Underuse of Cardiac Rehabilitation in Workers With Coronary Artery Disease — Claims Database Survey in Japan —

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Background: Workers with coronary artery disease (CAD) require evidence-based care in order to return to work safely. We assessed the use of cardiac rehabilitation (CR) among workers with CAD, and identified the factors associated with CR use.

Methods and Results: A retrospective cohort study based on data from a health insurance claims database was conducted. We identified workers aged ≥ 18 years who underwent percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG) between 2006 and 2013, and reviewed the utilization of inpatient or outpatient CR. Logistic regression was used to identify the factors associated with CR use. A total of 1,699 patients were included. The frequency of inpatient and outpatient CR use was 23.7% ($n=402$) and 4.2% ($n=72$), respectively. Patients diagnosed with ST-elevated myocardial infarction were most likely to receive inpatient CR, and patients undergoing CABG were more likely to receive inpatient CR than those undergoing PCI. Moreover, inpatient CR use was associated with longer hospitalization duration, catecholamine use, and no history of chronic kidney disease. Furthermore, both unstable and stable angina were negatively correlated with outpatient CR use.

Conclusions: Most of the Japanese workers with CAD in this study did not undergo CR. The type of CAD was strongly associated with inpatient and outpatient CR use. Thus, a strong evidence-practice gap exists in secondary preventative care within this group of patients.

Key Words: Cardiac rehabilitation; Coronary artery disease; Insurance claims; Workers

Coronary artery disease (CAD) is a major social burden worldwide.¹ Because of recent improvements in CAD survival rates,² secondary prevention has been receiving greater attention in many countries, including Japan.³ Cardiac rehabilitation (CR) is a type of secondary preventative care that significantly improves the morbidity and mortality rates;^{4,5} hence, many cardiology societies strongly recommend CR for patients with CAD, including stable angina and myocardial infarction, as well as for patients undergoing percutaneous coronary intervention (PCI) or coronary artery bypass grafting (CABG).^{6–8}

Previous reports suggest that the use of CR remains sub-optimal in many countries.^{9–13} To address this problem, studies have investigated the medical and social profiles of patients with heart disease, and identified the factors associated with CR use.^{9,10,14–17} However, these studies have primarily focused on elderly patients, and hence, little is known about the status or modality of CR utilization among working-age CAD patients. Recurrent coronary events in these patients would not only lead to huge direct care costs, but also to large indirect costs in terms of lost

wages, lost productivity, and cardiac disability. Hence, the provision of evidence-based secondary preventative care for workers is necessary.

In the present study, we assessed the utilization of CR and the factors involved therein among workers with CAD in Japan.

Methods

Design

We conducted a retrospective cohort study using data obtained from a claims database in the Japanese health insurance system.

Data Source

Japan has a universal health insurance system (i.e., all those living in Japan must be covered by public insurance). The “Social Insurance System”, which is one of the public insurance systems, covers large-scale corporate employees and their dependents aged < 75 years (≈ 30 million individuals). Japan Medical Data Center (JMDC) Co., Ltd. (Tokyo,

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Japan) maintains a medical claims database for >50 social insurance societies.¹⁸ The database covers >2.75 million beneficiaries (employees and their dependents), which is equivalent to 2.2% of the Japanese population. A total of 31,002 patients with CAD aged <65 years were enrolled in the JMDC database, which accounts for approximately 18.7% of the patients with CAD aged <65 years in Japan (total number of patients, 166,000).¹⁹ Moreover, the number of cases of revascularization among these patients with CAD aged <65 years accounted for 0.3% of cases in all age groups in Japan (percentage based on 2012 data as a reference).²⁰ The JMDC database is not a hospital-based but a beneficiary-based database, and hence includes all the medical claims of beneficiaries regardless of the facility type (hospital/clinic) or whether inpatient or outpatient. We used the JMDC database because we needed sequential medical claims of both inpatients and outpatients to assess the utilization of CR, focusing particularly on individuals of working age.

Patients

We selected our cohort of employed patients with CAD using the following criteria.

Inclusion Criteria At least 1 admission based on the need for CABG or PCI for CAD between January 1, 2005, and August 31, 2013. We defined CAD using the International Classification of Diseases, 10th Revision (ICD-10) codes I21–I25, excluding I201, I23, and I241. PCI and CABG were identified by the relevant treatment codes (CABG: K552 and K552-2; PCI: K546, K547, K548, K549, K550, K550-2, and K551). If there were ≥ 2 admissions, the earliest admission was considered the index admission, and patients had to be aged 18–65 years at the time of the admission.

