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Hospitalization Costs for Patients With Acute Congestive Heart Failure in Japan

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Background: With aging of the population, the economic burden associated with heart failure (HF) is expected to increase. However, little is known about the hospitalization costs associated with HF in Japan.

Methods and Results: In this cross-sectional study, using data from The Japanese Registry of All Cardiac and Vascular Diseases (JROAD) and JROAD-Diagnosis Procedure Combination databases between 2012 and 2014, we evaluated hospitalization costs for acute cardiovascular diseases (CVDs), including HF. A total of $1,187 million/year (44% of the hospitalization costs for acute CVDs) was spent on patients with HF. We identified 273,865 patients with HF and the median cost per patient was $8,089 ($5,362–12,787) per episode. The top 1% of spenders accounted for 8% ($80 million/year), and the top 5% of spenders accounted for 22% ($229 million/year) of the entire cost associated with HF. The costs associated with HF for patients over 75 years of age accounted for 68% of the total cost.

Conclusions: The costs associated with HF were higher than the hospitalization cost for any other acute CVD in Japan. Understanding how the total hospitalization cost is distributed may allow health providers to utilize limited resources more effectively for patients with HF.

Key Words: Diagnosis procedure combination (DPC) discharge database; Healthcare provision; Heart failure; Japanese Registry of All Cardiac and Vascular Diseases (JROAD) database

Heart failure (HF) is one of the most important public health problems because of its high prevalence and mortality. Approximately 26 million adults are living with HF worldwide, and the prevalence increases with age, accounting for 12% of elderly people over 80 years old.[1] HF is also one of the leading causes of hospitalization in Japan, the USA, and Europe, representing 1–2% of all hospitalizations.[2–4] Although the mortality rate for HF has slightly improved because of improved care, the 30-day readmission rate is 24.4% and the 5-year mortality remains 52.6%.[5,6] Roger et al reported that the total HF costs in the USA would increase from $20.9 billion in 2012 to $53.1 billion in 2030, and almost 80% of the costs would be related to hospitalization.[1] The hospitalization cost of HF is a significant concern worldwide.

Japan is the most rapidly aging country worldwide. The elderly population (and aging rate) was 3,514 million (27.7%) in 2017. It has been reported that outpatients with left ventricular dysfunction accounted for 0.8% (979,000 people) of the total population in Japan in 2005.[7,8] This is predicted to reach 1.3 million by 2030, as the number of elderly people increases.

With the increase in the population of elderly individuals in Japan, HF places a significant burden on society as a leading cause of hospitalization. Despite the economic burden, there have been few studies on hospitalization costs for patients with acute HF in Japan.

Methods

Study Design and Data Sources

This retrospective cross-sectional study used The Japanese Registry of All Cardiac and Vascular Diseases (JROAD) and the Diagnosis Procedure Combination (DPC) discharge databases to analyze the hospitalization costs, period of hospitalization, and deaths from cardiovascular diseases (CVDs) from April 1, 2012, to March 31, 2015.

