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ORIGINAL ARTICLE
Cardiac Rehabilitation

Hospital-Level Variation in Cardiac Rehabilitation After Myocardial Infarction in Japan During Fiscal Years 2014–2015 Using the National Database

Jun Komiyama; Takehiro Sugiyama, MD, PhD; Masao Iwagami, MD, PhD; Miho Ishimaru, PhD; Yu Sun, MD, PhD; Hiroki Matsui; Keitaro Kume, PhD; Masaru Sanuki, PhD; Teruyuki Koyama, MD, PhD; Genta Kato, MD, PhD; Yukiko Mori, MD, PhD; Hiroaki Ueshima, PhD; Nanako Tamiya, MD, PhD

Background: Cardiac rehabilitation (CR) is an evidence-based medical service for patients with acute myocardial infarction (AMI); however, its implementation is inadequate. We investigated the provision status and equality of CR by hospitals in Japan using a comprehensive nationwide claims database.

Methods and Results: We analyzed data from the National Database of Health Insurance Claims and Specific Health Checkups in Japan for the period April 2014–March 2016. We identified patients aged ≥20 years with postintervention AMI. We calculated hospital-level proportions of inpatient and outpatient CR participation. The equality of hospital-level proportions of inpatient and outpatient CR participation was evaluated using the Gini coefficient. We included 35,298 patients from 813 hospitals for the analysis of inpatients and 33,328 patients from 799 hospitals for the analysis of outpatients. The median hospital-level proportions of inpatient and outpatient CR participation were 73.3% and 1.8%, respectively. The distribution of inpatient CR participation was bimodal; the Gini coefficients of inpatient and outpatient CR participation were 0.37 and 0.73, respectively. Although there were statistically significant differences in the hospital-level proportion of CR participation for several hospital factors, CR certification status for reimbursement was the only visually evident factor affecting the distribution of CR participation.

Conclusions: The distributions of inpatient and outpatient CR participation by hospitals were suboptimal. Further research is warranted to determine future strategies.

Key Words: Acute myocardial infarction; Cardiac rehabilitation; Evidence-practice gap; National database

Cardiac rehabilitation (CR) is an evidence-based program for coronary artery disease that reduces hospital readmission and mortality and improves physical function and quality of life.[1–5] CR for acute myocardial infarction (AMI) after percutaneous coronary intervention (PCI) is recommended by some clinical practice guidelines, including the Japanese guidelines.[2–4] In Japan, CR is covered by public health insurance and implemented at certified institutions that are approved to provide CR to patients with heart disease.

Several countries, including Japan, have reported suboptimal CR participation.[6–8] A previous study that used the National Database of Health Insurance Claims and Specific Health Checkups of Japan (NDB) showed a low proportion of CR participation among outpatients with coronary artery disease.[9] However, that study did not report

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Graduate School of Comprehensive Human Sciences (J.K., Y.S.), Department of Health Services Research, Institute of Medicine (J.K., T.S., M. Iwagami, Y.S., N.T.), Health Services Research and Development Center (T.S., M. Iwagami, M. Ishimaru, Y.S., H.U., N.T.), Department of Clinical Medicine (K.K., M.S.), University of Tsukuba, Tsukuba; Diabetes and Metabolism Information Center, Research Institute (T.S.), Institute for Global Health Policy, Bureau of International Health Cooperation (T.S.), National Center for Global Health and Medicine, Tokyo; Department of Oral Health Promotion, Graduate School of Medical and Dental Sciences, Tokyo Medical and Dental University, Tokyo (M. Ishimaru); Department of Clinical Epidemiology and Health Economics, School of Public Health, University of Tokyo, Tokyo (H.M.); Department of Rehabilitation, Kameda Medical Center, Kamogawa (T.K.); Solutions Center for Health Insurance Claims (G.K.), Division of Medical Information Technology and Administration Planning (Y.M.), Kyoto University Hospital, Kyoto; and Center for Innovative Research and Education in Data Science, Institute for Liberal Arts and Sciences, Kyoto University, Kyoto (H.U.), Japan

Mailing address: Takehiro Sugiyama, MD, PhD, Department of Health Services Research Institutes of Medicine, Building #861, University of Tsukuba, 1-1-1 Tenno-dai, Tsukuba 305-8575, Japan. email: tsugiyama@md.tsukuba.ac.jp

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on the proportion of CR participation in hospitals. Because AMI is an emergency condition, patients cannot choose to be admitted to a qualified hospital beforehand, especially considering accessibility to inpatient and outpatient CR and how many patients are taking part in CR at a given hospital. Inequality in the provision of inpatient and outpatient CR among hospitals could deprive patients with AMI of the opportunity to take part in CR. However, to the best of our knowledge, no studies have examined CR participation status and its inequality in hospitals in Japan.

Therefore, in the present study, we investigated the proportions of inpatient and outpatient CR participation among postoperative patients with AMI at the hospital level, as well as inequalities in CR participation, using the NDB. We also examined the association between the hospital-level proportions of inpatient and outpatient CR participation and hospital characteristics obtained from the NDB.

Methods

Data Source

We conducted an observational study using the NDB, a Japanese administrative claims database provided by the Ministry of Health, Labour and Welfare (MHLW). The NDB covers approximately 98% of the data on healthcare services provided by healthcare institutions[10] and excludes medical practices not reimbursed by health insurance. The NDB contains claims information, including anonymous individual identification numbers, age, sex, disease code, medical care procedures and drug prescriptions. We extracted data from the NDB for patients with at least 1 recorded diagnosis of AMI or implementation of PCI or coronary artery bypass grafting (CABG) between April 2014 and March 2016. In this study, the authors obtained the NDB data, and less than 1,000 disease codes and Japan-specific procedure codes were excluded in advance.

