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Medical Costs and Readmissions After Intensive Poststroke Rehabilitation: Japanese Claims Data

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A B S T R A C T

Objectives: This study examined the association between intensive rehabilitation for subacute stroke patients and medical costs and readmission ratio during the year after discharge.
Design: This was a natural experiment study.
Setting and Participants: We identified individuals with a diagnosis of cerebrovascular disorder (*ICD-10*: I60-I69 cerebrovascular disease) in an insurance claims database in Japan from January 2005 to December 2017. From the database, 980 patients who were admitted to a convalescent rehabilitation unit with stroke were identified. After excluding 575 patients, 405 were eligible for the study.
Methods: In Japan, from April 2011, a new policy was established that allows special costs to be added as rehabilitation time increases. This policy provides an additional medical fee for inpatients in a convalescent rehabilitation unit who receive more than 120 minutes of rehabilitation therapy. We defined high-intensity rehabilitation as transfer from hospitalization to a convalescent rehabilitation unit after April 2011. Outcomes were total direct medical costs and readmission ratio during the year after discharge from the convalescent rehabilitation unit.
Results: Daily rehabilitation time, total rehabilitation time, and total medical costs of the high-intensity rehabilitation group were significantly higher than those of the low-intensity rehabilitation group ($P < .001$, $P < .001$, $P = .011$, respectively). However, there was no significant difference in the medical costs during the year after discharge ($P = .653$) or in the readmission ratio (hazard ratio: 1.09, 95% confidence interval: 0.55-2.18, $P = .804$).
Conclusions and Implications: Intensive rehabilitation did not reduce medical costs or the readmission ratio during the first year after discharge. Future studies should consider the necessary rehabilitation intensity given the severity of the patient's condition, using large sample sizes.

Stroke is a major disease that is associated with care needs worldwide because many patients have permanent disability following stroke.[1] Further, the various diseases caused by disability after stroke are reflected in the exceptionally high long-term costs of providing health care to people who have experienced stroke.[2–4] These high costs indicate the urgent need for effective rehabilitation, which could reduce national expenditure for stroke-related health care services.[5] Intensity of rehabilitation is an important factor in effective rehabilitation.[6–9] Therefore, focus on long-term medical costs is essential to assess the impact of intensive rehabilitation on total stroke costs.

In Japan, a convalescent rehabilitation unit is the main system of inpatient rehabilitation covered by the medical insurance system.[10,11] These facilities provide intensive rehabilitation via an interdisciplinary team approach (physical therapy, occupational therapy, speech therapy) to subacute patients after stroke (≤3 hours/d, including weekends; maximum length of stay: 180 days). All patients who continue to require assistance with activities of daily living after acute hospital treatment are transferred to these facilities. There is no similar rehabilitation system elsewhere in the world that provides such intensity of rehabilitation.[10] Previous studies have demonstrated that

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high-intensity rehabilitation is related to outcomes such as improving optimal function in a shorter length of stay.[12–14] Additionally, it has been reported that patients who received high-intensity rehabilitation following stroke had a lower readmissions ratio and less mortality worldwide.[15,16] Therefore, when focusing on rehabilitation in the recovery phase, it is important to examine the spillover effects of intensive rehabilitation with medical costs and readmission ratio as outcomes in the long term.

However, these previous studies investigated the impact of high-intensity rehabilitation at the functional level at the time of discharge, but the impact was not investigated after discharge, or consisted of a short-term verification of about 3 months after discharge. Moreover, most studies did not adjust for confounds that may influence the outcome of rehabilitation. It is necessary to examine whether improved function following high-intensity rehabilitation is associated with a reduction in medical costs after discharge and a lower readmission ratio in the long term, after adjusting for confounds. By focusing on these issues, it will become possible to make proposals to further reduce the medical costs associated with high-intensity poststroke rehabilitation over the long term. Furthermore, it will be possible to elucidate the clinical value of high-intensity rehabilitation.

Therefore, we hypothesized that improving function through high-intensity rehabilitation would contribute to reduced medical costs and fewer readmissions due to the prevention of various diseases, such as aspiration pneumonia, and falls even after discharge from hospital. Therefore, the purpose of this study was to examine the association between intensive rehabilitation for patients with subacute stroke and medical costs and the readmission ratio during the 1 year after discharge.