Exclusion Criteria Patients who died during the admission (we only included patients who were discharged alive so that both outpatient and inpatient CR could be assessed); and patients who were registered as dependents.

Status of CR Use

We adopted use of exercise-based CR as the primary outcome. We defined CR use as payment of insurance claims for at least 1 session of CR (Treatment code: H000) during admission or within 60 days of discharge. We also obtained the duration and total time of CR based on the CR fee.

Factors Related to CR Use

The possible factors related to CR use included patient demographics (sex and age), disease-related factors (diagnosis, severity, type of intervention, medication prescribed at discharge, and comorbidity), characteristics of admission (hospitalization duration and fiscal year of admission), and hospital characteristics (number of beds and type of institution); these parameters were determined from the inpatient insurance claims.

For patients with ≥ 2 cases of CAD, we defined the primary disease in the following order (as described in a previous study¹⁰): ST-elevated myocardial infarction (STEMI), non-STEMI (NSTEMI), unstable angina pectoris (uAP), stable angina pectoris (sAP), and other CAD including acute ischemic heart disease and chronic ischemic heart disease. We used percutaneous cardiopulmonary support system (PCPS) and catecholamine injection as proxies for disease severity. If patients underwent both PCI and CABG during the index admission, CABG was considered the primary surgery.¹⁰ We also identified 12 comorbidities

from the inpatient and outpatient insurance claims during the 6 months before the index admission (hypertension, hyperlipidemia, diabetes, chronic heart failure, cerebrovascular disease, chronic obstructive pulmonary disease, chronic kidney disease, psychiatric disorders, arthritis, cancer, dementia, and ophthalmic disorders). These have been found in previous studies to be possible factors related to CR or exercise therapy.^{9,10,14,21,22} To adjust for the effect of payment system revisions in terms of medical service and facility standards, we created 4 groups based on the index admission date: April 2006 to March 2008, April 2008 to March 2010, April 2010 to March 2012, and April 2012 to August 2013. The hospital characteristics included the number of beds (<500 vs. ≥ 500 beds) and type of institution (national/public hospital, teaching hospital, private hospital, or clinic). Moreover, to estimate the effect of CR, cases of revascularizations after the index admission were followed during the entire study period. We defined revascularization as admission for CABG or PCI for CAD after the index admission.

Japanese hospitals must acquire specific certification to be eligible for providing CR. As we could not determine whether each hospital was certified based on the claims data, we defined hospitals that claimed CR ≥ 1 times as CR-providing hospitals (CR hospitals) and the remaining as non-CR hospitals.

Statistical Analysis

We assigned patients to 2 groups based on the type of hospital to which they were admitted (CR hospital vs. non-CR hospital), and used bivariate analysis to compare each variable between the groups. Categorical variables were compared using the χ^2 -test and continuous variables were compared using the U-test.

Thereafter, in the CR hospital group, the proportion of patients who received CR was determined, and the factors

related to CR use were investigated. First, we performed bivariate analysis to estimate the differences in the proportion of CR use according to patient characteristics. Second, we conducted multiple logistic regression analysis to identify the determinants of inpatient CR use. We identified input variables based on those reported by previous studies or those that were likely to be clinically important,^{9,10,14,21,22} including sex, age, type of diagnosis (STEMI, NSTEMI, uAP, sAP, or other CAD), type of intervention (CABG or PCI), fiscal year of index admission, hospitalization duration, comorbidities, and hospital characteristics. We also used a multiple logistic regression model to identify the determinants of outpatient CR use among inpatient CR users. We derived odds ratios (ORs) and corresponding 95% confidence intervals (95% CIs) from these models. We used Stata software (version 13.1, Stata Corp LP, College Station, TX, USA) for all analyses. A P-value of <0.05 was considered statistically significant for all analyses.