Table 1. Participant and Hospital Characteristics

	Inpatient CR				Outpatient CR			
	Overall	No CR	CR	P value	Overall	No CR	CR	P value
Total (n)	35,298	13,908	21,390		33,328	29,934	3,394	
Participant characteristics								
Age category (years)				<0.001				<0.001
20–39	404 (1.1)	184 (1.3)	220 (1.0)		390 (1.2)	337 (1.1)	53 (1.6)	
40–49	2,444 (6.9)	937 (6.7)	1,507 (7.0)		2,358 (7.1)	2,048 (6.8)	310 (9.1)	
50–59	4,708 (13.3)	1,792 (12.9)	2,916 (13.6)		4,542 (13.6)	3,943 (13.2)	599 (17.6)	
60–69	9,831 (27.9)	3,840 (27.6)	5,991 (28.0)		9,414 (28.2)	8,325 (27.8)	1,089 (32.1)	
70–79	11,149 (31.6)	4,554 (32.7)	6,595 (30.8)		10,502 (31.5)	9,454 (31.6)	1,048 (30.9)	
80–89	6,161 (17.5)	2,409 (17.3)	3,752 (17.5)		5,594 (16.8)	5,594–y (–)	y (–)	
≥90	601 (1.7)	192 (1.4)	409 (1.9)		528 (1.6)	528–x (–)	x (–)	
Male sex	26,996 (76.5)	10,676 (76.8)	16,320 (76.3)	0.321	25,645 (76.9)	22,881 (76.4)	2,764 (81.4)	<0.001
CABG	6,700 (19.0)	1,588 (11.4)	5,112 (23.9)	<0.001	6,111 (18.3)	5,488 (18.3)	623 (18.4)	0.993
PCI	28,598 (81.0)	12,320 (88.6)	16,278 (76.1)	<0.001	27,217 (81.7)	24,446 (81.7)	2,771 (81.6)	0.993
Hypertension	30,609 (86.7)	12,114 (87.1)	18,495 (86.5)	0.089	28,965 (86.9)	26,063 (87.1)	2,902 (85.5)	0.011
Dyslipidemia	29,576 (83.8)	11,686 (84.0)	17,890 (83.6)	0.343	28,225 (84.7)	25,294 (84.5)	2,931 (86.4)	0.005
Diabetes	18,382 (52.1)	7,362 (52.9)	11,020 (51.5)	0.01	17,273 (51.8)	15,612 (52.2)	1,661 (48.9)	<0.001
Atrial fibrillation	4,791 (13.6)	1,923 (13.8)	2,868 (13.4)	0.269	4,394 (13.2)	4,018 (13.4)	376 (11.1)	<0.001
Heart failure	21,034 (59.6)	8,059 (57.9)	12,975 (60.7)	<0.001	19,714 (59.2)	17,746 (59.3)	1,968 (58.0)	0.15
Cerebrovascular disease	8,723 (24.7)	3,664 (26.3)	5,059 (23.7)	<0.001	7,863 (23.6)	7,255 (24.2)	608 (17.9)	<0.001
COPD	1,571 (4.5)	629 (4.5)	942 (4.4)	0.616	1,465 (4.4)	1,329 (4.4)	136 (4.0)	0.262
Cancer	3,403 (9.6)	1,389 (10.0)	2,014 (9.4)	0.079	3,167 (9.5)	2,908 (9.7)	259 (7.6)	<0.001
CKD	3,988 (11.3)	1,741 (12.5)	2,247 (10.5)	<0.001	3,481 (10.4)	3,257 (10.9)	224 (6.6)	<0.001
ECMO use	391 (1.1)	131 (0.9)	260 (1.2)	0.019	258 (0.8)	204 (0.7)	54 (1.6)	<0.001
IABP use	5,415 (15.3)	1,735 (12.5)	3,680 (17.2)	<0.001	4,728 (14.2)	4,129 (13.8)	599 (17.6)	<0.001
NPPV or respirator use	7,755 (22.0)	2,166 (15.6)	5,589 (26.1)	<0.001	6,659 (20.0)	5,897 (19.7)	762 (22.5)	<0.001
Catecholamine use	19,514 (55.3)	6,918 (49.7)	12,596 (58.9)	<0.001	17,979 (53.9)	16,153 (54.0)	1,826 (53.8)	0.873
ACEI or ARB	21,619 (61.2)	7,772 (55.9)	13,847 (64.7)	<0.001	20,458 (61.4)	18,076 (60.4)	2,382 (70.2)	<0.001
β-blocker	24,779 (70.2)	8,494 (61.1)	16,285 (76.1)	<0.001	23,330 (70.0)	20,640 (69.0)	2,690 (79.3)	<0.001
Diuretics	12,293 (34.8)	3,958 (28.5)	8,335 (39.0)	<0.001	10,997 (33.0)	9,890 (33.0)	1,107 (32.6)	0.633
Statin	28,561 (80.9)	10,539 (75.8)	18,022 (84.3)	<0.001	27,143 (81.4)	24,168 (80.7)	2,975 (87.7)	<0.001

(**Table 1** continued the next page.)