JROAD is a nationwide registry conducted by the

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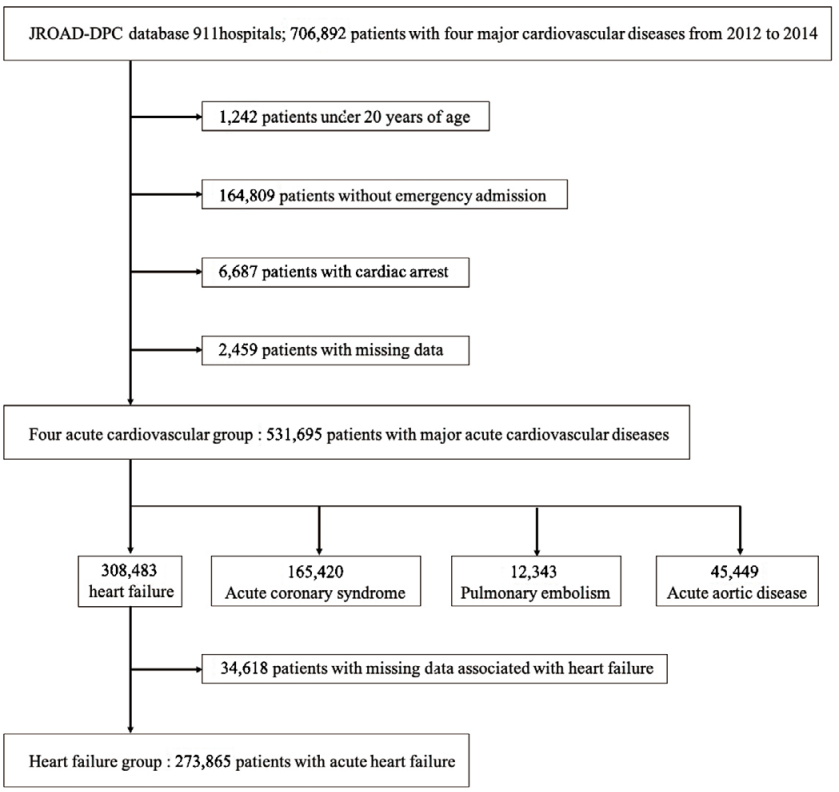

Figure 1. Study flow chart. JROAD, Japanese Registry of All Cardiac and Vascular Diseases-(DPC) Diagnosis Procedure Combination.

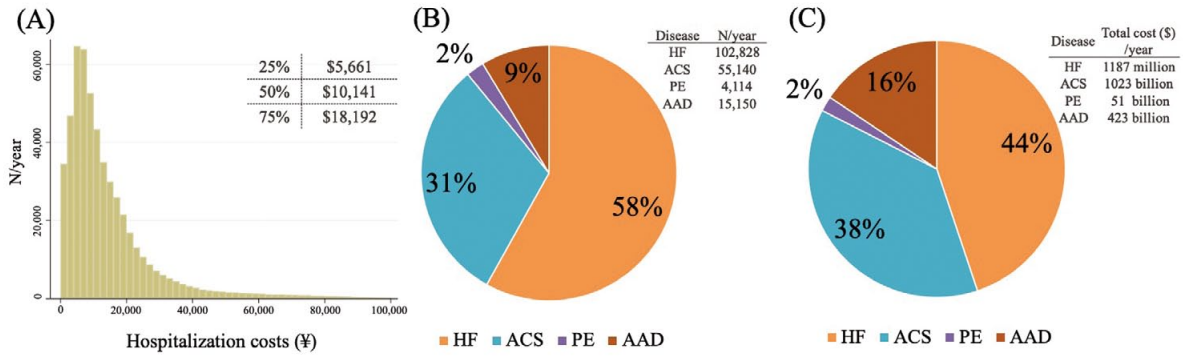

Figure 2. Annual number of patients with acute cardiovascular diseases and associated hospitalization costs. (**A**) Distribution of hospitalization costs for 4 acute major cardiovascular diseases. Inset: median (IQR) hospitalization costs. (**B**) Proportion of the number of patients per acute major cardiovascular disease. Inset: number of hospitalizations per year. (**C**) Proportion of the hospitalization costs per acute major cardiovascular disease. Inset: total costs for each disease. AAD, acute aortic disease; ACS, acute coronary syndrome; HF, heart failure; IQR, interquartile range; PE, pulmonary embolism.

Japanese Circulation Society (JCS), covering all cardiovascular training facilities.[9] JROAD includes hospital structural data collected from all participating training hospitals with cardiovascular beds, except for stroke. The response rates of the training and associate training hospitals were 100% in 2013. To use the individual data, we analyzed JROAD-DPC, using data from the Japanese DPC/Per-Diem Payment System (PDPS). DPC/PDPS is a case-mix patient classification system that has been linked to payments at acute-care hospitals in Japan. DPC/PDPS includes individual inpatient data, such as patient age and sex, main diagnoses and comorbidities, medical treatments, length of stay, discharge status, and hospitalization costs. A total of 71.9% of all training hospitals participating in JROAD in 2014 provided DPC/PDPS data to JCS, and the data were merged with the JROAD database.[10]

Cost Calculation

The total hospitalization costs were calculated as the sum of bundled payment and fee-for-service, without the food fee. DPC/PDPS is the bundled payment system of medical fees for acute inpatient medical care in Japan.[11] The bundled payment for each hospitalization was calculated according to the codes in the International Classification of Diseases 10th revision (ICD-10) and the coefficient for each facility. Fee-for-service was the sum of all prices for medical services, such as high-cost medical procedures.