Results

Characteristics of Index Admissions

The flowchart in **Figure** summarizes the cohort selection process. In total, 1,699 patients were extracted from the

database for this study. The baseline characteristics of the patients are summarized in **Table 1**. The most common diagnosis at admission was sAP (32.4%), and 96.7% of all the patients underwent PCI. The median hospitalization duration was 8 days (interquartile range [IQR], 4–15 days), and differed according to the diagnosis (STEMI, 13 days; NSTEMI, 14 days; uAP, 5 days; sAP, 4 days; other CAD, 5 days). Patients who underwent CABG remained in the hospital 3-fold longer than those who underwent PCI (25 vs. 8 days, respectively). Of the 1,699 patients, 831 (48.9%) were admitted to CR hospitals; a comparison of the characteristics of patients admitted to CR and non-CR hospitals is shown in **Table 1**.

Status of CR Use

The numbers of patients who underwent both inpatient and outpatient CR for at least 1 session were 402 (23.7%) and 72 (4.2%), respectively. Of the 831 patients admitted to a CR hospital, 396 (47.7%) underwent inpatient CR and 66 (7.9%) underwent outpatient CR. **Table 2** shows the proportion of CR use in the CR hospital group. Moreover, we found that 6 patients (0.7%) who were hospitalized in non-CR hospitals underwent outpatient CR after discharge. These CR sessions were provided by another facility, and

Characteristics	Overall (n=1,699), n (%)	Non-CR hospital (n=868), n (%)	CR hospital (n=831), n (%)
Sex			
Male	1,652 (97.2)	844 (97.2)	808 (97.2)
Age (years)			
Median (IQR)	56 (50–60)	56 (49.5–60)	56 (50–60)
20–29	4 (0.2)	1 (0.1)	3 (0.4)
30–39	75 (4.4)	45 (5.2)	30 (3.6)
40–49	327 (19.3)	171 (19.7)	156 (18.8)
50–59	782 (46.0)	386 (44.5)	396 (47.7)
60–65	511 (30.1)	265 (30.5)	246 (29.6)
Index event			
STEMI	391 (23.0)	179 (20.6)	212 (25.5)
Non-STEMI	300 (17.7)	164 (18.9)	136 (16.4)
Unstable angina	390 (23.0)	231 (26.6)	159 (19.1)
Stable angina	551 (32.4)	257 (29.6)	294 (35.4)
Other CAD	67 (3.9)	37 (4.3)	30 (3.6)
Surgery for index event			
CABG	57 (3.4)	17 (2.0)	40 (4.8)
PCI	1,642 (96.7)	851 (98.0)	791 (95.2)
Comorbidities			
Hypertension	858 (50.5)	434 (50.0)	424 (51.0)
Hyperlipidemia	832 (49.0)	422 (48.6)	410 (49.3)
Diabetes mellitus	619 (36.4)	308 (35.5)	311 (37.4)
CHF	127 (7.5)	54 (6.2)	73 (8.8)
CVD	115 (6.8)	48 (5.5)	67 (8.1)
COPD	53 (3.1)	25 (2.9)	28 (3.4)
CKD	63 (3.7)	36 (4.1)	27 (3.2)
Psychiatric disorder	138 (3.7)	76 (8.8)	62 (7.5)
Arthritis	18 (1.1)	10 (1.2)	8 (1.0)
Cancer	112 (6.6)	53 (6.1)	59 (7.1)
Dementia	0 (0.0)	0 (0.0)	0 (0.0)
Ophthalmic disorder	1 (0.1)	1 (0.1)	0 (0.0)

(Table 1 continued the next page.)

Characteristics	Overall (n=1,699), n (%)	Non-CR hospital (n=868), n (%)	CR hospital (n=831), n (%)
PCPS	137 (8.1)	52 (6.0)	85 (10.2)
Catecholamine	559 (32.9)	280 (32.3)	279 (33.6)
Prescription at discharge			
Aspirin	1,666 (98.1)	848 (97.7)	818 (98.4)
β -blocker	853 (50.2)	376 (43.3)	477 (57.4)
ACEI/ARB	1,112 (65.5)	552 (63.6)	560 (67.4)
Statin	1,431 (84.2)	719 (82.8)	712 (85.7)
Hospitalization duration			
Median (IQR)	8 (4–15)	7 (4–14)	9 (4–16)
Year			
Apr 2006–Mar 2008	110 (96.5)	69 (7.9)	41 (4.9)
Apr 2008–Mar 2010	341 (0.1)	167 (19.2)	174 (20.9)
Apr 2010–Mar 2012	686 (40.4)	358 (41.2)	328 (39.5)
Apr 2012–Aug 2013	562 (33.1)	274 (31.6)	288 (34.7)
Hospital characteristics			
No. of beds $\geq$ 500	830 (48.9)	337 (38.8)	493 (59.3)
National or public	410 (24.1)	251 (28.9)	159 (19.1)
Teaching hospital	255 (15.0)	111 (12.8)	144 (17.3)
Private hospital	997 (58.7)	476 (54.8)	521 (62.7)
Clinic	37 (2.2)	30 (3.5)	1 (0.1)
CR participation	402 (23.7)	6 (0.7)	396 (47.7)
Revascularization after index admission	322 (19.0)	181 (20.9)	141 (17.0)