	Inpatient CR				Outpatient CR			
	Overall	No CR	CR	P value	Overall	No CR	CR	P value
Institution characteristics[A]								
CR certification				<0.001				<0.001
Class 1	29,419 (83.7)	8,457 (61.1)	20,962 (98.4)		27,888 (83.7)	24,528 (81.9)	3,360 (99.0)	
Class 2	849 (2.4)	499 (3.6)	350 (1.6)		805 (2.4)	805–x (–)	x (–)	
No certification	4,886 (13.9)	4,886 (13.9)	0 (0.0)		4,635 (13.9)	4,606 (15.4)	34–x (–)	
Bed size	31,930 (90.8)	12,680 (91.6)	19,250 (90.3)	<0.001	30,242 (90.7)	27,214 (90.9)	3,028 (89.2)	0.001
Type of hospital				<0.001				<0.001
Special function hospitals	3,960 (11.3)	1,610 (11.6)	2,350 (11.0)		3,681 (11.0)	3,193 (10.7)	488 (14.4)	
Regional medical care support hospitals	19,002 (54.1)	6,934 (50.1)	12,068 (56.6)		18,025 (54.1)	16,300 (54.5)	1,725 (50.8)	
Other hospitals	12,192 (34.7)	5,298 (38.3)	6,894 (32.3)		11,622 (34.9)	10,441 (34.9)	1,181 (34.8)	
No. patients with AMI admitted per month				<0.001				0.001
Low	4,332 (12.3)	2,153 (15.6)	2,179 (10.2)		4,094 (12.3)	3,743 (12.5)	351 (10.3)	
Middle	9,025 (25.7)	3,622 (26.2)	5,403 (25.4)		8,525 (25.6)	7,618 (25.4)	907 (26.7)	
High	21,797 (62.0)	8,067 (58.3)	13,730 (64.4)		20,709 (62.1)	18,573 (62.0)	2,136 (62.9)	
No. PCI or CABG procedures per month				<0.001				0.255
Low	4,434 (12.6)	2,230 (16.1)	2,204 (10.3)		4,232 (12.7)	3,818 (12.8)	414 (12.2)	
Middle	9,492 (27.0)	3,914 (28.3)	5,578 (26.2)		8,970 (26.9)	8,084 (27.0)	886 (26.1)	
High	21,228 (60.4)	7,698 (55.6)	13,530 (63.5)		20,126 (60.4)	18,032 (60.2)	2,094 (61.7)	

Unless indicated otherwise, data are presented as n (%). In the publication of data using the National Database of Health Insurance Claims and Specific Health Checkups of Japan, the publication of information on <10 people is not permitted to ensure privacy protection. Therefore, information on <10 people was masked using "x" and "y". [A]Counted by patients who underwent percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG). ACEI, angiotensin-converting enzyme inhibitor; AMI, acute myocardial infarction; ARB, angiotensin II receptor blocker; CABG, coronary artery bypass grafting; CKD, chronic kidney disease; COPD, chronic obstructive pulmonary disease; CR, cardiac rehabilitation; ECMO, extracorporeal membrane oxygenation; IABP, intra-aortic balloon pumping; NPPV, non-invasive positive pressure ventilation.

Study Population

We identified patients aged ≥20 years with postintervention AMI who had a record of at least 1 PCI or CABG and a diagnosis of AMI in the period October 2014–September 2015. AMI was defined using the International Classification of Disease, Tenth Revision (ICD-10) codes I21x and I22x. We defined each intervention using the relevant category of Japan-specific procedure codes (PCI: K546, K547, K548, K549, K550, and K550-2; CABG: K552 and K552-2). If there were more than 2 interventions in different months, the earliest intervention was considered the index event. For the analysis of inpatient and outpatient CR, different exclusion criteria were used to define the respective study populations. These criteria were used to limit the study participants to determine those more eligible for CR. A detailed explanation of these exclusion criteria is provided in **Supplementary Table 1**.

The hospitals included in this study were those where eligible patients underwent PCI or CABG. Finally, we excluded hospitals with <10 eligible patients and those who were admitted, according to the NDB utilization regulations of the MHLW.

CR Participation Status

In Japan, patients with heart disease can participate in CR for 5 months after the first CR session. In this study we identified inpatient and outpatient CR participation status. Inpatient CR participation was defined as having at least 1 reimbursement for CR (treatment codes: 180027410, 180027510) at the hospital where the patient underwent PCI or CABG. Outpatient CR participation was defined as having at least 1 reimbursement for CR within 3 months of discharge.[9,11] If the patient was transferred to another hospital, except for long-term medical care hospitals and convalescent hospitals, we obtained CR information for 3 months from the time the patient was discharged from the last hospital.

Hospital- and Patient-Level Information

We collected the following hospital characteristics as binary or categorical variables: CR certification status (categorized as no CR certification, Class 2 CR certification, or Class 1 CR certification), number of beds (categorized as 0–199 or ≥200), type of hospital (categorized as regional medical care support hospitals, special function hospitals, or other hospitals), number of patients with AMI per month (categorized based on tertiles as low, middle, or high; see **Table 1**), and the number of PCI and CABG procedures per month (categorized based on tertiles as low, middle, or high; see **Table 1**). In Japan, hospitals require certification of their CR facilities to provide CR to patients under public health insurance. The CR hospital standards for certification are divided into Class 1 and Class 2. Class 1 CR certification requires more medical staff than Class 2 CR certification; however, the reimbursement of medical fees to hospitals is higher for Class 1 CR certification. In this study, we focused on hospital types with 2 distinct functions: regional medical care support hospitals and special function hospitals. Regional medical care support hospitals have ≥200 beds and have been certified by the prefectural government as core hospitals for the provision of normal medical care in each secondary medical area.[12] Special function hospitals have ≥400 beds and have been certified by the MHLW to provide advanced medical care and training, and to develop medical technology.[12] The number of patients with AMI per month was calculated on the basis of the number of study participants admitted to each hospital.

