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Relationship between Use of Rehabilitation Resources and ICU Readmission and ER Visits in ICU Survivors: the Korean ICU National Data Study 2008-2015

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ABSTRACT

Background: Despite the increasing importance of rehabilitation for critically ill patients, there is little information regarding how rehabilitation therapy is utilized in clinical practice. Our objectives were to evaluate the implementation rate of rehabilitation therapy in the intensive care unit (ICU) survivors and to investigate the effects of rehabilitation therapy on outcomes.
Methods: A retrospective nationwide cohort study with including > 18 years of ages admitted to ICU between January 2008 and May 2015 (n = 1,465,776). The analyzed outcomes were readmission to ICU readmission and emergency room (ER) visit.
Results: During the study period, 249,918 (17.1%) patients received rehabilitation therapy. The percentage of patients receiving any rehabilitation therapy increased annually from 14% in 2008 to 20% in 2014, and the percentages for each type of therapy also increased over time. The most common type of rehabilitation was physical therapy (91.9%), followed by neuromuscular electrical stimulation (29.6%), occupational (28.6%), respiratory, (11.6%) and swallowing (10.3%) therapies. After adjusting for confounding variables, the risk of 30-day ICU readmission was lower in patients who received rehabilitation therapy than in those who did not (P < 0.001; hazard ratio [HR], 0.70; 95% confidence interval [CI], 0.65–0.75). And, the risk of 30-day ER visit was also lower in patients who received rehabilitation therapy (P < 0.001; HR, 0.83; 95% CI, 0.77–0.88).

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Disclosure

The authors have no potential conflicts of interest to disclose.

Author Contributions

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Conclusion: In this nationwide cohort study in Korea, only 17% of all ICU patients received rehabilitation therapy. However, rehabilitation is associated with a significant reduction in the risk of 30-day ICU readmission and ER visit.

Keywords: Nationwide Cohort Study; Intensive Care Units; Survivors; Rehabilitation; Readmission

INTRODUCTION

Patients who received intensive care regardless of the reason for admission often experience various complications after hospital discharge, including physical, cognitive, and mental health impairments, which are collectively known as post-intensive care syndrome.[1] Moreover, these complications have patients experience persistent physical disability for a long time resulting in poor prognosis and low quality of life.[2,3]

Studies show that rehabilitation is not only feasible[4-6] but able to improve physical function of patients, reduce delirium, decrease the duration of mechanical ventilation, and reduce length of stay in the hospital and intensive care unit (ICU).[5,7-10] Early rehabilitation interventions such as mobilization, passive and active exercise, training of activities of daily living, and neuromuscular electrical stimulation (NMES) improved outcomes of critically ill patients.[11,12] Lack of early ICU mobility therapy in survivors of respiratory failure requiring mechanical ventilation was associated with increased rates of hospital readmission or death within 12 months of hospital discharge.[13]

However, there is limited evidence regarding the utilization of rehabilitation at ICU evaluating patients recovering from critical illness.[14-18] The study aims to evaluate the utilization of rehabilitation resources among critically ill patients during hospital admission and its impact on health outcomes.

METHODS

Study population

We conducted a retrospective cohort analysis of the Health Insurance and Review Assessment (HIRA) database from the Korean Ministry of Health. Because Korea has a single-payer national health system, the Korean government covers approximately 97% of Koreans, with the remaining 3% who cannot afford national insurance being covered by the Medical Aid Program (MAP).[19] Claims submitted for reimbursement to the Korean National Health Insurance (KNHI) and MAP are reviewed by HIRA, a central office in the Korean Ministry of Health. Therefore, the HIRA database used in this study covered virtually all ICU admissions in Korea between January 1, 2008 and May 31, 2015.

We selected patients > 18 years of age and who hospitalized to ICU for the first time from January 1, 2007 to May 31, 2016 (n = 2,169,258). We excluded patients whose hospitalization period including before January 1, 2008 or after May 31, 2015 (n = 491,318) and died during the initial hospitalization (n = 212,164). The final sample therefore included 1,465,776 patients: 836,584 men and 629,192 women (**Fig. 1**).