Methods

Design

This was a natural experiment study, which represents a method of making causal inferences using a situation in which participants are naturally separated into 2 groups (eg, due to a change in policy): those receiving the intervention and those not receiving it.[17–19] Unlike traditional randomized experiments, natural experiments are not controlled by researchers but rather observed and analyzed. In this design, it can be assumed that the characteristics of the patients are homogeneous before and after the policy and the causal effect can be estimated without the influence of confounding factors.

In Japan, from April 2011, a new policy was established that allows special costs to be added as rehabilitation time increases. This policy provides an additional medical fee for inpatients in convalescent rehabilitation units who receive more than 120 minutes/d of rehabilitation (physical therapy, occupational therapy, and speech and language therapy). This policy provides an incentive for health care practitioners to provide more intensive rehabilitation for patients who are hospitalized during the recovery phase. It has been reported that rehabilitation intensity has improved since implementation of this policy.[20] Therefore, we defined patients admitted to convalescent rehabilitation units before March 2011 as the low-intensity rehabilitation group, and patients admitted to convalescent rehabilitation units after April 2011 as the high-intensity rehabilitation group. Confounding factors such as severity in both groups were homogeneous, because it can be assumed that there was no difference between patients admitted before March 2011 and after April 2011. We conducted an intention-to-treat analysis[21]; therefore, even if the patients were admitted before 2011 and received rehabilitation more than 120 minutes/d, they were analyzed as a low-intensity group. We considered this analytic method to be valid for an evaluation of policies that induce intensive rehabilitation.

Data Source

We retrospectively extracted data from a Japanese insurance claims database (JMDC Inc, Tokyo, Japan). The JMDC contains data from more than 60 insurers and approximately 1.5 million insured individuals in 2013, most of whom are employees of Japanese companies and their family members. The database contains information on administrative claims data for clinic visits and hospital admissions. Diagnoses are recorded using the *International Classification of Diseases, 10th Revision* (*ICD-10*), codes. The need for informed consent was waived because of the deidentified nature of the data. The study was approved by the ethics committee at the Kanagawa University of Human Services (no. 71-27).

Study Population

We identified individuals in the JMDC database with a diagnosis of cerebrovascular disorder (*ICD-10*: I60-I69 cerebrovascular disease) from January 2005 to December 2017. The inclusion criteria were patients with a first episode of cerebrovascular disease (no diagnosis of cerebrovascular disease in the prior year), who were hospitalized in a convalescent rehabilitation unit, with acute hospitalization during this episode, no hospitalization history in the year before the stroke, hospitalization in a convalescent rehabilitation unit for more than 1 month (30 days), with follow-up for 1 year after discharge from the convalescent rehabilitation unit, and who returned home after discharge from the convalescent rehabilitation unit.

Outcome and Exposure

The outline of this study is shown in the Supplementary Figure 1. Outcomes were total direct medical costs and the readmission ratio during 1 year after discharge from the convalescent rehabilitation unit. Exposure was defined as the average rehabilitation time per day (daily rehabilitation time: rehabilitation intensity). The average rehabilitation time per day was calculated as the total duration (minutes) of rehabilitation during hospitalization divided by the length of hospital stay. We defined high-intensity rehabilitation as hospitalization to a convalescent rehabilitation unit after April 2011 because high-intensity rehabilitation was implemented as policy since that date in Japan. We defined low-intensity rehabilitation as hospitalization to a convalescent rehabilitation unit before March 2011. Medical costs were converted to US dollars using average currency conversion rates in March 2020 (http://www.x-rates.com/; 0.009303 US dollars per 1 Japanese yen).

Statistical Analysis

We compared baseline characteristics between groups using 2-tailed independent *t* tests for continuous data, Mann-Whitney *U* tests for ordinal data, and chi-square tests for categorical data. Regarding the main outcomes, the medical costs for 1 year after discharge were compared using multiple regression analysis; for comparing readmissions, the odds ratio was calculated using multiple logistic analysis and the hazard ratio was calculated using cox regression analysis. The regression analyses were conducted by adjusting for potentially confounding factors affecting health care costs and readmissions (age, gender, length of hospital stay in subacute rehabilitation unit, and length of hospital stay in acute phase). All outcomes were assessed according to intention-to-treat analysis. All statistical analyses were performed using Stata, version 15.1 (StataCorp, College Station, TX), and for all analyses, $P < .05$ was considered statistically significant.

