Circulation Reports
Circ Rep 2022; 4: 353–362
doi:10.1253/circrep.CR-22-0058

ORIGINAL ARTICLE
Epidemiology

Hospitalizations for Cardiovascular Diseases During the Early Stage of the COVID-19 Pandemic in Japan

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Background: Although reductions in hospitalizations for myocardial infarction and heart failure have been reported during the period of COVID-19 pandemic restrictions, it is unclear how the overall number of hospitalizations for cardiovascular disease (CVD) treatment changed in the early stages of the pandemic.

Methods and Results: We analyzed the records of 574 certified hospitals affiliated with the Japanese Circulation Society and retrieved data from April 2015 to March 2020. Records were obtained from the nationwide Japanese Registry of All Cardiac and Vascular Diseases–Diagnosis Procedure Combination database. A quasi-Poisson regression model was used to estimate the number of hospitalizations for CVD treatment. Between January and March 2020, when the number of COVID-19 cases was relatively low in Japan, the actual/estimated number of hospitalizations for acute CVD was 18,233/21,634 (84.3%), whereas the actual/estimated number of scheduled hospitalizations was 16,921/19,066 (88.7%). The number of hospitalizations for acute heart failure and scheduled hospitalizations for valvular disease and aortic aneurysm were 81.1%, 84.6%, and 83.8% of the estimated values, respectively. A subanalysis that considered only facilities without hospitalization restrictions did not alter the results for these diseases.

Conclusions: The spread of COVID-19 was associated with a decreased number of hospitalizations for CVD in Japan, even in the early stages of the pandemic.

Key Words: Cardiovascular disease; COVID-19; Hospitalizations; Japanese Registry of All Cardiac and Vascular Diseases–Diagnosis Procedure Combination (JROAD-DPC)

Because of its high transmissibility and associated mortality rate, COVID-19 continues to negatively affect the lives of people worldwide. As a result of a lack of adequate testing systems and personal protective equipment, as well as limited knowledge of the disease, the COVID-19 pandemic, particularly in the early stages, significantly affected the care of patients with non-communicable diseases at medical institutions. The number of patients hospitalized due to acute myocardial infarction and heart failure reportedly decreased during periods of COVID-19 pandemic restrictions.[1–4] Without government restrictions, the initial response to the COVID-19 pandemic in Japan was successful, with few cases and deaths. However, as in other countries, the pandemic led to restrictions accessing hospitals and medical treatment, and some scheduled treatments could not be performed because

Received June 5, 2022; accepted June 6, 2022; J-STAGE Advance Publication released online July 1, 2022 Time for primary review: 1 day

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ISSN-2434-0790

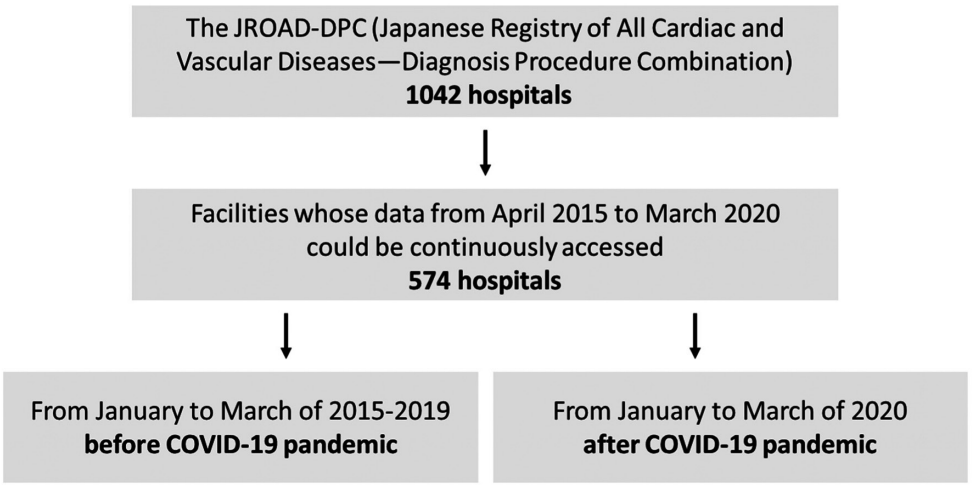

Figure 1. Flowchart of data retrieval.

of a lack of personal protective equipment.[5] In fact, during the COVID-19 pandemic in Japan, the use of medical facilities for health-related events was reportedly decreased, especially among the elderly.[6] Despite the COVID-19 pandemic having affected people's lifestyles and behaviors in Japan and many other parts of the world, it remains unclear whether these changes affected cardiovascular events. In this study, we explored changes in cardiovascular hospitalizations in the early phase of the COVID-19 pandemic in Japan, with a special focus on acute cardiovascular diseases (CVD) and scheduled treatments.

Methods

The Japanese Registry of All Cardiac and Vascular Diseases–Diagnosis Procedure Combination (JROAD-DPC) is a nationwide claims database comprising data from 1,086 hospitals in Japan collected between April 2012 and March 2020. From the JROAD-DPC database, we selected 574 facilities with all data from April 2015 to March 2020 in the database (**Figure 1**). For each year, we used International Classification of Diseases, Tenth Revision (ICD-10) codes to extract data for patients aged ≥20 years who were hospitalized for acute CVD (acute myocardial infarction, acute heart failure, ruptured aortic aneurysm, or venous thromboembolism) or had scheduled surgeries or procedures for CVD (ischemic heart disease, valvular heart disease, aortic aneurysm, atrial septal defect, peripheral arterial disease, or venous thromboembolism), scheduled catheter ablation, scheduled permanent pacemaker implantation and exchange, or scheduled left ventricular assist device implantation between January and March. The ICD-10 codes registered as the main, admission-precipitating, or most resource-consuming diagnosis for each disease or procedure are listed in the **Supplementary Table**.