Information was collected for the following patient characteristics: age, sex, type of intervention (PCI or CABG), comorbidities, the use of extracorporeal membrane oxygenation (ECMO), intra-aortic balloon pumping (IABP), the use of non-invasive positive pressure ventilation or a respirator, and prescribed medication. Age was categorized into the follow groups: 20–39, 40–49, 50–59, 60–69, 70–79, 80–89, and ≥90 years. We identified 9 comorbidities (hypertension, dyslipidemia, diabetes, atrial fibrillation, chronic heart failure, cerebrovascular disease, chronic obstructive pulmonary disease, cancer, and chronic kidney disease) using the ICD-10 codes from claims data for the 6 months prior to the admission date for AMI. The medications prescribed during hospitalization included catecholamines, β-blockers, angiotensin-converting enzyme inhibitors or angiotensin II receptor blockers, diuretics, and statins.

Statistical Analysis

Initially, we described patient characteristics, hospital information, and CR participation status for all patients. We compared patient characteristics with and without inpatient and outpatient CR participation using the Chi-squared test for binary variables and the Wilcoxon rank-sum test for ordinal variables. Thereafter, we calculated the proportions of inpatient and outpatient CR participation in each hospital. We focused our analysis on the hospital-level proportion of CR participation. Subsequently, we showed the distribution of hospital-level proportions of inpatient and outpatient CR participation overall and by hospital characteristics. The proportions of inpatient and outpatient CR participation according to different variables were compared using the Wilcoxon rank-sum test. Bonferroni correction was performed when variables relating to hospital characteristics were categorized into 3 groups.

We drew Lorenz curves and thereafter calculated the Gini coefficient to evaluate the equality of the proportions of inpatient and outpatient CR participation by each hospital. Lorenz curves and the Gini coefficient were originally used to analyze income distribution and inequality; however, this method has been used to analyze inequality in medical staff and the utilization of medical services.[13,14]

We also calculated the proportions of inpatient and outpatient CR participation by prefecture and present the results in a centipede plot. Spearman's rank correlation was used to determine the relationship between the hospital-level proportion of CR participation and population density. Population density by prefecture was calculated using the population data from the 2015 Census of Japan[15] and prefecture area from the 2015 Municipalities Area Statistics of Japan.[16] In addition, to investigate CR participation status by prefecture, independent of patient and hospital characteristics, we estimated the proportion of CR participation adjusted for patient and hospital characteristics. Therefore, we conducted a multivariable logistic regression analysis, with the outcomes being inpatient and outpatient CR participation. The covariates were age, sex, type of intervention, comorbidities, the use of ECMO, IABP, the use of non-invasive positive pressure ventilation or a respirator, prescribed medication, CR certification status, number of patients with AMI per month, number of PCI and CABG procedures per month, number of beds, and type of hospital. Thereafter, we used logistic regression models for marginal standardization and obtained a marginal proportion of inpatient and outpatient CR participation.

In addition, we calculated the hospital-level proportion of outpatient CR participation only for participants who took part in inpatient CR. Subsequently, we calculated the Gini coefficient and described the distributions of the hospital-level proportion of overall outpatient CR participation by hospital characteristics and using a centipede plot. We used the logistic regression models to obtain the marginal proportions of inpatient and outpatient CR participation by prefecture.

We conducted all statistical analyses in Stata version 15.0 (StataCorp, College Station, TX, USA). Statistical significance was set at 2-sided $P<0.05$.

Ethical Considerations

This study was approved by the Ethics Committee of the University of Tsukuba (Approval no. 1476-2). The need for informed consent from individuals was waived because the NDB data were anonymized before they were made available to the researchers.

Results

Study Participants and Characteristics

The participants for the analysis of inpatients were 35,298 patients from 813 hospitals, whereas the participants for the analysis were 33,328 patients from 799 hospitals. The flowchart in **Figure 1** shows the process of selecting study participants. Participant characteristics are presented in **Table 1**.

Proportion of CR Participation by Hospitals and Prefectures

Table 2 presents the median and interquartile range (IQR) of proportions of inpatient and outpatient CR participation overall and according to hospital characteristics. The median hospital-level proportion of inpatient and outpatient CR participation was 73.3% (IQR 9.5–90.9%) and 1.8% (IQR 0.0–13.3%), respectively. The median hospital-level proportion of CR participation for both inpatients and outpatients was larger for Class 1 CR certification than for the other certification statuses. For inpatient CR, hospitals with <200 beds had a larger hospital-level proportion of CR participation than those with ≥200 beds. Hospitals with fewer AMI patients per month had smaller hospital-level proportions of inpatient and outpatient CR participation than the other groups. Hospitals with fewer PCI and CABG procedures per month had smaller hospital-level proportions of inpatient and outpatient CR participation than the other groups. Special function

