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Effect of Regional Cooperation on Efficiency of Medical Care Delivery in Secondary Medical Areas of Japan

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Abstract

The Japanese population is aging and requires regional health facilities to cooperate to use medical resources efficiently. This study evaluated the impact of regional cooperation on the efficiency of medical care delivery in secondary medical areas. The discharge adjustment implementation rate of each secondary medical area was used as a proxy for regional cooperation. The study data were obtained from publicly available sources. The efficiency scores of secondary medical areas were calculated using the input-oriented Banker–Charnes–Cooper model for Data Envelopment Analysis. The inputs used were the number of general beds and the average length of hospital stay for each secondary medical area. The outputs used were the number of discharged patients and inpatient medical expenses per person. In addition, the relationship between discharge adjustment implementation rates and efficiency scores were assessed using tobit multiple regression analysis. The models were adjusted for the 7 variables. Ten secondary medical areas had an efficiency score of 1.00 (i.e., highest efficiency). Tobit regression analysis was performed on the 340 secondary medical areas for which efficiency scores were obtained. The discharge adjustment implementation rates and efficiency scores were significantly positively correlated ($p = 0.032$). While studies that quantitatively evaluate regional cooperation and efficiency are limited, these findings suggest that implementing regional cooperation may improve the efficiency of medical care delivery in secondary medical areas.

Keywords: data envelopment analysis, efficiency, health care rationing, health facility administration, patient discharge, Tobit regression analysis

1. Introduction

The conventional medical system in Japan is hospital-centric, that is, it aims to provide all necessary care within one hospital. The system is mainly designed for adolescent or middle-aged patients and do not have clear divisions for acute, rehabilitation, and chronic care.

However, the Japanese population is aging, and the prevalence of chronic conditions is increasing. Patients with chronic conditions often require continuous medical care to manage their symptoms, while maintaining or improving their quality of life. In addition, it is becoming increasingly difficult to navigate the intrahospital referrals that are necessary to provide treatment within a single medical institution. With the aging population and low birthrate, there is an increasing burden on the medical system and younger generations. Without the appropriate intervention, this trend threatens the sustainability of the medical system (Ministry of Health, Labour and Welfare Health Insurance Bureau, 2015; National Council Reform of Social Security System, 2013).

Previous studies have identified the need for a regional interhospital referral model that creates functional differentiation, promotes collaboration among acute, rehabilitation, and chronic care teams, and enhances community care after discharge (Expert Committee on Promoting Reforms Using Medical and Nursing Information, 2015). This model may promote more efficient use of medical resources (National Council Reform of Social Security System, 2013).

Research on Organization for Economic Cooperation and Development countries has shown that the lack of coordination among services and misallocation of medical resources can negatively impact the population health (Retzlaff-Roberts, Chang, & Rubin, 2004). It has been suggested that healthcare systems, where primary care physicians act as the gatekeepers provide more efficient care than countries without these gatekeepers (Bhat, 2005). Previous research in Japan has shown that the efficiency of secondary medical areas is related to the number of long-term beds, population, and regional area (Ogawa & Kubo, 2015). Other studies have shown that the resources of secondary medical area facilities impact the efficiency of nearby municipal hospitals (Adachi, 2013).

In Japan, there are several secondary medical areas for each prefecture. A secondary medical area is a regional unit that provides inpatient medical care based on geographical conditions and traffic conditions. In 2016, there were 344 secondary medical areas in Japan (Ministry of Health, Labour and Welfare [MHLW], 2019a).

The Ministry of Health, Labor and Welfare supports community-based care through the differentiation of medical functions and cooperation of regional health facilities in an effort to provide high-quality and efficient medical care (Ministry of Health, Labour and Welfare Health Policy Bureau, 2016; Ministry of Health, Labour and Welfare Health Policy Bureau, 2018). However, no studies have quantitatively assessed the efficiency of the healthcare system. This study aimed to evaluate the relationship between regional cooperation and the efficiency of secondary medical areas.

2. Method

2.1 Data

This study used a cross-sectional design. All data were obtained from publicly available sources. Therefore, the approval of an ethics committee was not required. The study uses datasets from different years from 2015 to 2017. However, during this period, there was no change in the number of secondary medical areas, and we believe that changes in Japan's health care policy that affect the characteristic values and efficiency of each secondary medical area are negligible.