Study Population for Major CVDs

The number of cases of acute CVD has been increasing with the increase in the elderly population, and we selected patients with emergency admissions.[12] We identified patients who were hospitalized for acute CVDs including HF, acute coronary syndrome (ACS), pulmonary embolism (PE), and acute aortic dissection or aortic aneurysm (AAD). The diagnosis of acute CVD was based on the following ICD-10 codes: HF (I50.0, I50.1, I50.9, I11.0, I13.0, I13.2); ACS (I20.0, I21.1, I21.2, I21.3, I21.4, I21.9, I22.0, I22.1, I22.8, I22.9, I24.9); PE (I26.0, I26.9); and AAD (I71.0, I71.1, I71.2, I71.3, I71.4, I71.5, I71.6, I71.7, I71.8, I71.9). If a patient had duplicate diagnosis codes for acute CVDs, the diagnosis priority order was defined as AAD, PE, ACS, and HF. The inclusion criteria were adults over 20 years old with emergency hospitalization related to these 4 major acute CVDs. To analyze the total hospitalization costs for these CVDs, we analyzed all hospitalizations, including readmissions. We excluded patients under age 20 years, without an emergency admission, and if they had data were missing.

The analysis was performed for 2 groups: (1) acute CVD group, including HF, ACS, PE, and AAD, and (2) HF group.

Analysis of 4 Acute CVDs

Patients with emergency hospitalization for the 4 CVDs in the JROAD-DPC database were identified. The total number of hospitalizations, hospitalization cost and length, and in-hospital death were analyzed for each patient. The distribution of hospitalization costs of acute CVD was also described. Consequently, the proportion of the total number of hospitalizations and total hospitalization cost were analyzed for each acute CVD.

Analysis of HF

Patients with emergency hospitalization for HF in the JROAD-DPC database were identified. First, we determined the number of hospitalizations, hospitalization cost and length, and in-hospital deaths for HF. We examined the distribution of the total hospitalization costs for HF. Second, the patients with HF were categorized into quintiles on the basis of their inpatient medical costs. Age was categorized into 4 groups: non-elderly population (aged 20–64 years), young-old population (aged 65–74 years), old-old population (aged 75–84 years), and super-old population (aged ≥85 years). The proportion of patients with HF to the total hospitalization costs for HF by age was analyzed. The patients' characteristics in the highest quintile were described by age category. Finally, we determined the in-hospital mortality and the home discharge rates by cost and age category.

We obtained the following variables: patient variables of interest (age, sex, Charlson score, comorbidities, etiology

Table 1. Characteristics, Treatments, and Outcomes of Patients With HF

No. of patients/year	91,288
Age, median (IQR) years	81 (73–87)
Male, n (%)	52
Charlson score, median (IQR)	2 (1–3)
Comorbidities, n (%)	
Hypertension	52
Diabetes mellitus	26
Dyslipidemia	17
Atrial fibrillation	28
Chronic kidney disease	13
Pneumonia	11
Stroke	7
Malignant tumor	6
Etiology of HF (%)*	
Ischemic heart disease	12
Valvular disease	12
Cardiomyopathy	5
Ambulance use (%)	40
NYHA class (%)	
I	7
II	26
III	34
IV	33
Number of hospital beds where HF patients were treated (%)	
Small (≤199)	7
Medium (200–399)	46
Large (≥400)	47
Treatments (%)	
Ventilator	20
CRRT	2
PCI	4
Catheter ablation	0.1
CABG	0.7
IABP	0.8
PCPS	0.1
LVAD	0.004
Discharge destination (%)	
Home	76
Hospital	9
Nursing facility	5
In-hospital death	10
Hospital length of stay, median (IQR)	17 (11–28)
Cost ($), median (IQR)	8,089 (5,362–12,784)

Continuous variables are expressed as median (IQR) for skewed data. *Sum of the percentages of the etiology of HF was not 100%, because the extracted etiologies were described in the DPC database. CABG, coronary artery bypass graft; CRRT, continuous renal replacement therapy; DPC, Diagnosis Procedure Combination; HF, heart failure; IABP, intra-aortic balloon pumping; IQR, interquartile range; LVAD, left ventricular assist device; PCI, percutaneous coronary intervention; PCPS, percutaneous cardiopulmonary support.