Statistical Analyses

First, we compared inpatient and background data of the study participants for each CVD before and after (January–March 2020) the onset of the COVID-19 pandemic. Next, we applied a quasi-Poisson regression model to data from January to March in 2015 to 2019 to estimate the weekly number of hospitalizations between January and March from 2015 to 2020.[7,8] Unlike the normal Poisson regression model, the quasi-Poisson regression model can handle overdispersed count variables, which are frequently observed, especially under pandemic situations. Our quasi-Poisson regression model consisted of a trend and seasonality expressed as Fourier terms with 2 sine and cosine waves considering 1-year and 0.5-year cycles,[8–10] as follows:

$$var(Y_t) = \phi E(Y_t)$$

and

$$\log(E(Y_t)) = \alpha_0 + \alpha_1 t + \beta_1 \sin\left(\frac{14t\pi}{365.25}\right) + \beta_2 \cos\left(\frac{14t\pi}{365.25}\right) + \beta_3 \sin\left(\frac{2*14t\pi}{365.25}\right) + \beta_4 \cos\left(\frac{2*14t\pi}{365.25}\right)$$

where E is the expectation operator, Y_t is the number of hospitalizations at Week t, α and β are regression parameters, and ϕ is the dispersion parameter. The parameters, including φ, were estimated using the quasi-likelihood approach.

Using the equations above, we calculated the ratio of actual to estimated number of hospitalizations from January to March 2020 as the primary endpoint, and set the point estimate and upper and lower bounds of the 2-sided 95% prediction interval (PI) for the purpose of comparison with hospitalizations before the COVID-19 pandemic as the secondary endpoints.

All data are presented as the mean±SD, number (percentage), or median with interquartile range, as appropriate. Between-group differences were evaluated using the Student's t-test for normally distributed continuous variables, the Mann-Whitney U test for non-normally distributed continuous variables, and Chi-squared or Fisher's exact

tests for categorical variables. For all tests, 2-sided P<0.05 was considered significant. Data were analyzed using the open source statistical software R (version 4.0.2; R Foundation for Statistical Computing; www.R-project.org).

Subgroup Analysis Using Questionnaire Data

To minimize the effects of factors that influenced hospitals' decisions to limit hospitalizations for CVD, we performed a subgroup analysis using questionnaire data on the restriction of hospitalizations for CVD. The Japanese Circulation Society regularly performed questionnaire surveys to record departmental experiences and polices during the COVID-19 pandemic.[11,12] We used data from the first questionnaire, performed on April 13, 2020. That survey evaluated hospital and departmental policies regarding the restriction of emergency hospitalizations and procedures for CVD from January to March 2020. We merged the questionnaire data with data from the JROAD-DPC dataset. Subgroup analyses were conducted for diseases for which hospitalizations were at least 15% below estimated levels and below the 95% PI per week between January and March 2020.

Results

Acute CVD

Table 1 summarizes the characteristics of patients hospitalized for acute CVD. Compared with those hospitalized in 2015–2019, patients hospitalized for acute CVD in 2020 did not differ in age, but there was a higher proportion of men and patients had a higher body mass index, more comorbidities, lower in-hospital mortality, and a higher Barthel Index score at admission and discharge. The actual/estimated number of hospitalizations for acute CVD between January and March was 16,934/17,026 (99.5%) in 2018, 18,605/19,278 (96.5%) in 2019, and 18,233/21,634 (84.3%) in 2020. During the third week of January 2020, the number of hospitalizations for acute CVD was less than the 95% PI of the estimated value (**Figure 2**).

Among patients hospitalized for acute CVD, the number of hospitalizations for acute myocardial infarction, acute

