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ORIGINAL ARTICLE
Cardiac Rehabilitation

Relationship Between Participation of In-Hospital Cardiac Rehabilitation and Regional Characteristics in Japan

— Insight From the Japanese Registry of All Cardiac and Vascular Diseases and the Diagnosis Procedure Combination —

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Background: The influence of various regional backgrounds on participation in cardiac rehabilitation (CR) remains underexplored. We investigated the regional characteristics that potentially promote CR participation.

Methods and Results: This was a nationwide cross-sectional cohort study using the Japanese Registry of All Cardiac and Vascular Diseases and the Diagnosis Procedure Combination. This study included a cohort of 2.7 million inpatients hospitalized between April 2012 and March 2021. The CR participation rate for each hospital was calculated as the percentage of eligible patients who underwent CR during their admission. Among all hospitals, those that do not perform CR were defined as No-CR hospitals. The remaining hospitals were categorized into High- and Low-CR hospitals based on the median level of the CR participation rate (41.5%). High-CR hospitals had significantly smaller medical service areas (P<0.0001), a higher number of physicians per population (P<0.0001), higher air temperature (P=0.02), and fewer primary industry workers (P=0.005) than the other 2 groups. Logistic regression analyses revealed that a lower consumer price index was a significant regional factor that characterized High-CR hospitals, and a lower population aged ≥65 years was a factor approaching significance that characterized the region where High-CR hospitals are located.

Conclusions: High-CR hospitals were found in regions with a lower consumer price index and a trend towards a lower population aged ≥65 years.

Key Words: Cardiac rehabilitation; Epidemiology; Japanese

Cardiovascular diseases are major causes of mortality worldwide, particularly in developed countries.[1] Cardiac rehabilitation (CR) is widely recognized for its pivotal role in enhancing the prognosis of cardiovascular diseases.[2] The guidelines recommend CR in a class I designation for improving exercise tolerance and quality of life in patients with heart failure.[3–5] Increasing participation of eligible patients in CR is significant to improve prognosis in cardiovascular diseases.[6] However, participation in CR remains insufficient despite its significance.

Patient characteristics, such as sex, age, marital status, and socioeconomic status, impede CR participation.[7–9] However, data on whether regional characteristics affect CR participation are limited. An array of regional factors, including climatic conditions, socioeconomic contexts, infrastructure development, and other characteristics, could

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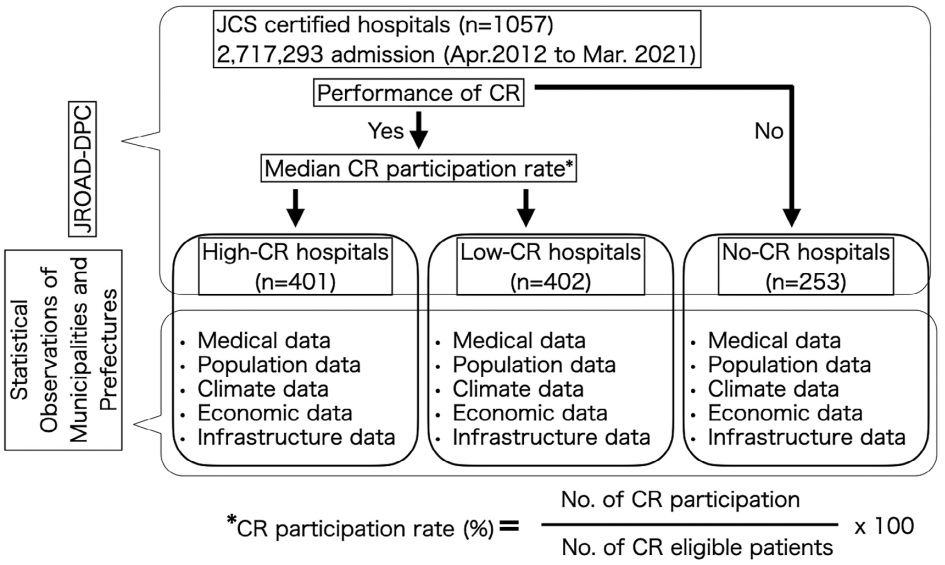

Figure 1. Study flow chart. Cardiac rehabilitation (CR)-eligible patients were defined as those with heart failure, acute coronary syndrome, and aortic diseases. JCS, Japanese Circulation Society; JROAD-DPC, Japanese Registry of All Cardiac and Vascular Diseases and the Diagnosis Procedure Combination.