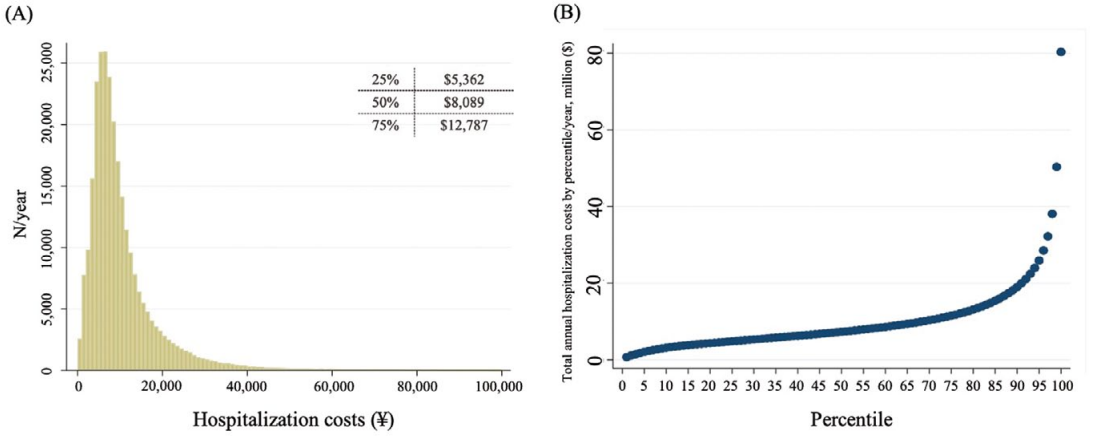

Figure 3. Distribution of hospitalization costs for acute heart failure. (**A**) Distribution of the hospitalization costs per heart failure patient. Inset: median (IQR) hospitalization costs. (**B**) Total annual hospitalization cost for heart failure patients by percentile. IQR, interquartile range.

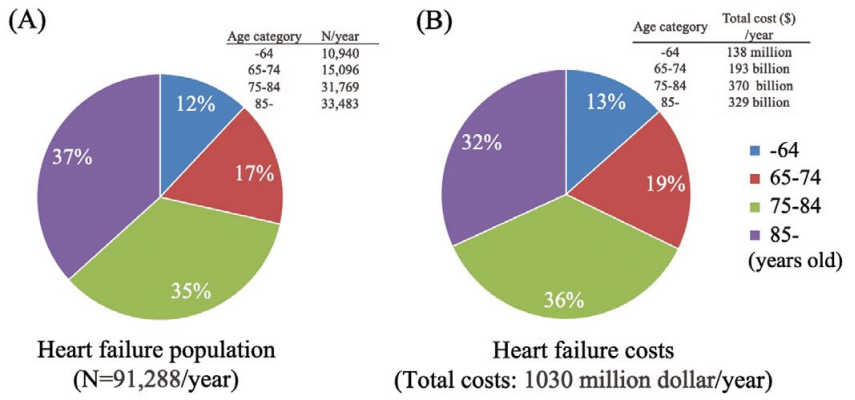

Figure 4. Number of patients with heart failure and associated hospitalization costs by age category. (**A**) Proportion of patients with heart failure by age category. (**B**) Proportion of total costs for patients with heart failure by age category.

of HF, ambulance use, and New York Heart Association [NYHA] score), number of hospital beds, and medical treatments. The etiologies of HF were determined on the basis of the DPC codes: ischemic heart disease (I21, I22, I252, I255), valvular disease (I34, I35), and cardiomyopathy (I42, I43), as described in the DPC records. The procedures were collated on the basis of the procedure codes from the DPC data.