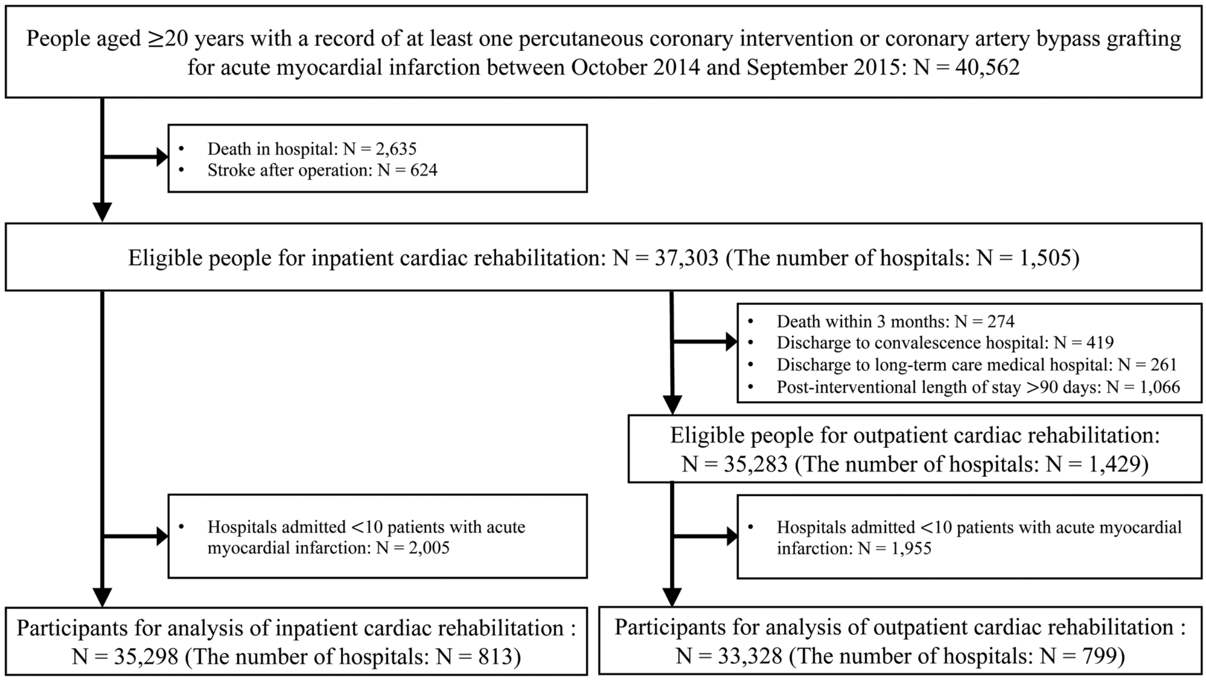

Figure 1. Flowchart showing the selection of study participants.

Table 2. Hospital-Level Proportions of Inpatient and Outpatient CR Participation by Hospital Characteristic

	Inpatient CR				Outpatient CR			
	n	Median	IQR	P value	n	Median	IQR	P value
Total	813	73.3	9.5–90.9	–	799	1.8	0.0–13.3	–
CR certification								
Class 1 (a)	619	83.9	61.5–93.3	a vs. b: <0.001	610	4.9	0.0–18.9	a vs. b: <0.001
Class 2 (b)	26	39.0	14.3–74.6		26	0.0	0.0–0.0	a vs. c: <0.001
No certification (c)	168	0.0	0.0–0.0		163	0.0	0.0–0.0	b vs. c: 1.000
Bed size								
<200	96	87.2	22.2–95.2	0.004	92	4.4	0.0–13.8	0.305
≥200	717	72.5	8.0–89.7		707	1.7	0.0–13.3	
Type of hospital								
Special function hospitals (a)	79	70.0	43.0–86.5	a vs. b: 1.000	77	7.4	0.9–18.1	a vs. b: 0.002
Regional medical care support hospitals (b)	379	75.3	18.2–90.9	a vs. c: 1.000	375	1.8	0.0–11.7	a vs. c: 0.002
Other hospitals (c)	355	72.7	0.0–91.7	b vs. c: 1.000	347	0.0	0.0–13.3	b vs. c: 1.000
No. patients with AMI admitted per month								
Low (a)	262	61.5	0.0–90.9	a vs. b: 0.030	270	0.0	0.0–9.1	a vs. b: 0.013
Middle (b)	270	78.0	20.5–92.3	a vs. c: 0.044	264	2.7	0.0–12.9	a vs. c: <0.001
High (c)	281	75.3	36.7–88.3	b vs. c: 1.000	265	3.3	0.0–15.4	b vs. c: 0.291
No. PCI or CABG procedures per month								
Low (a)	271	53.8	0.0–92.3	a vs. b: 0.031	264	0.0	0.0–10.0	a vs. b: 0.002
Middle (b)	271	76.1	20.5–92.0	a vs. c: 0.014	269	3.2	0.0–11.9	a vs. c: <0.001
High (c)	271	75.8	42.3–88.2	b vs. c: 1.000	266	3.4	0.0–16.5	b vs. c: 0.318

IQR, interquartile range. Other abbreviations as in Table 1.