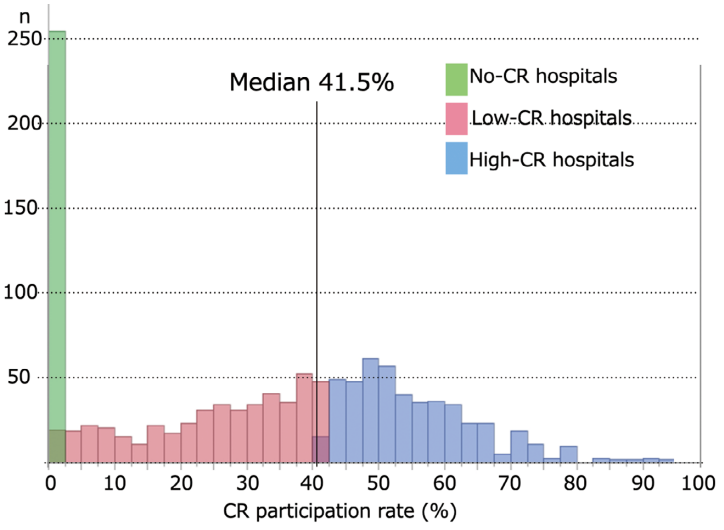

Figure 2. Histogram of cardiac rehabilitation (CR) participation rate and number of hospitals. Red and blue bars denote Low- and High-CR hospitals, respectively.

potentially influence CR participation.

Therefore, the present study primarily aimed to investigate the regional characteristics that potentially promote CR participation.

Methods

Data Source

This was a nationwide cross-sectional per-facility basis study that included Japanese Circulation Society (JCS)-certified training hospitals in Japan. We used the following 3 nationwide databases: the Japanese Registry of All Cardiac and Vascular Diseases and the Diagnosis Procedure Combination (JROAD-DPC) provided by the JCS, and the Statistical Observations of Municipalities and Statistical Observations of Prefectures maintained by the Statistics Bureau of Japan's Ministry of Internal Affairs and Communications (**Figure 1**).

The JROAD-DPC is a claims database generated from each hospitalization derived from the Japanese DPC/Per Diem Payment System. It includes >1,000 JCS-certified training hospitals and provides comprehensive patient information on a per-facility basis. This database includes information on the number of admitted patients, the 10th

Table 1. Regional Characteristics of the High- and Low-CR Hospital Locations

	High-CR hospitals (n=401)		Low-CR hospitals (n=402)		No-CR hospitals (n=253)		P value
Medical data							
In-hospital CR participant (%)	52.8	47.7–60.5	28.1	16.7–36.3	0	0–0	
Medical service area (km²)*	6.04	2.62–12.33	8.98	3.50–18.44	7.77	3.67–21.82	<0.0001†,§
No. physicians (per 100,000 persons)*	299	231–459	244	190–362	215	174–295	<0.0001†,‡,§
Population data							
Population density (persons/km²)*	2,474	1,215–6,901	1,924	913–6,879	2,013	724–6,406	0.004†,§
Population aged ≥65 years (%)*	25.5	22.8–28.3	26.3	23.5–29.2	26.7	23.9–30.3	0.002†,§
No. people per household*	2.4	2.2–2.5	2.4	2.2–2.6	2.4	2.3–2.6	0.007†,§
Forest area (%)	56.6	38.7–68.1	62.8	34.7–67.7	62.8	34.7–70.3	0.93
Climate data							
Air temperature (°C)	17	15.9–17.5†	16.8	15.7–17.5	16.8	15.7–17.5	0.02†
Sunshine hours (h)	2,090	2,039–2,179	2,090	2,022–2,180	2,090	2,005–2,180	0.20
Precipitation (mm)	1,999	1,637–2,057	1,952	1,481–2,057	1,979	1,530–2,057	0.43
Economic data							
Household income (¥1,000/year)*	5,447	4,849–5,956†	5,595	5,022–5,956	5,584	5,022–5,952	0.007†
Unemployed person (%)*	4.49	3.85–5.17	4.4	3.84–4.96	4.44	3.84–5.07	0.38
Employed person in primary industry (%)*	1.41	0.47–3.53	1.77	0.64–4.17	1.87	0.74–5.73	0.005§
Consumer price index	99.2	97.8–100.3	99.5	98.2–100.6	99.7	98.3–100.8	0.02§
Social welfare expenditure (%)	5.39	4.86–5.86	5.15	4.82–5.68	5.13	4.65–5.86	0.04
Ratio of job vacancies to application	1.14	1.04–1.39	1.14	1.04–1.39	1.14	1.05–1.35	0.98
Infrastructure data							
Paved municipal roads (%)	86.8	80.8–90.6	85	80.0–90.6	85	80.0–90.5	0.051
Public parks area (m²)	9.8	7.61–13.53	9.86	6.86–13.59	9.7	6.86–13.42	0.59