Table 1. Inpatient and Background Data of the Study Participants

	January–March 2015–2019[C]	January–March 2020	P value
Hospitalization for acute CVD[A]			
Total no. hospitalizations	79,312	18,251	–
Length of stay (days)	15.56±11.81	15.32±11.80	0.013
In-hospital mortality (%)	12.5	11.9	0.022
Within 24 h	4.9	4.2	<0.001
Within 7 days	7.6	7.2	0.058
Barthel Index score at discharge	80.0±31.4	80.7±30.85	0.009
Hospitalization costs (JPY)	857,000 [519,000–1,537,000]	897,000 [568,000–1,534,000]	<0.001
Age (years)	76.61±13.40	76.70±13.58	0.377
Male (%)	57.7	58.8	0.008
BMI (kg/m^2)	22.89±4.98	23.08±5.19	<0.001
Barthel Index score at admission	46.6±41.62	48.45±41.7	<0.001
Charlson comorbidity index	2.18±1.39	2.28±1.46	<0.001
Scheduled surgeries or procedures for CVD[B]			
Total no. hospitalizations	68,819	16,952	–
Length of stay (days)	6.96±9.14	7.02±9.29	0.479
In-hospital mortality (%)	0.53	0.50	0.567
Hospitalization costs (JPY)	1,105,000 [871,000–765,000]	1,051,000 [819,000–2,036,000]	<0.001
Age (years)	70.81±11.57	71.74±11.77	<0.001
Male (%)	74.3	73.8	0.211
BMI (kg/m^2)	23.86±4.51	23.84±4.18	0.751
Barthel Index score at admission	95.1±16.1	94.95±16.35	0.2
Charlson comorbidity index	1.70±1.41	1.76±1.45	<0.001
Scheduled catheter ablation			
Total no. hospitalizations	23,142	7,393	–
Length of stay (days)	3.96±3.20	3.71±2.99	<0.001
In-hospital mortality (%)	0.03	0.02	>0.999
Hospitalization costs (JPY)	2,059,000 [1,560,000–2,325,000]	2,064,000 [1,727,000–2,285,000]	0.007
Age (years)	62.91±13.94	64.39±13.66	<0.001
Male (%)	66.6	66.6	>0.999
BMI (kg/m^2)	24.21±6.97	24.56±9.72	0.001
Barthel Index score at admission	98.9±7.65	98.95±7.85	0.624
Charlson comorbidity index	0.72±0.89	0.79±0.94	<0.001

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

	January–March 2015–2019[C]	January–March 2020	P value
Scheduled permanent pacemaker implantation			
Total no. hospitalizations	5,133	1,351	–
Length of stay (days)	12.01±8.66	11.47±8.08	0.038
In-hospital mortality (%)	0.20	0.07	0.556
Hospitalization costs (JPY)	1,729,000 [1,555,000–3,354,000]	1,498,000 [1,393,000–3,777,000]	<0.001
Age (years)	73.49±13.21	74.49±12.95	0.013
Male (%)	56.8	58.8	0.196
BMI (kg/m^2)	23.26±3.87	23.22±3.82	0.73
Barthel Index score at admission	93.0±19.1	93.25±18.8	0.64
Charlson comorbidity index	1.20±1.21	1.29±1.26	0.011
Scheduled pacemaker generator exchange			
Total no. hospitalizations	4,846	1,233	–
Length of stay (days)	7.06±4.85	6.37±4.09	<0.001
In-hospital mortality (%)	0.17	0.08	0.787
Hospitalization costs (JPY)	1,171,000 [1,031,000–1,419,000]	1120000 [994,000–1,298,000]	<0.001
Age (years)	75.95±14.98	76.99±14.81	0.03
Male (%)	50.3	49.6	0.659
BMI (kg/m^2)	23.15±4.76	23.01±4.15	0.347
Barthel Index score at admission	88.1±25.45	88.15±25.8	0.938
Charlson comorbidity index	0.97±1.07	1.15±1.10	<0.001
Scheduled LVAD implantation			
Total no. hospitalizations	350	118	–
Length of stay (days)	20.52±12.07	19.50±12.20	0.429
In-hospital mortality (%)	1.43	1.69	>0.999
Hospitalization costs (JPY)	5,303,000 [4,419,000–6,037,000]	5,473,000 [4,533,000–5,944,000]	0.648
Age (years)	62.04±16.49	64.44±14.70	0.162
Male (%)	62.3	68.6	0.257
BMI (kg/m^2)	22.65±3.73	23.50±3.17	0.027
Barthel Index score at admission	95.1±15.1	92.8±22.7	0.216
Charlson comorbidity index	1.83±1.04	1.75±1.06	0.505

Unless indicated otherwise, data are given as the mean±SD or median [interquartile range]. [A]Acute myocardial infarction, acute heart failure, ruptured aortic aneurysm, and VTE. [B]Ischemic heart disease, valvular heart disease, aortic aneurysm, atrial septal defect, peripheral arterial disease, and VTE. [C]Data were collected between January and March for the period 2015–2019. BMI, body mass index; CVD, cardiovascular disease; JPY, Japanese Yen; LVAD, left ventricular assist device; VTE, venous thromboembolism.