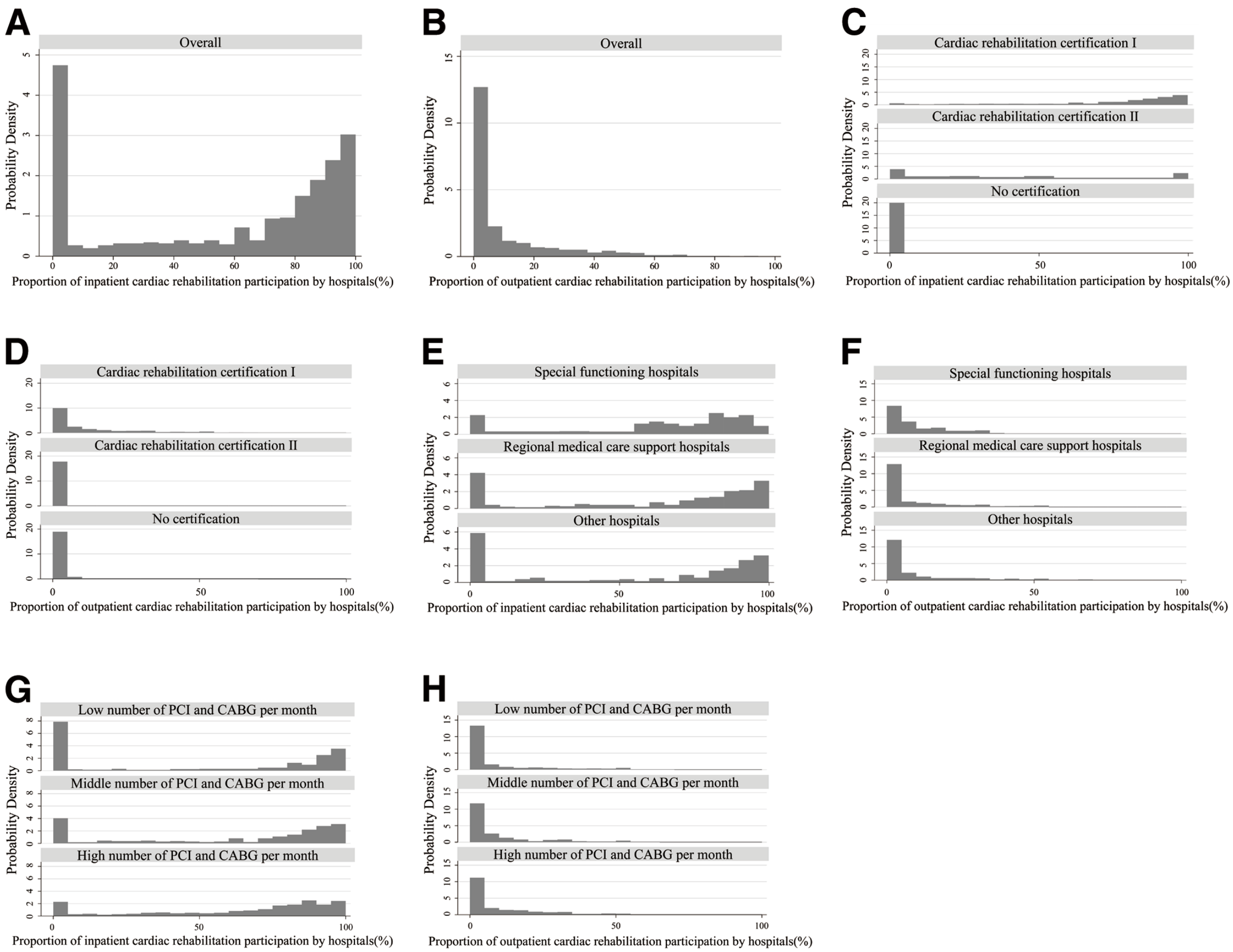

Figure 2. Histograms showing the distribution of the hospital-level proportions of inpatient and outpatient cardiac rehabilitation (CR) participation overall and according to hospital characteristics. According to the National Database of Health Insurance Claims and Specific Health Checkups of Japan utilization regulations of the Ministry of Health, Labour and Welfare, we cannot show columns with <3 hospitals in the histogram; thus, we leveled these columns with nearer columns and showed histograms with probability density plotted on the vertical axis. (**A**,**B**) Overall inpatient (**A**; n=813) and outpatient (**B**; n=799) CR. (**C**) Inpatient CR according to certification status (Class 1: n=619; Class 2: n=26; no certification: n=168). (**D**) Outpatient CR according to certification status (Class 1: n=610; Class 2: n=26; no certification: n=163). (**E**) Inpatient CR according to type of hospital (special function hospitals: n=79; regional medical care support hospitals: n=379; other hospitals: n=355). (**F**) Outpatient CR according to type of hospital (special function hospitals: n=77; regional medical care support hospitals: n=357; other hospitals: n=347). (**G**) Inpatient CR according to the number of percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) procedures per month (low: n=271; middle: n=271; high: n=271). (**H**) Outpatient CR according to the number of PCI and CABG procedures per month (low: n=264; middle: n=269; high: n=266).

hospitals had a larger hospital-level proportion of CR participation than other types of hospitals for outpatient CR. **Figure 2** and **Supplementary Figure 1** illustrate the distributions of the hospital-level proportions of inpatient and outpatient CR participation, aggregately and according to hospital characteristics. The distribution of the hospital-level proportion of inpatient CR was bimodal, with peaks near 0% and 100%. The distribution of the hospital-level proportion of outpatient CR was skewed to the right, with a peak closer to 0%. The distribution of the hospital-level proportion of inpatient CR differed by CR certification status. There were no major differences in the distribution for other hospital-level characteristics. Approximately 23.3% of hospitals did not provide any inpatient CR, and 46.7% did not provide any outpatient CR.

Supplementary Figure 2 shows the Lorenz curves of the hospital-level proportions of inpatient and outpatient CR participation. The Gini coefficients of the hospital-level proportions of inpatient and outpatient CR participation were 0.37 and 0.73, respectively.

Figure 3 shows the distribution of the hospital-level proportions of inpatient and outpatient CR participation by prefecture as a centipede plot. The median hospital-level proportion of CR participation by prefecture ranged from 0.0% to 97.2% (between-prefecture difference) for inpatient CR. Within-prefecture differences in the median of the hospital-level proportion of CR participation ranged from a maximum of 0.0–100.0% to a minimum of 83.0–90.9%.