2.2 Dependent Variable

Efficiency was used as the dependent variable. Efficiency scores were calculated using the input-oriented Banker–Charnes–Cooper model for Data Envelopment Analysis (DEA). The analysis was performed using DEA-Solver-Pro 12.1 software (Saitech, Inc., Tokyo, Japan). The activity of an entity is the process of converting inputs to outputs. Thus, the efficiency of the entity can be quantified as the quotient of the output divided by the input. In DEA, multiple inputs and outputs with different units are converted into one input and one output to assess the efficiency of each Decision-Making Unit (DMU) (Tone, 1996; Nakata, 2015; Nozao, 2007). In this study, each secondary medical area was defined as a DMU. The efficiency of a DMU is expressed as a score between 0 and 1, which can be compared among different DMUs. Within the study sample, the most efficient DMU has designated an efficiency score of 1, and other DMUs were scored relative to the most efficient unit. This method was proposed in 1978 and has been used in various fields since, including in the efficiency evaluation of both for-profit and non-profit organizations (Tone, 1996).

The inputs for this analysis included the number of general beds and the average length of hospital stay for each secondary medical area. The outputs used were the number of discharged patients and inpatient medical expenses per person. Data were obtained from several publicly available sources including the 2017 Medical Facility Survey for the number of general beds, 2017 Hospital Report for the average hospital stay, 2017 Patient Survey for the number of discharged patients, and the 2016 regional medical expenses data for the inpatient medical expenses per patient (MHLW, 2018b; MHLW, 2018a; MHLW, 2019b; MHLW, 2019c). The number of general beds indicated the medical resources within the area. The average length of hospital stay indicated the time required for treatment. Since inpatient medical care typically ends with discharging the patient, the number of discharged patients was used as an indicator of treatment results. Lastly, inpatient medical expenses were used to indicate the costs of treatment. It was assumed that lower medical expenses are desirable. Therefore, the inverse of inpatient medical expenses per person was used in the analysis.

We excluded four secondary medical areas that did not have long-term beds, including Minamiaizu (Fukushima Prefecture), Tosho (Tokyo), Tsushima (Nagasaki Prefecture), and Kumage (Kagoshima Prefecture). These sites were excluded to ensure consistency in the data, as the availability of long-term beds may affect the outcome. After excluding the four medical areas without long-term beds, there were 340 secondary medical areas or DMUs.

2.3 Independent Variable

Regional cooperation was used as the independent variable. Discharge adjustment implementation rate was used as a proxy for regional cooperation. The discharge adjustment implementation rate was calculated by dividing the number of patients for whom the "discharge support addition I" fee was charged by the total number of discharged patients (excluding deaths) (All Japan Hospital Association, 2019). Discharge support addition I is a newly established medical fee that was introduced during the medical fee schedule revision in 2016. This provision of discharge support required hospitals to establish discharge planning departments, assign discharge support staff on hospital wards, collaborate with more than 20 medical institutions and nursing care facilities, as well as share information with partner institutions at least three times per year (Elsevier Japan, 2016b). For discharge support addition I, patients who required discharge support were defined as difficult to discharge after three days of hospitalization, required interprofessional collaboration within seven days of hospitalization, and involved information sharing with other medical or nursing care institutions (Elsevier Japan, 2016a). The introduction of discharge support addition I was intended to promote discharge planning efforts and cooperation among medical institutions, allowing patients to continue receiving care after returning home (Ministry of Health, Labour and Welfare Health Insurance Bureau, 2016).