Data are presented as median (interquartile range). Climate data are presented as yearly averages. *Data for municipality level. Other data are at the prefectural level. †P<0.05 between the High- and Low-CR hospital group. ‡P<0.05 between the Low- and No-CR hospital group. §P<0.05 between the High- and No-CR hospital group. CR, cardiac rehabilitation.

revision of the International Statistical Classification of Diseases (ICD-10) codes, and patients' participation in CR.

We used the data where the hospitals were located based on the statistical observations of municipalities and prefectures.[10,11] These databases contain detailed regional socioeconomic and geographical information, including population composition, climate, and infrastructure status on per-municipality or per-prefecture levels. Data for municipalities included medical service area, population density, population aged ≥65 years, number of people per household, household income, unemployed persons, and employed persons in primary industry. Other data were at the prefectural level. We created the dataset for analysis by merging the data of the regional characteristics where the subject hospitals were located. In the present study, the consumer price index was the regional difference index of consumer price. It expresses the price level of each region as an index value with the national average set at 100. Detailed definitions of the other regional characteristic variables are shown in the **Supplementary Files**.

CR Participation Rate

The present study included a cohort of 2.7 million inpatients admitted to the subject hospital from April 2012 to March 2021. We defined CR-eligible patients as those admitted with the following ICD-10 codes as a primary diagnosis, admission-precipitating diagnosis, or the most resource-consuming diagnosis: heart failure (I50); acute coronary syndrome (I20–I23); and aortic diseases (I71). Additionally, we considered the following procedural codes for open chest surgery: K539-2; K540; K544; K551–K561; K577; K592; K592-2; and K593. The CR participation rate for each hospital was calculated as the percentage of eligible patients who underwent CR during their admission. The hospitals that did not perform CR during the study period were defined as No-CR hospitals. Based on the median level of the CR participation rate among hospitals that conducted CR during the study period, these hospitals were categorized into High- and Low-CR hospitals (**Figure 1**).

Statistical Analysis

Continuous variables are presented as median and interquartile range, and the variable distributions between the 3 groups were compared using the Kruskal-Wallis test. Multiple comparisons among the 3 groups were performed using the Steel-Dwass test. Uni- and multivariable logistic regression analyses were conducted to identify regional factors associated with High-CR hospitals. Variables with P<0.10 in the univariable analysis were included in the multivariable analysis. All statistical analyses were performed with JMP Pro (version 13.0; SAS Institute, Cary, NC, USA). A value of P<0.05 was considered statistically significant.

The requirement for individual informed consent was waived because all data were anonymized at the source.

Table 2. Logistic Regression Analyses for High-CR Hospitals

Value	Univariable analyses		P value	Multivariable analyses		P value
	OR	95% CI		OR	95% CI	
Medical service area	0.98	0.97–0.99	<0.0001	0.98	0.97–0.99	0.003
No. physicians*	1.01	1.01–1.02	<0.0001	1.01	1.01–1.02	<0.0001
Population density‡	1.03	1.00–1.05	0.06	1.08	0.98–1.12	0.93
Population aged ≥65 years	0.95	0.92–0.97	0.0002	0.97	0.93–1.00	0.054
No. people per household	0.30	0.14–0.63	0.002	1.35	0.69–2.66	0.38
Forest area*	1.00	0.93–1.08	0.98			
Air temperature	1.04	0.98–1.10	0.16			
Sunshine hours	1.00	1.00–1.00	0.33			
Precipitation†	1.02	0.99–1.04	0.22			
Household income†	0.97	0.95–0.99	0.002	0.98	0.95–1.00	0.07
Unemployed persons	1.04	0.92–1.17	0.58			
Employed persons in primary industry	0.95	0.92–0.98	0.002	1.00	0.95–1.05	0.94
Consumer price index	0.92	0.87–0.98	0.01	0.88	0.81–0.95	0.001
Social welfare expenditure	1.16	1.03–1.31	0.01	1.09	0.95–1.25	0.23
Ratio of job vacancies to application	1.17	0.68–2.01	0.57			
Paved municipal roads	1.01	1.00–1.02	0.07	1.00	0.99–1.01	0.95
Public parks area	1.01	0.98–1.03	0.58			

Area under the curve (AUC): * per 10 units increase; † per 100 units increase; ‡ per 1,000 units increase; CI, confidence interval; CR, cardiac rehabilitation; OR, odds ratio.