Ethics Statement

The institutional review boards of both the JCS and the Nara Medical University approved the study protocol and waived the requirement for individual informed consent because no information specifying individuals was included (registration no. 1604). Patient data were anonymized using the original DPC data.

Statistical Analysis

Continuous variables were described using median (interquartile range [IQR]) for asymmetrically distributed data. For categorical variables, frequencies and percentages were used.

Lowess smoothing (bandwidth 0.8) was used to show the in-hospital mortality and home discharge rates by cost and age category. STATA (Version 14, Stata Corp., College Station, TX, USA) was used for the analyses.

Results

Hospitalization Costs for 4 Acute CVDs

We collected data for 706,892 patients with 4 acute CVDs in 911 hospitals. We excluded 1,242 patients aged less than 20 years, 164,809 patients without an emergency admission, 6,687 patients with cardiac arrest, and 2,459 patients with missing data. Therefore, we analyzed 531,695 patients in 885 hospitals (**Figure 1**).

Among the 4 major CVDs, the annual hospitalization cost per patient were right-skewed (**Figure 2A**), with a median (IQR) cost of $10,141 ($5,661–18,192), median (IQR) length of hospitalization at 15 (9–25) days, and in-hospital mortality rate at 11.2%.

The numbers of patients were as follows: HF, 102,828/

Table 2. Characteristics, Treatments, and Outcomes of Patients With HF for the Highest Cost Quintiles by Age Category

	Hospitalization cost >80th percentile			
	≤64 years	65–74 years	75–84 years	≥85 years
No. of patients/year (%)	2,426 (13)	2,816 (19)	6,071 (37)	7,277 (31)
Cost ($), median (IQR)	22,449 (17,450–34,102)	22,925 (17,726–34,645)	21,684 (17,306–30,352)	20,016 (16,764–25,781)
Total costs, million US dollars /year (%)	226 (15)	324 (22)	565 (37)	392 (26)
Age, median (IQR)	58 (50–62)	70 (67–73)	80 (78–82)	88 (86–91)
Male (%)	74	65	53	36
Charlson score, median (IQR)	2 (1–3)	2 (1–3)	2 (1–3)	2 (1–3)
Comorbidities (%)				
Hypertension	49	46	46	46
Diabetes mellitus	40	41	32	20
Dyslipidemia	23	21	17	13
Atrial fibrillation	18	22	26	25
Chronic renal failure	15	17	16	14
Pneumonia	11	13	15	19
Stroke	5	8	9	10
Malignant tumor	3	6	7	6
Etiology of HF (%)*				
Ischemic heart disease	17	18	15	12
Valvular disease	8	10	12	14
Cardiomyopathy	14	7	4	2
Ambulance use (%)	43	46	48	49
NYHA class (%)				
I	6	6	5	5
II	21	21	22	21
III	30	32	33	34
IV	42	41	40	40
Number of hospital beds where HF patients were treated (%)				
Small (≤199)	4	5	6	7
Medium (200–399)	34	36	41	48
Large (≥400)	62	59	53	44
Treatments (%)				
Ventilator	46	48	41	31
CRRT	9	9	6	3
PCI	21	22	18	10
Ablation	0.4	0.8	0.6	0.3
CABG	6	6	3	0.4
IABP	7	6	3	1
PCPS	1.5	0.9	0.4	0.1
LVAD	0.1	0	0	0
Discharge destination (%)				
Home	84	77	65	48
Hospital	9	12	18	24
Nursing facility	0.4	1.3	4.0	9.3
In-hospital death	6	10	13	19
Hospital length of stay, median (IQR)	35 (24–50)	36 (24–53)	41 (27–58)	47 (33–64)

Continuous variables are expressed as median (IQR) for skewed data. For categorical variables, frequencies, and percentages are used. Percentages in this column may not add up to exactly 100% because of rounding. *Sum of the percentages of the etiology of HF was not 100%, because the extracted etiologies were described in the DPC database. Abbreviations as in Table 1.

year; ACS, 55,140/year; PE, 4,114/year; and AAD, 15,150/year. The median (IQR) hospitalization costs were as follows: HF, $8,115 (5,302–13,023); ACS, $16,114 (9,227–23,639); PE, $9,725 (6,270–14,760); and AAD, $12,774 (4,532–47,789). The median (IQR) lengths of hospital stay were as follows: HF, 18 (11–28) days; ACS, 11 (5–17) days; PE, 17 (11–26) days; and AAD, 18 (6–30) days. The in-hospital mortality rates were as follows: HF, 11.2%; ACS, 8.0%; PE, 9.4%; and AAD, 23.3%.