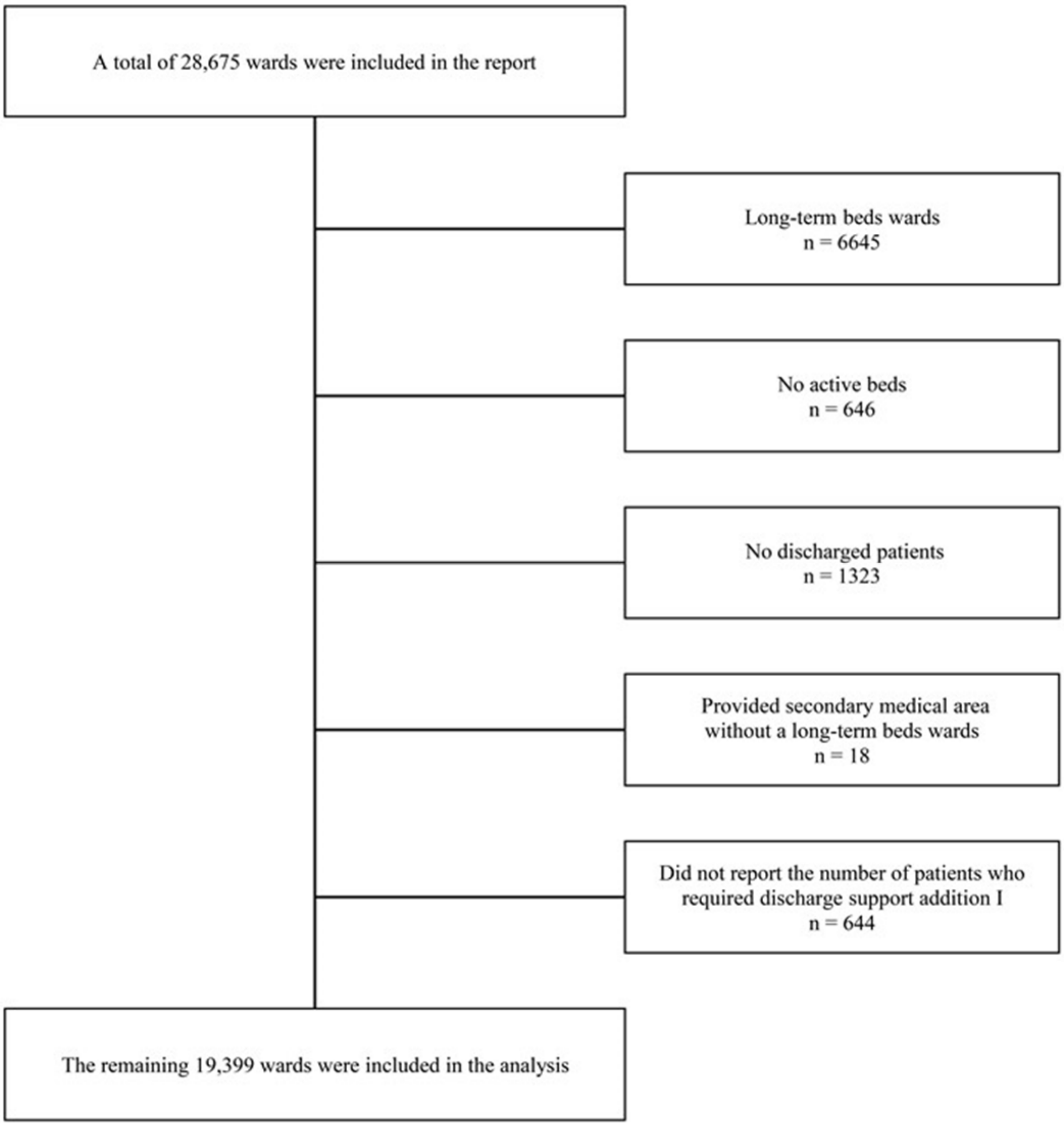

Figure 1. A flowchart of the data usage process

The discharge adjustment implementation rate data were obtained from the 2017 Bed Function Report (MHLW, 2019d). A total of 28,675 wards were included in the report. A flowchart of the data usage process is shown in Figure 1. The exclusion criteria included long-term beds wards (n = 6,645), those with no active beds (n = 646), those with no discharged patients (n = 1,323), those that provided secondary medical areas without a ward with long-term beds (n = 18), and those that did not report the number of patients who required discharge support addition I (n = 644). In addition, in wards with fewer than ten patients requiring discharge support addition I did not report their total. For these wards (n = 3,222), it was assumed that five patients required discharge support addition I. After exclusions, the remaining 19,399 wards were included in the analysis. This was the total number of wards used for the secondary medical areas.

For these wards (n = 3,222), it was assumed that five patients required discharge support addition I. These wards are used in total for each secondary medical area.