ACEI, angiotensin-converting enzyme inhibitor; ARB, angiotensin-receptor blocker; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CHF, congestive heart failure; CKD, chronic kidney disease; CR hospital, hospital certified to provide cardiac rehabilitation; COPD, chronic obstructive pulmonary disease; CVD, cerebrovascular disease; IQR, interquartile range; Non-CR hospital, hospital not certified to provide cardiac rehabilitation; PCI, percutaneous coronary intervention; PCPS, percutaneous cardiopulmonary support system; STEMI, ST-elevated myocardial infarction.

so these patients were excluded from the subsequent analysis.

The median total time spent in a CR program was approximately 180 min (IQR, 80–360 min) per patient; the median time of participation in inpatient CR programs was approximately 160 min (IQR, 80–300 min). For patients who participated in both inpatient and outpatient CR programs, the median time spent in these programs was approximately 380 min (IQR, 240–820 min). The median period of outpatient CR program participation was 3 months (IQR, 2–5 months).

The proportion of cases of revascularization after the index admission was 20.9% in the non-CR hospitals and 17.0% in the CR hospitals ($P=0.04$). Moreover, this proportion was 19.8% among non-CR users, 17.4% among inpatient CR users, and 10.1% among inpatient and outpatient CR users ($P=0.10$). Logistic regression analysis indicated that the OR of revascularization, adjusted by age and sex (reference: non-CR users), were 0.83 (95% CI, 0.60–1.14) for inpatient CR users and 0.44 (95% CI, 0.20–0.98) for inpatient and outpatient CR users.

Factors Related to CR Use

Table 3 shows the factors related to CR use, as determined by logistic regression analysis. Patients with STEMI were most likely to undergo inpatient CR. With regard to the type of intervention, patients who underwent CABG were more likely to receive inpatient CR than those who underwent PCI. Moreover, the use of catecholamine injections increased the probability of participation in inpatient CR programs. In contrast, a history of chronic kidney disease and admission to a large hospital (≥ 500 beds) were nega-

tively correlated with the use of inpatient CR. In terms of outpatient CR utilization, logistic regression analysis showed that a diagnosis of uAP or SAP, compared with STEMI, was associated with a decreased probability of outpatient CR program participation. Moreover, the use of PCPS and admission to clinics increased the probability of participation in outpatient CR programs.

Discussion

In the current study, we assessed the status of CR use and the factors related to CR use among employed Japanese individuals with CAD, based on data from a large health insurance claims database.

Inpatient CR Use

We showed that $<25\%$ of the total cohort participated in an inpatient CR program. Even if we limited our study to patients who were admitted to CR hospitals under the assumption that these patients are more likely to participate in a CR program, $<50\%$ of such patients were found to have participated in inpatient CR programs. A study in Germany found that approximately one-third of patients underwent rehabilitation after an acute cardiovascular event,²³ consistent with the present results. However, that report was published 10 years previously, and CR programs are now increasingly provided in an outpatient form in Germany; hence, it is likely that the status has changed.

To enhance the utilization of inpatient CR, a more intensive approach by medical staff, including the use of an automatic referral system or clinical pathway, may be needed.