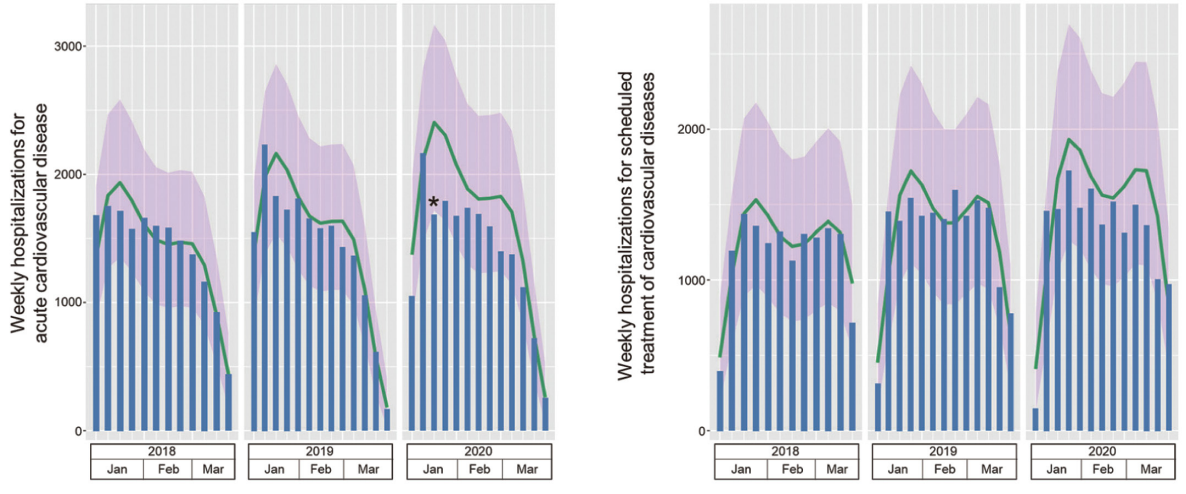

Figure 2. Weekly hospitalizations for acute and scheduled treatment of cardiovascular diseases. Green lines indicate the estimated number of hospitalizations per week. Purple shaded areas indicate the 95% prediction intervals of hospitalizations per week. Asterisks indicate weeks in which the number of hospitalizations was less than 95% of the estimated value.

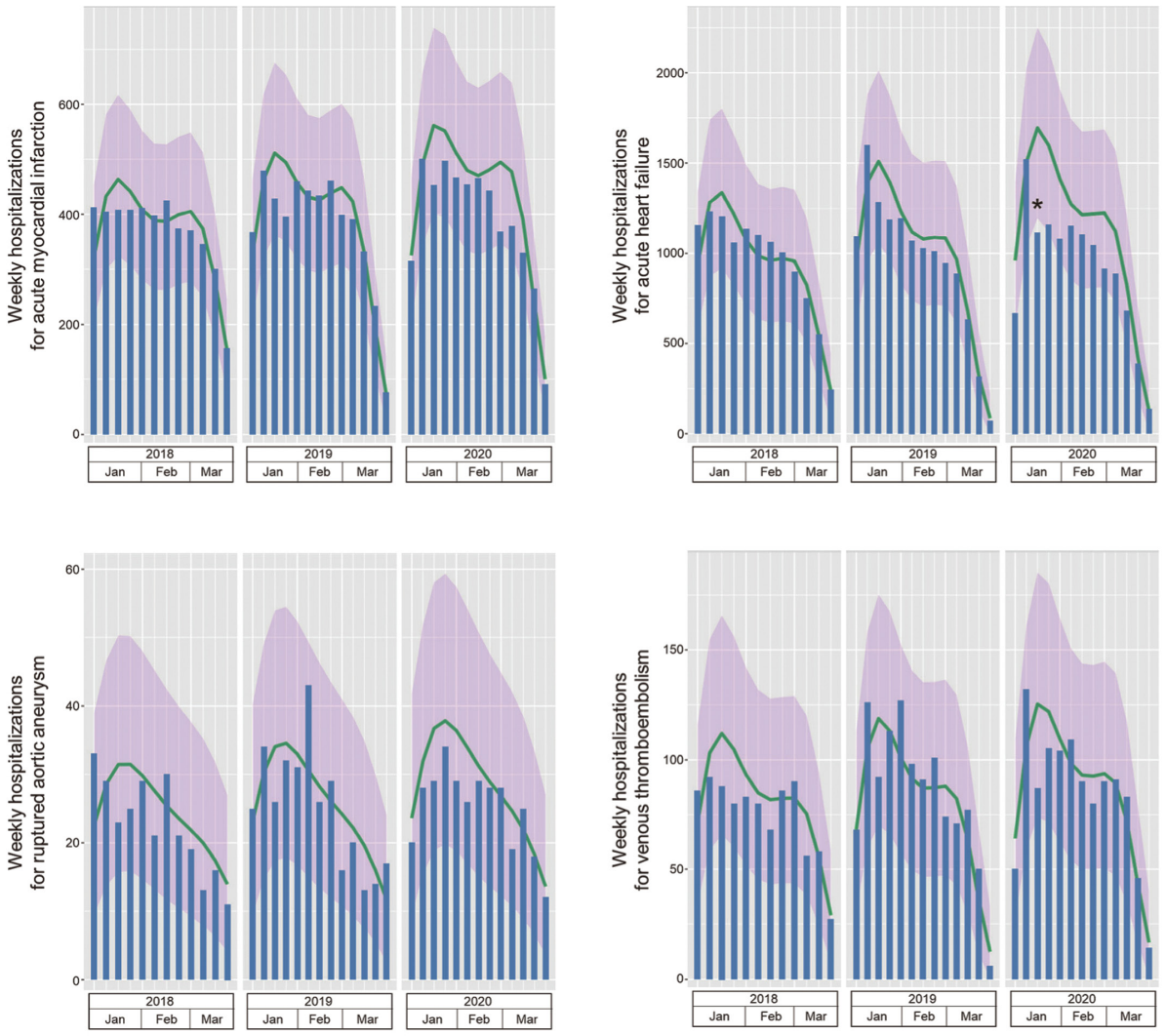

Figure 3. Weekly hospitalizations for acute cardiovascular diseases by disease. Green lines indicate the estimated number of hospitalizations per week. Purple shaded areas indicate the 95% prediction intervals of hospitalizations per week. Asterisks indicate weeks in which the number of hospitalizations was less than 95% of the estimated value.

heart failure, ruptured aortic aneurysm, and venous thromboembolism were 90.1%, 81.1%, 88.8, and 96.0% of the estimated values, respectively. During the third week of January 2020, the number of hospitalizations for acute heart failure was less than the 95% PI of the estimated value (**Figure 3**). The characteristics of patients hospitalized for acute myocardial infarction, acute heart failure, ruptured aortic aneurysm, and venous thromboembolism are summarized in **Table 2**. There were no significant changes in the age or in-hospital mortality of patients hospitalized for acute heart failure. However, the proportion of patients with New York Heart Association Class III or IV at admission was significantly higher in 2020 (75%) than in 2015–2019 (66%).

