.296$, $p < 0.001$), heart disease ($r = -0.124$, $p = 0.020$), and life expectancy ($r = 0.370$, $p < 0.001$) in men (Table 3).

The coefficients obtained by multiple regression analysis are shown in Table 4. In this analysis, the increase in the number of physicians, other healthcare and socioeconomic resources, and regionality indices were forcibly assigned. The analysis revealed a relationship between the increase in the total number of physicians and life expectancy ($\beta = 1.011$, $p = 0.003$). Supplementary analysis showed a relationship between the increase in the number of physicians in clinics and life expectancy ($\beta = 0.859$) in men.

Table 1. Standardized mortality ratio and life expectancy among the healthcare districts in Japan (N = 358)

	Men				Women			
	Median	IQR	Min	Max	Median	IQR	Min	Max
Standardized mortality ratio								
All-cause	102.0	10.4	83.0	129.1	99.7	8.6	76.7	123.6
Neoplasm	98.8	12.0	72.6	136.1	96.7	11.0	73.4	128.1
Heart disease	101.2	19.0	64.6	146.5	100.7	18.3	70.3	140.4
Cerebrovasucular disease	103.0	24.8	64.3	165.6	100.8	22.3	54.9	164.2
Life expectancy, year	78.5	1.2	75.6	80.7	85.7	0.9	84.3	87.2

IQR: interquartile range (25th percentile to 75th percentile)

Table 2. Healthcare and socioeconomic resources among the health districts in Japan（N＝358）

	Median	IQR	Min	Max
Health resources				
The ratio of physician*	1.1	0.2	0.8	1.8
The ratio of physician in hospital*	1.0	0.3	0.6	3.0
The ratio of physician in clinic*	1.1	0.2	0.5	2.0
The number of physician†	162.8	66.1	71.5	1150.0
The number of physician in hospital†	98.7	51.1	16.1	863.2
The number of physician in clinic†	66.0	23.8	15.9	286.8
The number of hospital†	6.8	4.3	2.0	25.4
The number of emergency center†	3.5	2.1	0.0	15.8
The number of hospital bed†	723.2	276.9	120.0	2001.5
The number of clinic†	71.8	22.3	32.1	292.4
Socioeconomic resources				
The number of population, x1000	211.2	355.3	23.7	2628.8
The number of live birth†	6.7	2.9	0.2	15.1
The number of aged household‡	421.6	361.0	64.4	5764.5
The number of marriage†	4.1	1.8	0.0	8.5
The number of divorce†	1.6	0.6	0.1	3.0
The number of totally-unemployed §	59.6	48.7	0.3	5854.0
The number of secondary industry worker §	79.8	155.6	0.1	3188.1
The number of tertiary industry worker §	258.9	226.5	0.2	11150.8
The number of habitable area, km2	230.3	221.3	11.9	3165.0

IRQ: inter quantile range (25% centile – 75% centile)

*Ratio obtained by dividing population:physician ratio in 2006 by the ratio in 1996, † per 100,000 people, ‡ per1,000 households, § per 1,000 labor force

Table 3. Correlation analysis between health resources and the standardized mortality ratio/life expectancy in Japan