Table 2. Proportion and Status of CR Use in the CR Hospital Group of Japanese Workers With CAD

Characteristics	Total, n	Inpatient CR user, n (%)	Outpatient CR user, n (%)
Entire cohort	831	396 (47.7)	66 (7.9)
Sex			
Male	808	385 (47.7)	64 (7.9)
Female	23	11 (47.8)	2 (8.7)
Age (years)			
20–29	3	2 (66.7)	0 (0.0)
30–39	30	16 (53.3)	2 (6.7)
40–49	156	89 (57.1)	18 (11.5)
50–59	396	191 (48.2)	27 (6.8)
60–65	246	98 (39.8)	19 (7.7)
Index event			
STEMI	212	178 (84.0)	30 (14.2)
Non-STEMI	136	97 (71.3)	19 (14.0)
uAP	159	44 (27.7)	5 (3.1)
sAP	294	67 (22.8)	9 (3.1)
Other CAD	30	10 (33.3)	3 (10.0)
Surgery for index event			
CABG	40	33 (82.5)	2 (5.0)
PCI	791	363 (45.9)	64 (8.1)
Comorbidities			
Hypertension	424	166 (39.2)	22 (5.2)
Hyperlipidemia	410	161 (39.3)	24 (5.9)
Diabetes mellitus	311	124 (39.9)	16 (5.1)
CHF	73	26 (35.6)	4 (5.5)
CVD	67	22 (32.8)	3 (4.5)
COPD	28	11 (39.3)	2 (7.1)
CKD	27	6 (22.2)	0 (0.0)
Psychiatric disorder	62	27 (43.6)	1 (1.6)
Arthritis	8	37 (43.0)	3 (3.5)
Cancer	59	27 (45.8)	4 (6.8)
PCPS	85	71 (85.5)	17 (25.8)
Catecholamine required (yes)	279	187 (67.0)	26 (39.4)
Hospital characteristics			
No. of beds ≥500	493	228 (46.3)	39 (7.9)
No. of beds <500	338	168 (49.7)	27 (8.0)
National or public	159	86 (54.1)	12 (7.5)
Teaching hospital	144	72 (50.0)	17 (11.8)
Private hospital	521	233 (44.7)	35 (6.7)
Clinic	7	5 (71.4)	2 (28.6)
Total time of CR (min) (limited to CR users)			
Median (IQR)	180 (80–360)	160 (80–300)	380 (240–820)

CR, cardiac rehabilitation; sAP, stable angina pectoris; uAP, unstable angina pectoris. Other abbreviations as in Table 1.

In a previous study, CR referral by doctors prior to discharge was shown to increase the probability of outpatient CR use.²⁴ Moreover, efforts to provide basic education regarding CR and support to patients have also been shown to be effective for improving the utilization of these programs in the USA.²⁵ Hence, referral and direct contact with patients during hospitalization, including under inpatient CR settings, play important roles in improving the outpatient CR utilization rate. Thus, efforts should also be made to increase inpatient CR use.

Outpatient CR Use

The proportion of patients who received outpatient CR after discharge was low in the CR hospital group (7.9%), and extremely low in the overall cohort (4.2%), as compared with the proportion of patients who received inpatient CR. However, Western countries tackling underutilization of CR have reported a higher use rate (11.7–58.7%) than these results.^{9,11} Thus, our results suggest a very serious problem in Japan. A previous study reported that patients who underwent invasive procedures were more likely to use CR than other patients.¹⁰ In the present study, we only evaluated patients who underwent invasive procedures;