Results

Baseline Characteristics

We identified 143,203 people with a diagnosis of cerebrovascular disorder (*ICD-10*: I60-I69 cerebrovascular disease) from January 2005 to December 2017. The final analysis considered 405 individuals (Figure 1). Table 1 presents the characteristics of each group. The groups were equivalent in terms of medical costs during the year before stroke onset, age at onset, and diagnosis.

Outcome and Exposure

Table 2 shows the outcomes and exposures of this study. In the acute phase, there were no significant differences between groups in daily rehabilitation time, total rehabilitation time, length of hospital stay, and total hospital cost. In the convalescent rehabilitation unit, the high-intensity rehabilitation group exhibited significantly higher values than did the low-intensity rehabilitation group for daily rehabilitation time ($P < .001$), total rehabilitation time ($P < .001$), and total medical costs ($P = .011$). This indicates that the rehabilitation intensity increased after April 2011.

Regarding outcomes, there was no significant difference in medical costs during the year after discharge ($P = .653$) nor in the readmission ratio (odds ratio: 1.24, 95% confidence interval: 0.53-2.89, $P = .612$, hazard ratio: 1.09, 95% confidence interval: 0.55-2.18, $P = .804$). These results suggest that high-intensity rehabilitation did not affect medical costs or the readmission ratio during the first year after discharge.

Discussion

This is the first natural experimental design to investigate the association between rehabilitation intensity and each of medical costs and the readmission ratio 1 year after discharge from convalescent rehabilitation units. The intensity of rehabilitation increased significantly after April 2011 and was equivalent to the high-intensity rehabilitation reported in previous studies.[14] Contrary to our hypothesis, rehabilitation intensity did not impact medical costs or the readmission ratio during the first year after discharge. These results suggest that even if rehabilitation intensity was high, medical costs after discharge were not reduced and the readmission ratio did not decrease. Furthermore, the sample in this study involved a relatively young generation, which suggests that they were also the generation that could benefit from rehabilitation. Therefore, we believe that the results of this study provide a significant view of the spillover effects of rehabilitation. These results challenge conventional wisdom and could represent a landmark in consideration of rehabilitation intensity for subacute poststroke patients.

Previous studies have shown that high-intensity rehabilitation increased physical function and was associated with decreased risk of both hospital readmission and mortality.[7–9,15,16,22] Contrary to the results of previous studies, the current study showed that high-intensity rehabilitation did not reduce the readmission ratio. The reason for the discrepancy between results could be that the current study involved longer-term observation than did previous studies. In addition, the definition of high-intensity rehabilitation in previous studies was inconsistent. Hsieh et al[7] considered high-intensity rehabilitation to be 15 sessions or more within 90 days, Liu et al[9] considered 3 hours or more in a community setting (total therapy hours divided by total number of therapy sessions), and Jette et al[12] considered 1.5 hours or more per day. Furthermore, similar to the present study, for the convalescent rehabilitation unit, Kamo et al[14] reported that high-intensity rehabilitation group was defined as stroke patients who received more than 15 hours of rehabilitation therapy per week (≥15 hours). In this study, we defined the high-intensity group as patients admitted to the hospital after April 2011 (in which case the hospital obtains additional insurance medical fee for more than 120 minutes/d of rehabilitation). The results of the present study showed that the intensity of rehabilitation was 135.3 (standard deviation: 30.9) minutes/d in the high-intensity group and 89.7 (standard deviation: 39.7) minutes/d in the low-intensity group. These results suggest that the low-intensity group in this study may have been receiving rehabilitation defined as high intensity in other