2.4 Potential Confounding Variables

Seven potential confounding variables were considered: the number of hospitals per 100,000 people; the number of clinics per 100,000 people; the number of home care facilities per 100,000 people; the number of doctors per bed; the percentage of the population 65 years or older; a dummy variable for small cities; and a dummy variable for depopulated areas. The total number of home care facilities per 100,000 people included both hospitals and clinics providing home care. The number of doctors per bed was calculated by dividing the number of doctors by the number of general beds. The city's population, area, and population density were used to classify the secondary medical areas into three categories: large city, small city, and depopulated area. Large cities were defined as secondary medical areas serving a population of more than 1,000,000, with a population density of more than 2000 per square kilometer. Small cities were defined as secondary medical areas serving between 100,000 and 200,000 people, with a population density of more than 200 per square kilometer. Cities that did not meet the criteria for large or small cities were considered depopulated areas (Takahashi, Eguchi, & Ishikawa, 2016). The number of hospitals per 100,000 people, the number of clinics per 100,000 people, and the number of home care facilities per 100,000 people were used to adjust for the medical resources of the secondary medical area. The number of physicians per bed was used to adjust for the quality of medical care. The percentage of the population 65 years and older was used to adjust for patient population characteristics. The small city and depopulated area dummy variables were used to adjust for the regional characteristics of the secondary medical area.

The number of hospitals per 100,000 people, the number of clinics per 100,000 people, the number of home care facilities per 100,000 people, and the number of doctors per bed were obtained from the 2017 Medical Facility Survey. Regional population, area, and population density data were obtained from secondary medical area basic data (Takumi-san) professional version 9.2.1 (MHLW, 2018b; MHLW, 2018c; MHLW, 2018d; MHLW, 2018e; MHLW, 2018f; Kabushiki gaisya WELLNESS, 2019). These data were provided by Wellness Co. Ltd. who collect medical welfare data and basic statistical information for each secondary medical area nationwide.

2.5 Statistical Analysis

Statistical analysis was performed using SAS 9.4 (SAS Institute, Cary, NC, USA). Tobit regression analysis was used to assess the relationship between variables. It is commonly used when the dependent variable has a limited or truncated range (Mizuochi, 2009). The tobit model represents the linear combination of independent variables that equals the dependent variable with the truncated range. When the dependent variable values are represented within a certain range, ordinary regression analysis concentrates the data at the lower or upper limit, resulting in inaccuracies. It accounts for this data feature, making it suitable for this analysis (Tobin, 1958). The significance level of 5% was used.

3. Results

The input and output data used in the DEA are shown in Table 1. Ten secondary medical areas had an efficiency score of 1.00 (i.e., highest efficiency). Tobit regression analysis was performed on the 340 secondary medical areas for which efficiency scores were obtained. The data for independent variables and potential confounding variables are summarized in Table 1. The results of tobit simple regression analysis for independent variables are shown in Table 2. A significant positive correlation was observed between discharge adjustment implementation rates and efficiency scores ($p = 0.002$). The results of tobit multiple regression analysis after adjustment for potential confounding variables are presented in Table 3. In the multiple regression, discharge adjustment implementation rate was significantly positively correlated with efficiency score ($p = 0.032$). Every potential confounding variable was significantly correlated with efficiency scores, with the exception of the percentage of the population 65 years and older. Efficiency scores were higher for the secondary medical areas of large cities compared to small cities and depopulated areas.

Table 1. Summary of the variable in secondary medical areas (n = 340)

Variable	Mean (SD), Median (Q1, Q3) or n/total (%)	Maximum	Minimum
Data Envelopment Analysis (DEA)			
Inputs			
Number of general beds	1,644 (770, 3,437)	25,536	111
The average length of hospital stay (day)	17.9 (4.1)	39.0	11.3
Outputs			
Number of discharged patients	78 (33, 187)	1,310	7
Inpatient medical expenses per patient (thousand yen)	265 (60)	436	170
Tobit multiple regression analysis			
Independent variable			
Discharge adjustment implementation rate (%)	10.1 (8.4)	50.0	0.0
Potential confounding variables			
Number of hospitals per 100,000 people	7.2 (3.5)	21.0	1.8
Number of clinics per 100,000 people	77.1 (18.9)	264.5	30.0
Number of home care facilities per 100,000 people	20.4 (8.4)	47.0	5.6
Number of doctors per bed	0.04 (0.03, 0.09)	1.28	0.01
Percentage of the population 65 years or older (%)	30.0 (5.1)	45.0	19.0
Dummy variable for small cities	160/340 (47)		
Dummy variable for depopulated areas	128/340 (38)		

SD, standard deviation; Q1, the first quartile; Q3, the third quartile.