Table 3. Factors Associated With Utilization of CR by Japanese Workers With CAD

Characteristics	Utilization of inpatient CR			Utilization of outpatient CR		
	Adjusted OR	95% CI	P value	Adjusted OR	95% CI	P value
Sex						
Male	1.79	0.61–5.31	0.291	1.59	0.31–8.05	0.578
Age (years)	0.97	0.95–1.00	0.059	0.99	0.96–1.03	0.731
Index event						
STEMI	Ref.			Ref.		
NSTEMI	0.43	0.23–0.78	0.006	0.91	0.46–1.78	0.773
uAP	0.08	0.04–0.14	<0.001	0.21	0.07–0.59	0.003
sAP	0.07	0.04–0.12	<0.001	0.23	0.10–0.55	0.001
Other CAD	0.06	0.02–0.20	<0.001	0.79	0.20–3.12	0.739
Surgery for index event						
CABG	3.06	1.10–8.52	0.033	0.71	0.13–3.77	0.691
PCI	Ref.			Ref.		
Comorbidities						
Hypertension	0.82	0.52–1.30	0.407	0.76	0.38–1.52	0.438
Hyperlipidemia	1.42	0.87–2.33	0.159	1.24	0.61–2.54	0.557
Diabetes mellitus	0.83	0.52–1.33	0.445	0.63	0.30–1.33	0.229
CHF	0.84	0.41–1.73	0.638	0.22	0.36–4.08	0.752
CVD	0.72	0.33–1.56	0.403	1.11	0.30–4.06	0.877
COPD	0.49	0.15–1.55	0.221	1.26	0.25–6.37	0.780
CKD	0.10	0.02–0.41	0.001	–		–
Psychiatric disorder	0.87	0.43–1.78	0.708	0.21	0.03–1.62	0.135
Arthritis	1.02	0.55–1.90	0.941	0.43	0.13–1.49	0.185
Cancer	1.21	0.58–2.55	0.610	1.04	0.34–3.18	0.952
Length of stay	1.09	1.06–1.12	<0.001	1.00	0.99–1.01	0.626
PCPS	1.83	0.83–4.03	0.136	2.39	1.11–5.14	0.025
Catecholamine	1.94	1.24–3.06	0.004	0.95	0.99–1.01	0.626
Hospital characteristics						
No. of beds ≥500	0.59	0.38–0.91	0.018	0.76	0.41–1.43	0.398
National or public	Ref.			Ref.		
Teaching hospital	1.36	0.71–2.60	0.347	2.35	0.98–5.62	0.055
Private hospital	0.99	0.60–1.64	0.968	1.06	0.52–2.19	0.869
Clinic	8.47	1.41–50.81	0.019	8.56	1.22–60.19	0.031
Year						
Apr 2006–Mar 2008	Ref.			Ref.		
Apr 2008–Mar 2010	6.00	2.11–17.02	0.001	1.05	0.98–5.62	0.941
Apr 2010–Mar 2012	7.53	2.74–20.70	<0.001	1.04	0.27–3.91	0.959
Apr 2012–Aug 2013	6.60	2.39–18.26	<0.001	1.29	0.34–4.87	0.711

Abbreviations as in Tables 1,2.

hence, the participation rate of all employed Japanese patients with CAD is expected to be even lower.

For employed individuals, it is possible that work schedules can interfere with CR utilization after discharge. Such scheduling conflicts were reportedly one of the major barriers against participation in outpatient CR.²⁶ Hence, CR programs with reduced temporal restrictions (such as home- or telephone-based arrangements) can be helpful for patients planning to return to work and simultaneously receive CR.²⁷ In the present study, we focused on hospital-based outpatient CR, and hence the use of private CR services, including CR at local sports facilities or as part of home-based programs, was not assessed. The non-outpatient CR users in the present study could have received such programs, so further studies are needed to assess whether the use of such programs compensates for the underutilization of outpatient CR.

Another explanation for the underutilization of outpatient CR may involve insufficient insurance coverage, as reported in other countries. However, Japanese patients with CAD are covered by insurance to receive CR programs for up to 150 days from CAD onset. Hence, all patients with CAD can receive CR programs during the eligibility period at a certificated CR hospital when referred by a doctor. Despite such adequate insurance coverage, outpatient CR remains markedly underutilized.

From our results, we noted that the strategies for outpatient enrollment in the CR program were not sufficiently developed, as non-users of inpatient CR rarely received subsequent outpatient CR (6 of 1,303 patients). This suggests that the low participation rate in inpatient CR leads to underutilization of outpatient CR. Previous studies have reported that low awareness of doctors or practitioners regarding the benefits of CR was a major cause of the low

referral of outpatient CR.²² Hence, education of medical staff regarding CR or the use of a computerized decision support system may be effective.²⁸

Moreover, a shortage of CR hospitals was found to be a likely cause of CR underutilization in Japan. At present, hospitals in Japan need certification to provide a CR program. In the present study, only 48.9% of all patients were admitted to CR hospitals, thus indicating that >50% of patients did not have the opportunity to receive CR. Although the number of CR hospitals has gradually increased over the past decade,²⁹ the overall number remains low.

Factors Related to CR Use

In the present study, we identified some factors that correlated with inpatient and outpatient CR use. In particular, STEMI or NSTEMI patients had a greater likelihood of inpatient CR use as compared with angina or other CAD patients; this trend was observed even after adjustment for the hospitalization duration. The type of intervention was also found to be related to CR use. Patients who underwent CABG were at least 3-fold more likely to receive inpatient CR than those who underwent PCI. These results are consistent with a previous study on outpatient CR,¹⁰ which indicated that the correlation between CR use and diagnosis or type of intervention was common in both settings. In particular, a strong correlation between CABG and CR use may reflect the high awareness surrounding this surgical procedure among patients, as well as the systematic referral for CR by cardiac surgeons. Accordingly, more suitable systematic referral procedures for patients undergoing PCI might be required.