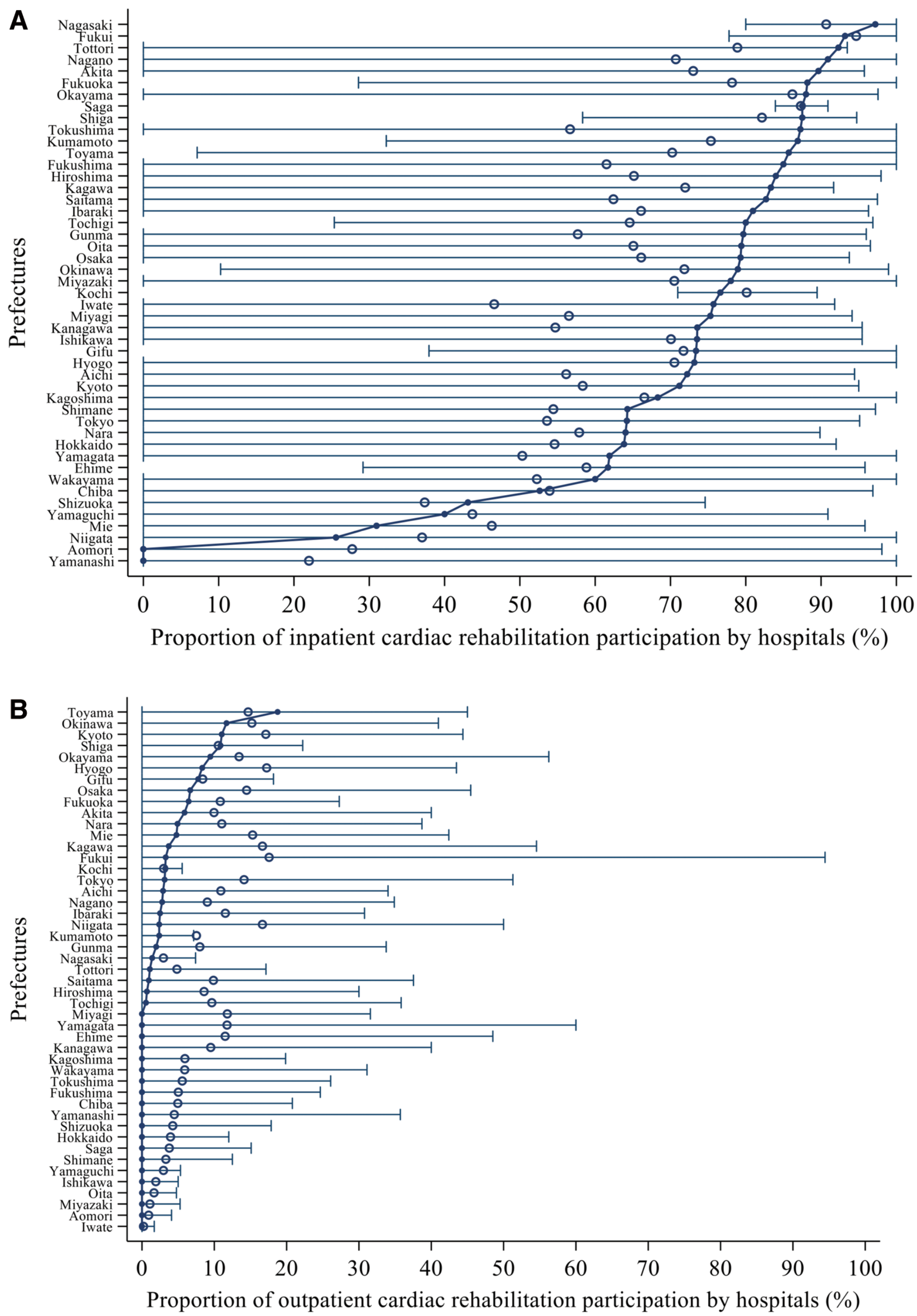

Figure 3. Centipede plots showing the distributions of the hospital-level proportions of (**A**) inpatient and (**B**) outpatient cardiac rehabilitation (CR) participation by prefecture. The centipede plots show both within- and between-prefecture differences in the hospital-level proportion of CR participation. Between-prefecture differences are expressed as the median (filled symbols) or mean (open symbols) of the proportion of CR participation. Within-prefecture differences are represented by the whiskers, which show the 10th to 90th percentiles of the proportion of CR participation. Prefectures are sorted by the median level of CR participation.

The median hospital-level proportion of CR participation by prefecture ranged from 0.0% to 18.8% (between-prefecture difference) for outpatient CR. Within-prefecture differences in the median of the hospital-level proportion of CR participation ranged from a maximum of 0.0–94.4% to a minimum of 0.0–1.7%. The hospital-level proportion of CR participation and population density for each prefecture are presented in **Supplementary Table 2**. **Supplementary Figure 3** shows scatterplots of the hospital-level proportion of inpatient and outpatient CR participation and population density. Regarding the relationship between the hospital-level proportion of CR participation and population density, only outpatient CR had a significant but weak correlation with population density (inpatient CR: ρ=0.02, P=0.873; outpatient CR: ρ=0.38, P=0.008).

Supplementary Table 3 and **Supplementary Figure 4** show the crude and covariate-adjusted proportions of inpatient and outpatient CR by prefecture. Regional differences were observed, despite adjustments for covariates.

In addition, we performed the same analysis as above but restricting the patients to those who participated in inpatient CR. This additional analysis showed similar results to the main analysis (**Supplementary Tables 4,5**; **Supplementary Figures 5–7**).