The number of patients with HF accounted for 58% of the 4 acute CVDs (**Figure 2B**). The total cost for acute CVD was $2684 million/year. HF was the main component

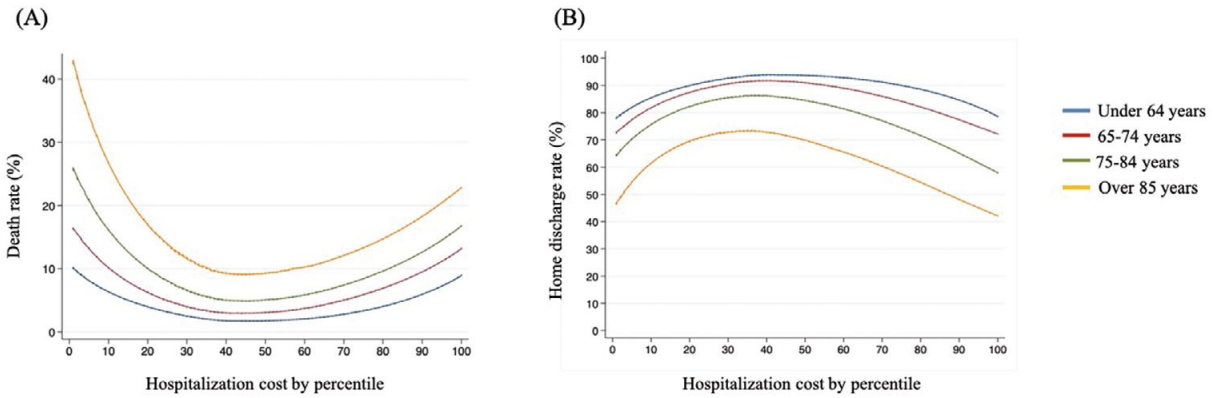

Figure 5. Mortality (**A**) and home discharge (**B**) rates by cost and age category.

in the total hospitalization costs, accounting for 44% of the 4 CVDs (**Figure 2C**).

Hospitalization Costs for HF

Of the 308,483 patients with HF, we excluded 34,618 with missing data associated with acute HF. We analyzed 273,865 patients in 885 hospitals (**Figure 1**).

The patients' characteristics are shown in **Table 1**. The median age was 81 years. The hospitalization costs for HF were right-skewed, with a median (IQR) cost of $8,089 (5,362–12,787) (**Figure 3A**). The total annual hospitalization cost for patients with HF was $1,030 million. The total hospitalization costs by percentile are shown in **Figure 3B**. The top 1% patients with high annual inpatient costs used 8% ($80 million/year) and the top 5% used 22% ($229 million/year) of the annual inpatient costs for HF. Compared with the entire population with HF, the top 5% of spenders were relatively younger with diabetes, chronic kidney disease, and NYHA class IV, and were likely to be treated with mechanical circulation devices (**Supplementary Table**).

The proportion of patients and the total hospitalization costs by age category are shown in **Figure 4**. The old-old and super-old patients accounted for 72% of all patients with HF (**Figure 4A**). The total costs for the old-old and super-old patients accounted for 68% of those for all patients with HF (**Figure 4B**).

Patients' Characteristics Associated With High Costs for HF by Age Category

Table 2 shows the patients' characteristics in the highest cost quintiles, stratified by age group. The numbers of old-old and super-old patients accounted for 37% and 31% of the highest cost quintile population, respectively. Younger patients tended to be hospitalized in large hospitals. The proportions of NYHA IV, etiology of cardiomyopathy, and treatments such as percutaneous coronary intervention, ablation, intra-aortic balloon pumping, percutaneous cardiopulmonary support, and left ventricular assist device were more common in the non-elderly population. However, the etiology of valvular disease and complication of pneumonia were common and the length of hospital stay was longer in the elderly population.