In the present study, catecholamine use, which we considered as a surrogate for severity, was associated with an increased probability of inpatient CR use. In contrast, a previous study reported no significant association between outpatient CR use and clinical severity, as evaluated by cardiac ejection fraction.²¹ Our finding suggested that the utilization of inpatient CR depends on acute physical status to a greater extent, as compared with outpatient CR use. Such discrepancies between previous studies and the present study were also observed in terms of sex. Our study showed no association between sex and CR use, in contrast to prior studies.³⁰ Moreover, in the present study, we found that age had no effect on CR use, consistent with a systematic review in which older age was found to be commonly associated with non-attendance, except for studies that only included individuals <65 years.³¹

We found that angina more strongly predicted non-participation in outpatient CR programs, as compared with MI. This trend was similar to that of inpatient CR use, and was consistent with that noted in previous studies.^{10,22,32} These findings suggested that the diagnosis at admission persistently influences the subsequent utilization of CR. As national and international guidelines recommend CR for patients diagnosed with angina and MI,⁶⁻⁸ the promotion of CR among this patient population is a common challenge worldwide. Similar to the promotion of inpatient CR, education of medical staff or use of a support system such as an automatic referral system might be helpful.

Number of CR Sessions

Our results suggested that the number of CR sessions in the current study may be insufficient. Japanese national guidelines for the management of patients with STEMI indicate that approximately 7 exercise sessions should be included

as part of an inpatient CR program over a typical 2-week clinical pathway.³³ The guidelines also recommend that the subsequent phase 2 outpatient CR should be continued for 3–5 months, with 1–3 sessions per week. In the present study, we estimated the total time of the inpatient CR program as 160 min, which is equivalent to 3–8 sessions, as a single session typically requires 20–60 min in Japan. In contrast, the total time of the outpatient CR program was estimated as 380 min, which is equivalent to 7–19 sessions. These findings suggested that CR programs are being provided to patients according to the Japanese guidelines in cases where CR is indicated.

Rate of Revascularization After the Index Admission

In the present study, we found that CR utilization reduced the risk of revascularization after discharge. This finding differed from that observed in a previous meta-analysis in which exercise-based CR did not significantly reduce the risk of revascularization, but did reduce the cardiovascular mortality.³⁴ The claims data we used did not contain clinical data, such as laboratory tests or the index of severity, or risk factors (e.g., blood pressure, blood lipid profile, smoking status, body mass index, and family history). Hence, our additional findings should be interpreted as preliminary results. Further research is needed on the effect of CR, including on revascularization, death, or return to work.

Study Limitations

Our study has certain limitations. First, as is inevitable in studies of cohorts derived from claims databases, the data obtained in the present study were limited to claims-based information and did not include clinical data such as left ventricular ejection fraction, body mass index, smoking habit, or CAD history prior to enrollment in the insurance system. Second, the database lacked geographic and socioeconomic information, which was reported to be relevant in previous studies in the USA.⁹ However, the influence of these factors may be relatively minor in the current study because access to health care in Japan is generally high, and the socioeconomic differences are less pronounced than in the USA. Third, the detailed content of each CR session was not assessed. According to Japanese regulations, an exercise-based CR program covered by insurance mainly consists of cardiopulmonary exercise testing, prescriptions, and exercise training. Hence, we believe that these sessions generally involved such programs, although the intensity of each training session remains unclear. Finally, the claims data used in the current study were derived from the Japanese population, and hence may not be generalizable to other countries.

Conclusions

Less than 25% of all CAD patients of working age received inpatient CR, and less than 10% of such patients received outpatient CR in Japan. Hence, secondary prevention of CAD among the employed population should be strengthened in order to guarantee a more effective labor force and to promote social welfare.

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Contributions

All the authors were fully involved in designing the study, analyzing the data, and interpreting the results, and have approved the final manuscript.

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Competing Interests / Grants

None.

Ethical Approval

Kyoto University Ethics Committee.

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