Discussion

This study described the hospital-level proportions of inpatient and outpatient CR participation by hospital characteristics and prefectures. The median hospital-level proportions of inpatient and outpatient CR participants were 73.3% and 1.8%, respectively. The hospital-level proportion of inpatient CR participation was bimodal; a large inequality in terms of the Gini coefficient was found among hospitals for outpatient CR provision. Several hospital characteristics were associated with CR provision by hospitals, including CR certification status, the number of beds, and the type of hospital. Of these, the bimodality of inpatient CR participation was explained primarily by CR certification status. Outpatient CR provision was low overall, regardless of hospital characteristics. The distribution of inpatient and outpatient CR participation by hospitals varied both between and within prefectures. To our knowledge, this is the first study showing the hospital-level distribution of CR participation in Japan using a nationwide database.

In other countries, because CR is often provided in an outpatient setting, most studies on CR have focused on outpatient CR. It was reported that the proportion of outpatient CR participation for patients with AMI in Japan was lower than that in the US.[6] This difference may be related to CR being considered an outpatient and home-based treatment, and activities were conducted with a clear goal of increasing the proportion of outpatient CR in the US.[17] In Japan, a few previous studies used Japanese claims data to investigate the proportion of CR participation.[9,18,19] These studies investigated the proportion of individuals participating in CR among patients with coronary artery disease. However, to the best of our knowledge, the distributions of the hospital-level proportion of CR participation have not been reported previously.

The median proportion of outpatient CR participation by hospitals was much smaller than that of inpatient CR participation. Inequality by hospitals existed for both inpatient and outpatient CR; however, the expression of inequality differed. The distribution of the proportion of inpatient CR participation was a bimodal, with more than half the hospitals having >70% inpatient CR participation. In contrast, 20.4% of hospitals where PCI or CABG was performed did not have CR certification and therefore did not conduct any inpatient CR. Because CR is recommended for patients who undergo PCI or CABG, hospitals that perform these 2 procedures should have a system to provide CR. However, the Cerebrovascular and Cardiovascular Disease Control Act was enacted in Japan on December 1, 2019.[20] This Act encourages CR and may have had an influence on the current situation. Indeed, the number of CR-certified hospitals has been reported to be increasing annually.[21,22] Although this problem may have improved, further research should clarify this point. In terms of the Gini coefficient, inequality was more significant for the provision of outpatient than inpatient CR. The proportion of outpatient CR participation was low, at approximately 10%. Although most hospitals had outpatient CR participation in the range 0–5%, a few hospitals had participation ≥50%. This may be related to the interest in outpatient CR of physicians at hospitals where PCI or CABG are performed and whether there are hospitals nearby that patients could be referred to for outpatient CR. Indeed, physician interest in outpatient CR and referral to outpatient CR have been reported as important factors for patient participation in outpatient CR.[22,23] For both inpatient and outpatient CR, in addition to the initiative to increase the number of CR-certified hospitals, the criteria for CR hospital certification may also be reconsidered.

The difference in the proportions of inpatient CR participation by CR certification status was visually evident. In contrast, the proportions of inpatient and outpatient CR participation by hospitals also differed significantly by several hospital characteristics; however, it was not visually evident, suggesting a relatively weak association. The human resources of each hospital, hospital location, and whether the hospital has a system to provide CR to patients may be relevant to the proportion of CR participation,[24–27] although this information was not available for the present study. Further research is warranted to investigate more detailed information that cannot be obtained from claims data, as well as to clarify factors related to the hospital-level proportion of CR participation.

Variations in the hospital-level proportions of inpatient and outpatient CR participation were observed among and within prefectures, with much lower median and mean values for outpatient CR participation. Differences between prefectures were observed even after adjusting for patient and hospital characteristics. The geographical variation shown in previous studies[18] was also observed in the present study. Further, in the present study, variations within prefectures were also found. Population density was not associated with the hospital-level proportion of inpatient CR participation, but was weakly correlated with the hospital-level proportion of outpatient CR participation. A previous study suggested that the distance between hospital and home was associated with outpatient CR participation.[28–30] Therefore, it is possible that poor transportation access was associated with a low proportion of outpatient CR participation in some low-density areas. Although it is important for each hospital to make efforts to improve the CR participation, cross-hospital and health policy measures such as regional collaboration are desirable to narrow the gap in CR participation between rural and urban areas. Particularly in rural areas, developing effective remote CR could promote recovery-phase CR, including outpatient CR, while overcoming geographical barriers.

This study has some limitations. First, hospitals that changed their hospital identification numbers may have been treated as different hospitals because the present study used anonymous hospital identification numbers listed in the NDB. Second, we were only able to examine hospital characteristics obtained from the NDB. Therefore, we were unable to examine the human resources of hospitals and their systems. Third, although the study participants were selected to include patients with AMI as accurately as possible, some patients with coronary artery diseases other than AMI may have been included. Finally, we used data from April 2014 to March 2016; therefore, the findings may not necessarily represent the current situation. Future studies using the latest data will be useful for evaluating the current medical fee system with respect to CR.

Conclusions

The proportion of CR participation in Japanese hospitals varied greatly for both inpatient and outpatient CR. In particular, the proportion of outpatient CR participation was low in many Japanese hospitals. Prefectural-level analysis suggested the need for measures to reduce urban–rural gaps in the provision of outpatient CR and to resolve geographic problems. A factor that was visually evident and associated with the provision of inpatient CR was the hospital's CR certification status. Further research is warranted to determine future strategies.

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Disclosures

All authors declare that they have no conflicts of interest. All authors meet the ICMJE criteria for authorship.

IRB Information

This study was approved by the Ethics Committee of the University of Tsukuba (Approval no. 1476-2).

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Supplementary Files

Please find supplementary file(s);
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