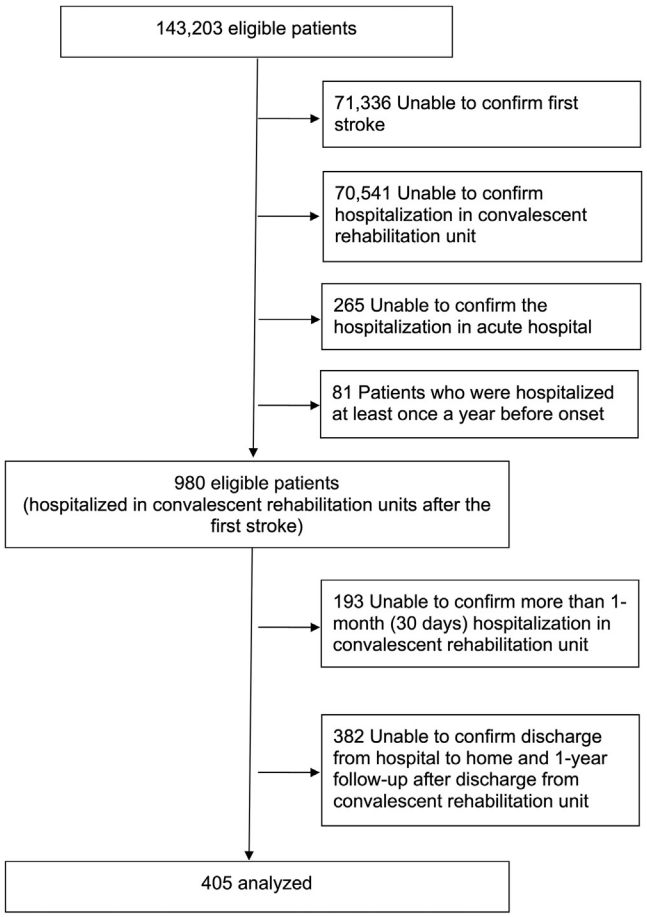

Fig. 1. Patient selection.

Table 1
Baseline Characteristics

	Low-Intensity Rehabilitation (n = 36)	High-Intensity Rehabilitation (n = 369)	*P* Value
Age, y, mean (SD)	52.6 (10.8)	52.1 (10.0)	.80
Gender, female	14 (38.9%)	111 (30.1%)	.28
Medical costs for 1 y before stroke onset, mean (SD)			
JPY	¥76,981.6 (14,357.8)	¥92,656.0 (16,686.6)	.59
USD	$716.2 (133.6)	$861.0 (155.2)	
Diagnosis, n (%)			
Subarachnoid hemorrhage	1 (2.7)	43 (11.7)	.65
Intracerebral hemorrhage	20 (55.6)	180 (48.8)	
Cerebral infarction	12 (33.3)	116 (31.4)	
Other	3 (8.3)	30 (8.1)	

JPY, Japanese yen; SD, standard deviation; USD, US dollars.

Table 2
Intensity of Rehabilitation and Outcomes

	Low-Intensity Rehabilitation, Mean (SD) (n = 36)	High-Intensity Rehabilitation, Mean (SD) (n = 369)	Coefficient	95% CI	*P* Value
Acute phase					
Daily rehabilitation time, min	44.1 (23.9)	52.9 (30.8)	8.8	−1.6 to 19.2	.098
Total rehabilitation time, min	1465.6 (1197.2)	1575.6 (1441.5)	110.0	−378.1 to 598.1	.658
Length of hospital stay, d	32.8 (27.1)	29.5 (18.8)	−3.3	−10.0 to 3.5	.339
Total medical costs					
JPY	¥1,715,808 (1,619,097)	¥1,998,848 (1,820,760)	283,040.0	−336,241.1 to 902,320.7	.370
USD	$15,962 (15,062)	$18,595 (16,938)			
Subacute rehabilitation unit					
Daily rehabilitation time, min	89.7 (39.7)	135.3 (30.9)	45.7	34.8 to 56.6	<.001
Daily rehabilitation time >120 min, n (%)	9 (25.0)	271 (73.4)	48.4%	−63.3% to −33.6%	<.001
Total rehabilitation time, min	7978.3 (4156.3)	13382.9 (7738.6)	5404.6	2831.7 to 7977.5	<.001
Length of hospital stay, d	93.5 (39.9)	96.3 (47.4)	2.8	−13.3 to 18.9	.732
Total medical costs					
JP yen*	¥2,799,126 (1,131,143)	¥3,636,482 (1,927,413)	837,357	194,872 to 1,479,841	.011
USD	$26,040 (10,523)	$33,830 (17,931)			
After discharge for 1-y follow-up					
Total medical costs					
JP yen*	¥930,616 (1,344,203)	¥811,260 (1,305,146)	−102,230	−549,018 to 344,558	.653
USD	$8658 (12,505)	$7547 (12,142)			
1-y readmissions, n (%)	8 (22.2)	92 (24.9)	2.7%	−11.6% to 17.0%	.719
Odds ratio†	*Reference*	1.24	NA	0.53 to 2.89	.612
Hazard ratio‡	*Reference*	1.09	NA	0.55 to 2.18	.804