Scheduled Hospitalizations for CVD

Table 3 summarizes the characteristics of patients hospitalized for scheduled treatments or procedures. Patients hospitalized for scheduled surgeries or procedures for CVD in 2020 were older and had more comorbidities than those hospitalized in 2015–2019, but there were no differences in sex, body mass index, in-hospital mortality, and Barthel Index score at admission. Except for patients who underwent left ventricular assist device implantation, the mean age of patients hospitalized in 2020 for scheduled surgery or procedures was higher than of those hospitalized in 2015–2019, but the in-hospital mortality or Barthel Index score at admission did not differ. The actual/estimated number of hospitalizations for scheduled CVD-related surgeries or procedures between January and March was 14,024/14,673 (95.6%) in 2018, 16,720/17,016 (98.3%) in 2019, and 16,921/19,066 (88.7%) in 2020. The number of hospitalizations for a scheduled surgery or procedure did not deviate from the 95% PI of the estimated value in any week. The number of hospitalizations for a scheduled catheter ablation, permanent pacemaker implantation,

Table 2. Characteristics of Patients Hospitalized for Acute Cardiovascular Diseases

	January–March 2015–2019[A]	January–March 2020	P value
Hospitalization for AMI			
Total no. hospitalizations	20,986	5,031	–
Length of stay (days)	12.29±10.12	11.94±10.01	0.026
In-hospital mortality (%)	15.1	12.9	<0.001
Within 24 h	8.6	6.6	<0.001
Within 7 days	11.7	10.1	0.001
Barthel Index score at discharge	89.7±25.4	89.75±25.3	0.916
Hospitalization costs (JPY)	1,723,000 [1,226,000–2,357,000]	1,623,000 [1,164,000–2,157,000]	<0.001
Age (years)	70.51±13.34	70.73±13.28	0.304
Male (%)	72.0	73.0	0.188
BMI (kg/m^2)	23.65±4.53	23.75±4.33	0.207
Barthel Index score at admission	36.95±43.4	39.95±43.65	<0.001
Killip classification III or IV (%)	22.2	21.2	0.14
Charlson comorbidity index	2.10±1.19	2.16±1.27	0.002
Hospitalization for acute HF			
Total no. hospitalizations	52,352	11,867	–
Length of stay (days)	17.14±12.10	16.99±12.13	0.224
In-hospital mortality (%)	10.5	10.6	0.822
Within 24 h	2.3	2.3	0.958
Within 7 days	4.9	5.1	0.378
Barthel Index score at discharge	76.25±32.45	77.0±31.95	0.03
Hospitalization costs (JPY)	727,000 [492,000–1,076,000]	766,000 [530,000–1,117,000]	<0.001
Age (years)	79.58±12.15	79.79±12.34	0.089
Male (%)	53.4	54.2	0.107
BMI (kg/m^2)	22.56±4.89	22.74±5.10	0.001
Barthel Index score at admission	50.05±40.15	51.7±40.15	<0.001
NYHA Class III or IV (%)	66.0	75.3	<0.001
Charlson comorbidity index	2.31±1.39	2.44±1.47	<0.001
Hospitalization for ruptured aortic aneurysms			
Total no. hospitalizations	1,436	326	–
Length of stay (days)	9.20±13.76	10.84±15.05	0.057
In-hospital mortality (%)	62.4	59.2	0.313
Within 24 h	48.9	43.3	0.076
Within 7 days	57.1	52.1	0.117
Barthel Index score at discharge	68.05±39.55	65.05±38.7	0.412
Hospitalization costs (JPY)	378,000 [156,000–3,681,000]	662,000 [173,000–4,247,000]	0.009
Age (years)	79.40±10.31	80.04±11.40	0.325
Male (%)	66.9	65.0	0.573
BMI (kg/m^2)	21.90±5.25	21.88±4.73	0.969
Barthel Index score at admission	17.5±34.65	16.2±47.7	0.563
Charlson comorbidity index	1.64±1.10	1.77±1.27	0.052
Hospitalization for VTE			
Total no. hospitalizations	4,731	1,082	–
Length of stay (days)	14.78±11.22	14.24±10.76	0.154
In-hospital mortality (%)	7.8	6.6	0.193
Within 24 h	2.8	2.2	0.309
Within 7 days	4.8	4.0	0.267
Barthel Index score at discharge	81.45±32.15	82.1±31.85	0.559
Hospitalization costs (JPY)	680,000 [432,000–1,049,000]	675,000 [466,000–987,000]	0.735
Age (years)	69.95±15.88	69.58±16.26	0.497
Male (%)	39.3	42.1	0.497
BMI (kg/m^2)	23.55±6.92	24.20±8.44	0.011
Barthel Index score at admission	58.25±40.75	60.2±41.2	0.165
Charlson comorbidity index	1.27±1.77	1.31±1.71	0.484

Unless indicated otherwise, data are given as the mean±SD or median [interquartile range]. [A]Data were collected between January and March for the period 2015–2019. AMI, acute myocardial infarction; BMI, body mass index; HF, heart failure; JPY, Japanese Yen; NYHA, New York Heart Association; VTE, venous thromboembolism.

pacemaker generator exchange, and left ventricular assist device implantation were 91.6%, 95.5%, 97.2, and 90.1% of the estimated values, respectively. The number of hospitalizations for scheduled catheter ablation declined between January and March 2020, but the estimated 95% PI for hospitalizations for scheduled catheter ablation was exceeded in the fifth week of March 2020 (**Supplementary Figure 1**).