	Standardized mortality ratio								Life expectancy, year	
	All-cause		Neoplasm		Heart disease		Cerebrovasucular disease			
	r	p value	r	p value	r	p value	r	p value	r	p value
Men										
The ratio of physician*	−0.296	<0.001	−0.036	0.502	−0.124	0.020	−0.155	0.003	0.370	<0.001
The ratio of physician in hospital*	0.004	0.944	−0.001	0.990	0.008	0.874	0.076	0.154	0.025	0.636
The ratio of physician in clinic*	−0.306	<0.001	−0.126	0.017	−0.102	0.055	−0.160	0.002	0.355	<0.001
The number of physician†	−0.161	0.002	0.004	0.943	−0.227	<0.001	−0.269	<0.001	0.165	0.002
The number of physician in hospital†	−0.143	0.007	0.023	0.662	−0.200	0.000	−0.240	<0.001	0.135	0.011
The number of physician in clinic†	−0.107	0.044	0.018	0.741	−0.175	0.001	−0.229	<0.001	0.121	0.022
The number of hospital†	0.229	<0.001	0.056	0.292	−0.015	0.774	−0.020	0.707	−0.346	<0.001
The number of emergency center†	0.208	0.000	−0.009	0.869	0.144	0.007	0.095	0.073	−0.333	<0.001
The number of hospital bed†	0.115	0.030	0.084	0.115	−0.048	0.369	−0.014	0.789	−0.201	0.000
The number of clinic†	−0.013	0.812	0.067	0.209	−0.181	0.001	−0.243	<0.001	0.047	0.378
Women										
The ratio of physician*	−0.054	0.308	0.131	0.014	−0.071	0.178	−0.054	0.308	0.128	0.016
The ratio of physician in hospital*	0.007	0.899	−0.066	0.216	−0.002	0.965	0.022	0.685	−0.012	0.818
The ratio of physician in clinic*	−0.050	0.348	0.071	0.183	−0.013	0.810	−0.046	0.382	0.113	0.032
The number of physician†	−0.204	0.000	0.092	0.084	−0.235	<0.001	−0.226	<0.001	0.238	<0.001
The number of physician in hospital†	−0.217	<0.001	0.072	0.177	−0.214	<0.001	−0.216	<0.001	0.234	<0.001
The number of physician in clinic†	−0.085	0.108	0.128	0.016	−0.178	0.001	−0.179	0.001	0.125	0.018
The number of hospital†	−0.169	0.001	−0.149	0.005	−0.092	0.082	−0.181	0.001	0.063	0.237
The number of emergency center†	−0.044	0.412	−0.127	0.016	0.063	0.237	−0.039	0.468	−0.071	0.179
The number of hospital bed†	−0.138	0.009	−0.043	0.421	−0.114	0.031	−0.088	0.097	0.098	0.065
The number of clinic†	−0.134	0.012	0.068	0.202	−0.207	0.000	−0.253	<0.001	0.155	0.003

r: Spearman's rank correlation coefficient

*Ratio obtained by dividing population:physician ratio in 2006 by the ratio in 1996, † per 100,000 people, ‡ per1,000 households, § per 1,000 labor force

Table 4. The multiple regression analysis between the ratio of physician and the standardized mortality ratio / life expectancy

	Standardized mortality ratio								Life expectancy	
	All-cause		Neoplasm		Heart disease		Cerebrovascluar disease			
	β	p value	β	p value	β	p value	β	p value	β	p value
Men										
The ratio of physician	−5.624	0.080	−0.186	0.964	−10.441	0.062	−6.721	0.360	1.011	0.003
The ratio of physician in hospital	−0.730	0.657	2.384	0.256	−5.229	0.066	−1.078	0.773	0.255	0.144
The ratio of physician in clinic	−6.604	0.015	−7.824	0.021	−3.417	0.468	−5.546	0.366	0.859	0.003
Women										
The ratio of physician	−2.787	0.337	2.376	0.496	−6.412	0.223	−9.848	0.166	0.392	0.095
The ratio of physician in hospital	−1.083	0.464	1.577	0.376	−2.538	0.344	−5.321	0.141	0.118	0.324
The ratio of physician in clinic	−2.714	0.266	−4.038	0.164	−0.030	0.995	−2.902	0.622	0.369	0.061

β : multiple regression coefficient with the other health and socio-economic resources.

Ratio of physician obtained by dividing population pyshician ratio in 2006 by the ratio in 1996.

IV. Discussion

We examined the relationship between a change in the number of physicians and mortality to determine appropriate allocation of physicians. The main outcome was that life expectancy in men was longer when the total number of physicians increased. Regardless of the number of physicians allocated to each district, an increase in that number may enhance longevity in men. These results could provide an important basis for a public project on the recruitment of physicians.