Table 2. Effect of independent variables on efficiency scores by tobit simple regression analysis (n = 340)

Variables	Coefficients	95% confidence interval		*P*-value
		Lower limit	Upper limit	
Discharge adjustment implementation rate	0.270	0.096	0.444	0.002

Table 3. Effect of independent variables on efficiency scores by tobit multiple regression analysis (n = 340) (R2 = 0.36)

Variables	Coefficients	95% confidence interval		*P*-value
		Lower limit	Upper limit	
Discharge adjustment implementation rate	0.162	0.014	0.310	0.032
Number of hospitals per 100,000 people	−0.012	−0.016	−0.008	<.001
Number of clinics per 100,000 people	0.002	0.001	0.003	<.001
Number of home care facilities per 100,000 people	−0.004	−0.006	−0.002	<.001
Number of doctors per bed	0.527	0.287	0.768	<.001
Percentage of the population 65 years or older	−0.339	−0.712	0.035	0.076
Dummy variable for small cities	−0.066	−0.104	−0.027	<.001
Dummy variable for depopulated areas	−0.085	−0.138	−0.031	<.001

4. Discussion

Using tobit regression analysis, a significant positive association was found between discharge adjustment implementation rates and efficiency scores calculated by DEA. These results suggest that the implementation of regional cooperation may promote the efficiency of medical care delivery in secondary medical areas.

Discharge planning may reduce the average length of hospital stay in secondary medical areas and, as a result, inpatient medical care can be provided to more patients with fewer beds and reduced medical expenses. With the aging population in Japan, the demand for medical and nursing care is expected to continue to increase. To address these trends, the government is exploring a comprehensive community care system that aims to provide seamless and unified medical and nursing care. The findings of this study highlight the potential benefit of this initiative.

In areas where discharge adjustment is not routinely performed, there is limited regional cooperation. This finding may be attributed to differences in regional characteristics among secondary medical areas. In this study, efficiency scores were higher in secondary medical areas of large cities compared to small cities and depopulated areas. In most small cities and depopulated areas, there are fewer organizations for regional cooperation and most cases are handled by one medical institution, which may hinder efficiency. Further research is warranted to review the allocation of medical resources and the boundaries of secondary medical areas, as efficiency may be achieved through reorganization.

In this analysis, doctors, nurses, and medical equipment involved inpatient care were not included as inputs. These variables were excluded because the quality of inpatient medical care is standardized across regions. For instance, the number of beds provides an indication of resourcing, as the Medical Law specifies the standard for staffing based on patient beds. Moreover, it is difficult to quantify accurately the number of doctors who were involved in the inpatient care.

This study had four limitations. Firstly, given the cross-sectional design of this study, causality could not be assessed. However, the results are considered valid because simple regression analysis and multiple regression analysis were statistically significant. Secondly, efficiency scores varied depending on the input and output variables used in DEA. Therefore, further research is warranted to validate these findings using other input and output variables. However, the variables selected were appropriate given that the secondary medical areas were regional units that provide inpatient medical care. Thirdly, we used the discharge adjustment implementation rate as a measure of regional cooperation. The discharge adjustment implementation rate accounts for both, the number of patients who required discharge support addition I as well as the total number of discharged patients. However, discharge support addition I is intended to promote collaboration among regional health facilities, allowing patients to continue receiving care after returning home (Ministry of Health, Labour and Welfare Health Insurance Bureau, 2016). Therefore, our choice of this variable is valid. Lastly, we did not consider patient inflows and outflows, and assumed that regional collaboration occurs only within the secondary medical area. Regional cooperation occasionally occurs between multiple secondary medical areas; however, it is usually within secondary medical areas because of proximity.

While studies that quantitatively evaluate regional cooperation and efficiency are limited, this study found a statistically significant association between discharge adjustment implementation rates and efficiency scores among secondary medical areas. As the demand for community-based care increases, discharge planning involving multiple care providers and institutions will be necessary.

5. Conclusions

We found a significant positive relationship between discharge adjustment implementation rates and efficiency scores obtained using DEA. These findings suggest that promoting regional cooperation may increase the efficiency of medical care delivery in secondary medical areas.

To the best of our knowledge, this is the first study to use discharge adjustment implementation rates to measure the impact of efficiency in secondary medical areas. Further research is necessary to understand how efficiency changes with improved discharge adjustment implementation rates in the secondary medical area, which this study found inefficient.

Competing Interests Statement

The authors declare that there are no competing or potential conflicts of interest.

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