Among patients hospitalized for scheduled CVD-related surgeries or procedures, the number of hospitalizations for valvular heart disease (84.6% of the estimated value) and aortic aneurysm (83.8% of the estimated value) was less than the 95% PI of the estimated value during the third week of January 2020 (valvular heart disease) and the first week of March 2020 (valvular heart disease and aortic aneurysm; **Supplementary Figure 2**). Except for those for venous thromboembolism (117.9% of the estimated value), hospitalizations for scheduled surgeries or procedures were lower than estimated. As indicated in **Table 3**, there was no significant change in the in-hospital mortality for any scheduled hospitalization.

Subgroup Analysis

We performed a subgroup analysis for acute heart failure, valvular heart disease, and aortic aneurysm from the primary and secondary endpoints. The results of the subanalyses of hospitalizations for these 3 diseases did not change, even when only facilities without the restriction of emergency hospitalizations and procedures for CVD were considered. Among the 243 facilities (42% of facilities participating in the main analysis) that had no restrictions on emergency care, the actual number of hospitalizations for acute heart failure was 72.4% of the estimated value, with hospitalizations below the 95% PI during the third and fourth weeks of January 2020 (**Figure 4**). Among the 239 facilities (42% of facilities participating in the main analysis) that had no restrictions on hospitalization for scheduled treatments, the actual number of hospitalizations for valvular heart disease was 75.0% of the estimated value, with hospitalizations below the 95% PI during the third week of January 2020 and first week of March 2020. Similarly, the actual number of hospitalizations for aortic aneurysm was 83.3% of the estimated value, with hospitalizations below the 95% PI during the first week of March 2020.

Discussion

Figure 5 summarizes the findings of the present study. The major findings are that: (1) the number of hospitalizations

Table 3. Characteristics of Patients Hospitalized for Scheduled Surgeries or Procedures for Cardiovascular Diseases

	January–March 2015–2019[A]	January–March 2020	P value
Scheduled surgery or procedures for IHD			
Total no. hospitalizations	46,142	10,649	–
Length of stay (days)	4.97±7.11	4.84±7.30	0.102
In-hospital mortality (%)	0.31	0.28	0.759
Hospitalization costs (JPY)	1,043,000 [868,000–1,354,000]	948,000 [790,000–1,223,000]	<0.001
Age (years)	70.29±10.15	70.93±10.28	<0.001
Male (%)	77.6	77.7	0.828
BMI (kg/m^2)	24.39±4.54	24.46±4.22	0.152
Barthel Index score at admission	97.3±11.55	97.3±11.55	0.962
Charlson comorbidity index	1.45±1.31	1.50±1.37	0.002
Scheduled surgeries or procedures for VHD			
Total no. hospitalizations	4,895	1,617	–
Length of stay (days)	21.70±11.08	19.25±11.22	<0.001
In-hospital mortality (%)	1.82	1.86	>0.999
Hospitalization costs (JPY)	5,430,000 [4,698,000–6,109,000]	5,557,000 [4,914,000–6,096,000]	<0.001
Age (years)	73.45±13.40	75.46±13.26	<0.001
Male (%)	49.2	50.0	0.608
BMI (kg/m^2)	22.90±3.80	22.86±3.74	0.73
Barthel Index score at admission	93.7±16.9	94.0±16.4	0.568
Charlson comorbidity index	1.48±1.21	1.57±1.28	0.006
Scheduled surgeries or procedures for aortic aneurysm			
Total no. hospitalizations	5,605	1,646	–
Length of stay (days)	15.07±10.44	14.28±9.98	0.007
In-hospital mortality (%)	1.30	1.09	0.587
Hospitalization costs (JPY)	3,627,000 [2,927,000–5,025,000]	3,789,000 [2,948,000–5,186,000]	0.076
Age (years)	73.40±10.65	74.06±10.52	0.029
Male (%)	78.9	79.0	0.963
BMI (kg/m^2)	23.58±4.66	23.55±3.57	0.77
Barthel Index score at admission	95.45±15.1	95.75±14.8	0.463
Charlson comorbidity index	2.00±1.21	1.98±1.15	0.584

(**Table 3** continued the next page.)