A satisfactory number of physicians improves the quality of healthcare— effective hospital utilization[16], reduced healthcare expenses[17], avoidable hospitalization[18], and effective healthcare against mortality from breast cancer[19], nosocomial pneumonia[20], and colon cancer[21] — and can contribute to a longer life expectancy.

This study revealed the healthcare indices that would be expected from a public project on the recruitment of physicians and indicated that only men would benefit from an increased number of physicians. Furthermore, it showed that an increased number of physicians in clinics may reduce the SMRs for all causes and cancer and may increase life expectancy. No relationship was noted between an increase in the number of physicians in hospitals and SMR/life expectancy. Similarly, there was no relationship between an increased number of physicians and SMR/life expectancy in women.

In addition to the lack of a relationship between an increase in the number of physicians and mortality/life expectancy in women, mortality was lower and life expectancy was greater in women than in men suggesting that in women, these indices might be saturated in relation to the number of physicians. Furthermore, there are differences in the use of health services between both sexes. Women consult doctors more often than men throughout the healthcare system and also take more prescribed medication in some countries[22]. They already tend to receive medical care more frequently and may be less influenced by an increase in the number of physicians than men, which probably accounts for the difference in the relationship of increase in the number of physicians and mortality/life expectancy between men and women.

The number of physicians can be considered as an index of access to healthcare[23]. Availability is the simplest level of access and determines whether healthcare service is adequately provided in an area. A potential indicator of this level is the number of physicians. Gaining access to healthcare is the next level and determines whether services can be utilized when they are needed. Potential indicators for this level are primary care consultations for a unit population. Finally, access to healthcare should deliver effective care that meets the health needs of the population and achieves the intended health outcomes. A potential indicator of the final level is the mortality rate[24]. Mortality is also associated with economic factors, smoking behavior[25], and social and community ties[26]. Healthcare planners should consider each of these elements.

In this study, the results differed between physicians in hospitals and those in clinics with regard to their numbers and the relationship of mortality and life expectancy. The relationship between the number of primary care physicians; life expectancy; and mortality from all causes, neoplasms, heart disease, and cerebral infarction has been reported previously[27]. Most physicians in clinics provide primary care, and an increase in their number may improve its quality and contribute to lower mortality. However, whether or not the quality of primary care is improved by such an increase has not been examined to date.

This study was population-based and ecological in design. Such findings are often associated with the ecological fallacy, which is the drawing of inferences at the individual level based on group-level data. In this study, we treated the events that occurred in each healthcare district comprehensively. Therefore, individual health conditions and healthcare use were not reflected. Furthermore, the recalculation method of SMRs and life expectancy of the healthcare districts that I adopted in this study may not be appropriate. However, I adopted this method out of necessity because I could not obtain information necessary to recalculate these indexes accurately.

V. Conclusions

An increase in the number of physicians is to some extent related to mortality and life expectancy. This should be considered when recruitment and allocation of physicians in a particular region or district is being planned.

VI. Competing interests

The authors declare that they have no competing interests.

VII. Author contributions

TN designed this study and wrote the draft of this paper. MO, SS, and EK provided initiatives and gave suggestions. All authors read and approved the final manuscript.

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日本における医師数増加と死亡率および平均寿命との関連

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要　　約

背景
医師の分布には偏在があり，医師数の増加または減少は医療体制の維持に重要である。本研究では医師数の変化と死亡率および平均寿命との関連を調査した。
方法
横断的生態学的研究で，全国二次医療圏の集団を対象とした。独立変数は医師数の増減とし，2006年の人口対医師数比を1996年のそれで割った比とした。従属変数は標準化死亡比（SMR）と平均寿命とした。
結果
医師数の増加と男性の平均寿命との間で有意な関連を認めた（$p = 0.003$）。副次的な解析では，診療所医師数の増加と男性の平均寿命との間で有意な関連を認めた。
結語
医師数の増減と平均寿命との間に関連があることから，医師数の経年変化もまた地域の医療計画の指標になりうる。

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