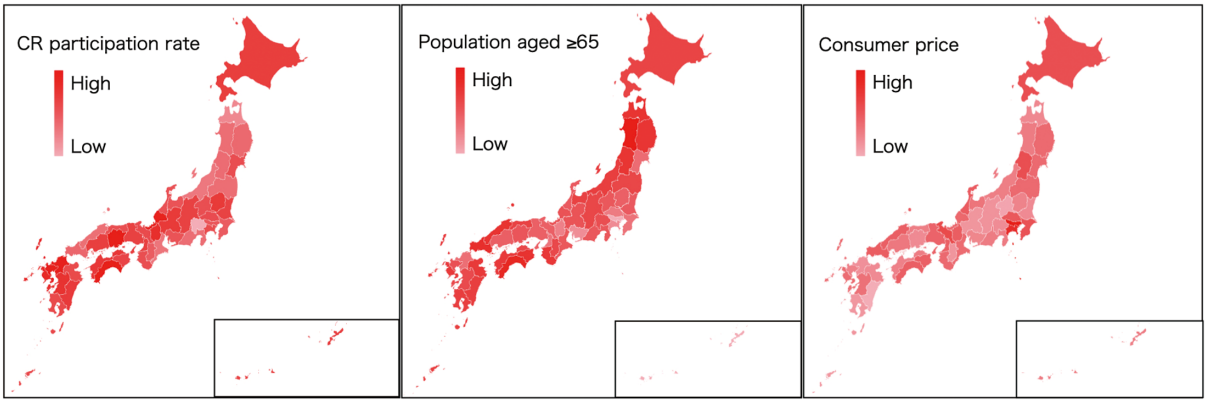

Figure 3. Color mapping of cardiac rehabilitation (CR) participation rate, population aged ≥65 years, and consumer price index. Dark red (or light red) denotes high values (or low values) of each variable.

Results

Of the 1,057 hospitals, 253 were classified as No-CR hospitals. The median CR participation rate of the remaining 803 hospitals was 41.5% (**Figure 2**). **Table 1** shows the comparison of regional characteristics among High-CR, Low-CR, and No-CR hospitals. In multiple comparisons, High-CR hospitals had a significantly smaller medical service area (P<0.0001 and P=0.0003 for comparisons with Low-CR and No-CR hospitals, respectively), a larger number of physicians (P<0.0001 and P<0.0001 for comparisons with Low-CR and No-CR hospitals, respectively), higher population density (P=0.02 and P=0.01 for comparisons with Low-CR and No-CR hospitals, respectively), a lower population aged ≥65years (P=0.03 and P=0.002 for comparisons with Low- and No-CR hospitals, respectively), and number of people per household (P=0.01 and P=0.04 for comparisons with Low-CR and No-CR hospitals, respectively) than the other 2 groups. In the data for Low-CR and No-CR hospitals, results were similar except for the number of physicians (P=0.003).

Regional Characteristics of High-CR Hospitals

We conducted logistic regression analyses to identify variables associated with the regions where High-CR hospitals were located (**Table 2**). The results indicated that a lower consumer price index remained significant even when considering variables related to regional medical data (medical service area and number of physicians). In addition, regions where High-CR hospitals were located

tended to have a lower population aged ≥65 years and lower household incomes. In contrast, climate and industry variables were not significantly associated with High-CR hospitals in multivariable analyses.

As Low-CR hospitals and No-CR hospitals had similar regional characteristics, we conducted logistic regression analyses excluding No-CR hospitals (**Supplementary Table 1**). As a result, the consumer price index remained an independent regional factor characterizing High-CR hospitals.