	January–March 2015–2019[A]	January–March 2020	P value
Scheduled surgeries or procedures for ASD			
Total no. hospitalizations	774	208	–
Length of stay (days)	8.75±6.57	8.25±6.20	0.328
In-hospital mortality (%)	0.13	0	>0.999
Hospitalization costs (JPY)	1,790,000 [1,526,000–2,473,000]	1,727,000 [1,507,000–2,379,000]	0.122
Age (years)	31.31±26.32	32.43±27.08	0.592
Male (%)	40.2	36.1	0.317
BMI (kg/m^2)	19.95±4.68	19.94±4.78	0.982
Barthel Index score at admission	94.05±19.1	95.2±17.75	0.486
Charlson comorbidity index	0.65±0.77	0.76±0.85	0.076
Scheduled surgeries or procedures for PAD			
Total no. hospitalizations	12,721	3,272	–
Length of stay (days)	6.39±9.15	6.21±9.66	0.336
In-hospital mortality (%)	0.90	0.70	0.316
Hospitalization costs (JPY)	938,000 [738,000–1,286,000]	976,000 [766,000–1,328,000]	<0.001
Age (years)	73.20±9.59	74.13±9.33	<0.001
Male (%)	72.1	72.9	0.409
BMI (kg/m^2)	22.56±4.01	22.60±3.92	0.617
Barthel Index score at admission	87.45±25.45	87.2±25.3	0.64
Charlson comorbidity index	2.65±1.45	2.68±1.49	0.215
Scheduled surgeries or procedures for VTE			
Total no. hospitalizations	244	46	–
Length of stay (days)	21.47±16.05	19.26±15.28	0.389
In-hospital mortality (%)	2.46	0	0.61
Hospitalization costs (JPY)	1,688,000 [876,000–2,288,000]	1,568,000 [836,000–2,167,000]	0.584
Age (years)	65.77±14.67	66.87±13.84	0.643
Male (%)	39.3	30.4	0.329
BMI (kg/m^2)	23.30±4.12	23.26±3.76	0.949
Barthel Index score at admission	86.2±27.65	81.15±35.4	0.288
Charlson comorbidity index	2.45±2.63	2.63±2.60	0.671

Unless indicated otherwise, data are given as the mean±SD or median [interquartile range]. [A]Data were collected between January and March for the period 2015–2019. ASD, atrial septal defects; BMI, body mass index; IHD, ischemic heart disease; JPY, Japanese Yen; PAD, peripheral arterial disease; VHD, valvular heart disease; VTE, venous thromboembolism.

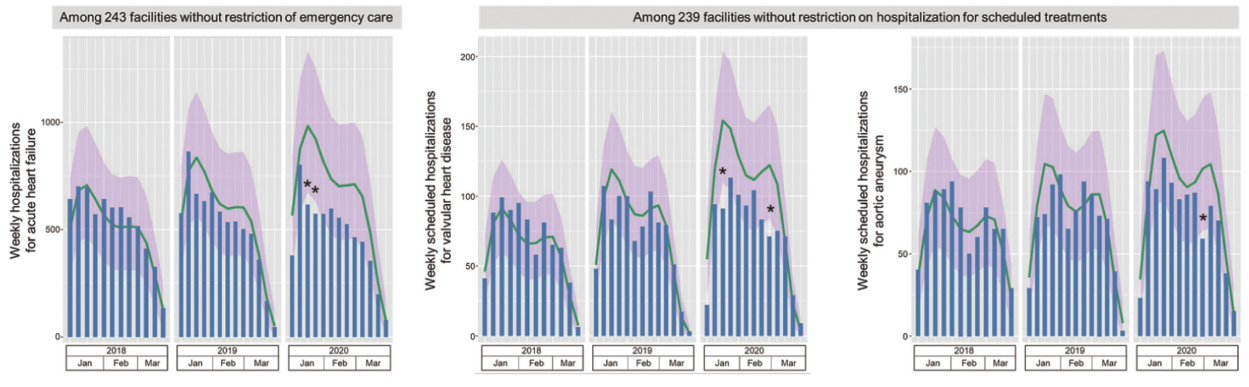

Figure 4. Weekly hospitalizations among facilities without restrictions to emergency hospitalizations and procedures for cardiovascular diseases. Green lines indicate the estimated number of hospitalizations per week. Purple shaded areas indicate the 95% prediction intervals of hospitalizations per week. Asterisks indicate weeks in which the number of hospitalizations was less than 95% of the estimated value.