CI, confidence interval; JPY, Japanese yen; SD, standard deviation; USD, US dollars.
*Multiple regression analysis: adjusted for age, gender, length of hospital stay in subacute rehabilitation unit, and length of hospital stay in acute phase.
†Multiple logistic regression analysis: adjusted for age, gender, length of hospital stay in subacute rehabilitation unit, and length of hospital stay in acute phase.
‡Cox proportional hazards regression analysis: adjusted for age, gender, length of hospital stay in subacute rehabilitation unit, and length of hospital stay in acute phase.

studies. Therefore, it may not be possible to simply compare the results of this study with those of other studies.

The current results also suggested that improving physical function via high-intensity rehabilitation did not contribute to directly reducing medical costs or the readmission ratio. However, we believe that high-intensity rehabilitation is not futile for subacute stroke patients. Hsieh et al[7] reported that among stroke patients with mild to moderate symptoms, high-intensity rehabilitation therapy within the first 90 days was associated with lower mortality risk compared with low-intensity therapy. Depending on the symptom severity and characteristics of patients, high-intensity rehabilitation may contribute to reducing medical costs and readmission after discharge. That is, although policies that encourage the provision of high-intensity rehabilitation are important in that they explicitly include patients who need such therapy, high-intensity rehabilitation is unlikely to be suitable for all patients. We believe that policies that set appropriate rehabilitation intensity according to patient characteristics and severity are important for patients and society alike.

Several limitations of this study should be acknowledged. First, the number of patients was unequal between 2 groups. In particular, in the low-intensity rehabilitation group, there were few data collected before 2011. However, there was no difference in patient characteristics between groups at baseline; that is, the groups were homogeneous. Therefore, the results of this study are unlikely to have been significantly affected by the sample size differences. Second, it is possible that there was bias in the sample due to the large number of patients who were excluded from the final analysis. In addition, the analysis was of health insurance association data, most of which consisted of employees of Japanese companies and their family members; as such, very few older people were represented in the sample. Therefore, it is difficult to generalize the results of this study to all stroke patients. However, it is unlikely that the results of this study would change significantly, even if the data included older people, as the subjects of this study were of ages at which rehabilitation effects would be expected. Finally, the data did not include information on severity of the patient's condition, so that stratified analysis was not possible. With information on severity of the patient's condition and a larger sample, a stratified analysis by severity might identify whether intensive rehabilitation affects postdischarge medical costs and the readmission ratio according to the severity of the patient's condition. Future studies could test the robustness of the results of this study by targeting wider age groups and assessing the severity of each patient's condition.

Conclusion and Implications

This study used a natural experimental design to provide initial insights into the association between rehabilitation intensity and each of medical costs and readmissions during the year after discharge from a convalescent rehabilitation unit. Contrary to the hypothesis, high-intensity rehabilitation did not reduce medical costs or the readmission ratio during the first year after discharge. When making policy decisions that promote intensive rehabilitation, it is important not only to increase intensity but also to set appropriate rehabilitation intensity. Therefore, future studies should use large sample sizes to determine how the necessary rehabilitation intensity depends on the characteristics and severity of the patient's condition.

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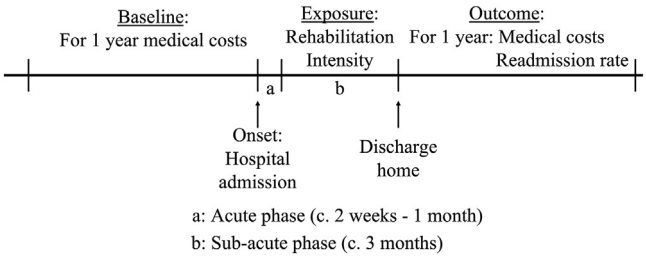

Supplementary Fig. 1. Outline of this study.