Prefecture Level Analyses

The color mapping of per-prefecture CR participation rates, population aged ≥65 years, and consumer price index are presented in **Figure 3** (detailed data are presented in **Supplementary Table 2**). Okayama had the highest CR participation rate (62.8%). Moreover, relatively higher CR participation rates were observed in North Kanto (Ibaraki, Tochigi, and Gunma), inland prefectures in Honshu (Nagano, Gifu, and Shiga), as well as Shikoku and Kyushu. The population aged ≥65 years tended to be lower in major metropolitan areas (Tokyo 22.9%; Aichi 25.5%; Kanagawa 25.7%; Osaka 27.7%; Fukuoka 28.2%). Tokyo has the highest (104.5) consumer price index, followed by regions adjacent to Tokyo, including Kanagawa (103.0), Saitama (100.3), and Chiba (100.6).

Discussion

Notably, a well established healthcare system is important for a high CR participation rate. We have shown that regional medical data variables, such as small medical service areas and a larger number of physicians, were significantly associated with High-CR hospitals. Although we focused on the relationship between regional characteristics and CR participation rates in the present study, we do not believe that regional characteristics outweigh institutional medical status in influencing CR participation rates. However, if there are regional characteristics that independently affect CR participation rates instead of medical data, they would provide valuable insights. Last, we also demonstrated that hospitals in regions with a lower consumer price index were independently associated with higher CR participation rates, while a tendency towards a less advanced aging population was observed. Although a lower aging population might suggest an urban setting, lower consumer prices imply rural areas. Tokyo, the capital city of Japan, had the lowest population aged ≥65 years (22.8%) and the highest consumer price index among 47 prefectures (**Supplementary Table 2**, **Supplementary Figure**).

Several previous studies reported disparities in healthcare between urban and rural areas. Sun et al. reported that mortality rates remained higher in rural rather than urban areas in patients with heart failure.[12] Nakayama et al. have shown that the greater the home-to-hospital distance is, the less the participation in outpatient CR programs in patients with heart failure.[13] In contrast, the findings of Van Iterson et al. do not support the generalization of disparities in the utilization of CR between urban and rural areas.[14] Additionally, results of the present study indicate that categorizing and discussing CR participation are challenging based on the dichotomy of urban and rural areas. We identified that both a lower percentage of the population aged ≥65 years, which indicates urban area characteristics, and a lower consumer price index, which indicates rural area characteristics, were associated factors in High-CR hospitals. In Japan, CR participation may be unsuitable for both excessively urban and rural environments, emphasizing the importance of a moderate urban setting. It would be necessary to develop ways to offer CR tailored to the specific regional characteristics in order to promote participation.

We revealed that a lower population aged ≥65 years was not a significant, but a factor approaching significance that characterized the region where High-CR hospitals are located. Previous studies have identified aging as an inhibiting factor for CR participation,[9,15] which is consistent with our results. However, older individuals are at a higher risk of developing hospitalization-associated disability.[16] The low CR participation rate in aging regions can be considered a manifestation of mismatches in the demand and supply of medical resources. In the present study, we also demonstrated that variables reflecting insufficiency in the healthcare system, such as larger medical service areas and smaller numbers of physicians, were regional characteristics of Low-CR and No-CR hospitals. Policy interventions are necessary to allocate sufficient medical resources in areas with advanced aging populations to address the mismatch of medical resources.

Study Limitations

The present study has limitations. First, this study focused on regional characteristics. Consequently, the variables examined were primarily regional characteristics. It is important to note that facility factors such as human resources, interprofessional collaboration, facility size, and CR equipment, as well as patient factors such as severity of illness and comorbidities, are likely to influence participation in CR. This study did not examine these important factors in order to focus on regional characteristics, and this limitation should be interpreted with caution.

Second, as an epidemiological investigation, this study does not definitively establish causation between CR participation rates and regional characteristics. Third, this study was conducted using data from Japan. Therefore, caution should be exercised when extrapolating our results to other countries. Fourth, this study targeted all JCS-certified facilities; however, not all facilities submitted DPC data annually during the study period, leading to missing data and selection bias.

Conclusions

In Japan, hospitals with high CR participation rates were found in regions with a lower consumer price index and a trend towards a lower population aged ≥65 years, indicating that CR participation may be suitable for a moderate urban setting. We suggest that when considering regional factors contributing to CR participation rates, focusing on detailed regional characteristics may be more important than relying on a binary contrast between urban and rural areas.

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Disclosures

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IRB Information

The Ethics Committee of Nippon Medical School approved the study protocol (Institutional Study No. 2022C0015).

Data Availability

The deidentified participant data will not be shared.

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Supplementary Files

Please find supplementary file(s);
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