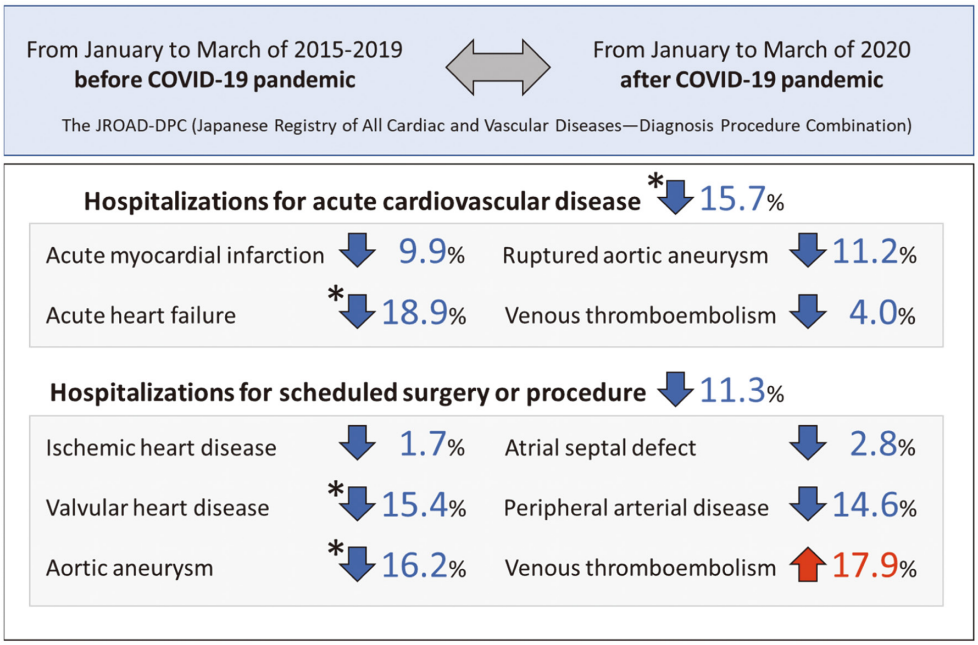

Figure 5. Summary of findings. Asterisks indicate diseases for which the estimated number of hospitalizations per week was less than the 95% prediction interval.

for acute CVD between January and March 2020 was low (84% of the expected value), with hospitalizations for acute heart failure being the lowest among all conditions (81% of the expected value) and (2) the number of hospitalizations for a scheduled treatment was 89% of the expected value, with hospitalizations for the scheduled treatment of aortic aneurysms and valvular disease being 84% and 85% of the expected values, respectively. There were periods when the number of hospitalizations per week for acute heart failure and scheduled hospitalizations for aortic aneurysms and valvular disease were clearly lower than expected.

Hospitalizations for CVD in Japan are increasing each year as the population ages, and it has become a major public health concern.[13] An increase in the number of hospitalizations was estimated by the model used in the present study. However, during the period January–March 2020, which corresponds to the beginning of the COVID-19 pandemic, hospitalizations for acute CVD and the number of scheduled treatments for CVD were both lower than expected. There was no increase in the in-hospital mortality associated with any disease or treatment, as reported in previous studies,[1,14,15] and no decrease in the Barthel Index score at admission.

The decrease in the number of hospitalizations for CVD observed in the present study can be attributed to environmental factors (e.g., the infectious disease pandemic), hospital-related factors (e.g., restrictions of hospitalizations for CVD), and patient-related factors (e.g., avoiding using medical facilities). The first case of COVID-19 in Japan was confirmed on January 15, 2020. At the end of March 2020, the number of patients diagnosed with COVID-19 per day (1.2 per million people) and the total number of patients with COVID-19 (18 per million people) in Japan were very low, making it unlikely that the COVID-19 pandemic was directly related to the hospitalization of patients with CVD. Even in hospitals without restrictions on emergency hospitalizations and procedures for CVD, the number of hospitalizations for acute heart failure and scheduled hospitalizations for aortic aneurysms and valvular disease decreased, suggesting that patient-related factors were the main cause of the decrease in the number of hospitalizations. These findings are consistent with research reports indicating that patients tended to avoid medical facilities during the COVID-19 pandemic in Japan.[6] Increases were observed in the proportion of critically ill (New York Heart Association Class III or IV) patients hospitalized for acute heart failure and in the number of scheduled hospitalizations for venous thromboembolism. However, it is difficult to determine from our results whether patients' reluctance to visit doctors or changes in their lifestyles to reduce the risk of developing CVD contributed to the decrease in the number of hospitalizations for CVD. A reduction in the number of hospitalizations does not necessarily indicate improved patient outcomes; rather, it is important to consider that patients may have missed out on necessary treatment.

This study has several limitations that need to be discussed. First, this study is not based on exhaustive data; therefore, the results should be interpreted with caution. Because this study included most facilities participating in the JROAD-DPC and an analysis of data collected through a questionnaire survey regarding medical restrictions, we believe that our results are adequate. Second, the subanalysis of hospitals without medical restrictions revealed lower rates of hospitalization for acute heart failure (72.4%) and scheduled hospitalizations for valvular heart disease (75.0%) than the main analysis (81.1% and 84.6%, respectively). It is possible that hospitalizations were

concentrated in those hospitals where restrictions were imposed; however, because we did not evaluate the uneven distribution of hospitalizations among the different facilities, additional research is required. Third, this study does not sufficiently explain why the number of scheduled hospitalizations for venous thromboembolism increased. Factors related to the COVID-19 pandemic may have been responsible for an increase in the incidence of venous thromboembolism, because individuals may have refrained from habitual exercise. Finally, this study only examined the early phase of the COVID-19 pandemic, and longer-term studies are required to determine the effects of COVID-19 on cardiovascular care.

Conclusions

The spread of COVID-19 was associated with a decrease in the number of hospitalizations for CVD in Japan, even in the early stages of the COVID-19 pandemic. The possibility of a decline in hospitalizations for CVD should be considered in the event of an emerging infectious disease pandemic.

Acknowledgment

The authors thank Editage (www.editage.com) for English language editing.

Sources of Funding

This work was supported by the Japanese Ministry of Health, Labour and Welfare Policy Research Grants, Special Research Program (Grant no. 21CA2002).

Disclosures

None of the authors has any conflicts of interest related to this study. However, K.N. and Y. Miyamoto are members of the *Circulation Reports*' Editorial Team.

IRB Information

The ethics committees of the Japanese Circulation Society and Mie University (U2021-034) approved the study protocol and waived the requirement for obtaining informed consent from participants because no personal identifying information was used in the study.

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Supplementary Files

Please find supplementary file(s);
http://dx.doi.org/10.1253/circrep.CR-22-0058