In-Hospital Mortality and Home Discharge Rates by Cost and Age Category

The association between in-hospital death and hospitalization costs by percentile, stratified by age category, is shown in **Figure 5A**. A U-shaped relationship was noted in all age categories.

The association between the home discharge rate and hospitalization costs by percentile, stratified by age category, is shown in **Figure 5B**. An inverted U-shaped relationship was noted in all age categories. The home discharge rate for all patients was 76%, but the rate for patients aged ≥85 years was 65%.

Discussion

The primary significant findings of our study were: (1) 58% of hospitalizations and 44% of the hospitalization costs for acute CVDs were for HF; (2) the top 5% of patients with high annual inpatient costs used 22% of the annual inpatient costs for HF; and (3) the total costs for old-old and super-old patients accounted for 68% of all patients with HF.

Although few reports are available on the cost for HF in Japan, similar findings have been reported in previous research in other settings. Sasaki et al showed in a study involving 261 hospitals in Japan that the mean hospitalization cost was $8,284 per patient.[13] In 2015 it was reported that the hospitalization costs for HF were right-skewed and the median cost of HF was $7,000 in the USA.[14] Farré et al showed that 10% of the total expenditure for HF was spent in the care of 1% of patients and half of the total expenditure was used for the care of 15% of patients.[15] Younger age, teaching hospitals, a higher number of procedures, and longer lengths of stay are associated with higher hospitalization costs.[16]

In addition, we analyzed the characteristics of patients with high-cost hospitalizations by age category. Compared with the older patients, the younger patients in the high-cost group were likely to be treated with mechanical circulation devices in large facilities. The findings led us to conclude that younger patients are treated with "aggressive" strategies and the elderly patients with "conservative" strategies. Because our study could not clarify whether these strategies are appropriate, further study is necessary

to examine whether the strategy of high-cost HF treatment leads to better outcomes. In contrast, older patients in the high-cost group had longer lengths of stay than the younger patients, which resulted in greater expenditure. Longer hospitalization might result from a higher incidence of comorbidities and complications.[16,17] Preventing unnecessary long hospitalization of elderly patients with HF would reduce the costs associated with HF, so efforts should be made to reduce in-hospital complications to improve both the outcomes and costs of HF.

No large descriptive study on the cost for CVD in Japan has been reported. Japan has the highest population with an accelerated aging rate worldwide.[18] In our study, more than half of the patients with HF were over the age of 80 years. Considering the projected increasing prevalence of HF in future, the costs will become huge. Our study provides information regarding the distribution of healthcare-related expenditure, which is useful for appropriate health cost management in Japan and in other countries with an aging population.

Study Limitations

Our study has a few limitations. First, we analyzed only patients with HF hospitalized in DPC hospitals, which may lead to a selection bias. Of the 7,474 general hospitals in Japan, 1,580 used the DPC/PDPS system in 2013.[19] Of those, we collect DPC data from 911 hospitals. Considering that the overall hospitalization costs for CVD, including cerebrovascular disease, were approximately $31 billion of the total national medical care expenditure of $410 billion in 2013 in Japan,[20] the total annual hospitalization cost for all patients in the JROAD-DPC registry, $9.4 billion, corresponds to approximately 30% of the total cost of cardiovascular hospitalizations. The present study is the largest study of acute CVD in Japan. Second, we analyzed the hospitalization costs in the DPC database, but could not calculate the outpatient costs. Although in the USA 80% of the costs attributed to HF are shown to be related to hospitalization, we may need to analyze outpatient costs using another database.[21] Finally, we could not analyze the cost of sudden death because we could not obtain accurate records.

Conclusions

The cost associated with HF was found to be higher than the hospitalization cost for any other acute CVD in Japan. Understanding how the total hospitalization cost is distributed may allow health providers to utilize limited resources more effectively for patients with HF.

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Supplementary Files

Please find supplementary file(s);
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