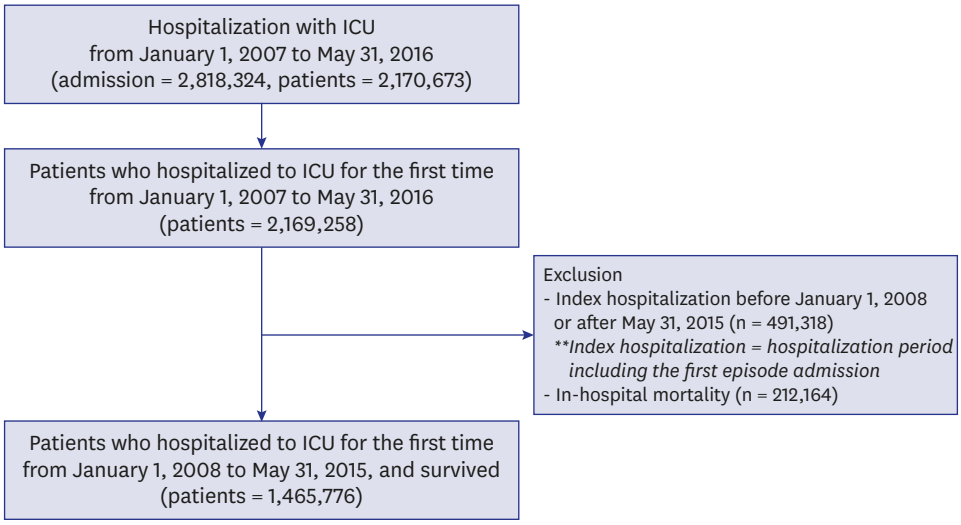

Fig. 1. Flowchart of study participants.
ICU = intensive care unit.

Data collection

We defined ICU admissions based on claim codes that hospitals in Korea are required to use when submitting cost claims to HIRA for ICU management during in-hospital stays (codes AJ100-AJ590900). These codes are based on the Korean Classification of Diseases 6th edition, which is a modified version of the International Classification of Diseases 10th revision, adapted for use in the Korean health system.[20] All ICU stays during the same hospitalization were considered a single ICU admission. Similarly, hospital stays separated by < 2 days were considered the same hospital admission.

Rehabilitation therapies during ICU admission included NMES (KNHI procedure codes MM060, MM151), occupational (MM111–MM114), physical (MM101, MM102, MM105, MM301, MM302), respiratory (MM290, MM360, MM430), or swallowing (MX141, MZ008) therapies. In terms of outcomes, emergency room (ER) visit or readmission to the ICU after the initial hospital discharge was included.

Information on comorbidities, procedures, prescriptions, and demographic characteristics was based on claim codes. Comorbidities were defined using 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) codes,[21] and summarized using the Charlson Comorbidity Index (CCI).[22,23] Patients with neurologic or neuromuscular disorders defined as patients with central nerve system disease (cerebrovascular disease [CVD], hemiplegia, and brain tumor; G45, G46, H34, I60-I69, G801, G802, G81, G830-834, C70, C71) or with spinal cord disease (paraplegia and spinal tumor; G82, G041, G114, G800, G839). Procedures of interest included mechanical ventilation (M5850, M5857, M5858, M5860), intermittent hemodialysis (O7020), peritoneal dialysis (O7062), continuous renal replacement therapy (CRRT; O7051–7054), and extracorporeal membrane oxygenation (ECMO; O1901–O1904). We identified the use of vasopressor drugs and antimicrobial agents using Korean Drug and Anatomical Therapeutic Chemical Codes.[24]

Hospitals were classified according to their capacity based on the number of hospital beds and a number of specialties, as defined by the Korean Health Law.[25] A hospital was

defined as a healthcare institution with more than 30 inpatient beds. Nursing care hospital was a hospital providing long-term inpatient stays. The general hospital was a hospital with more than 100 beds and more than seven specialty departments, including internal medicine, surgery, pediatrics, obstetrics and gynecology, anesthesiology, pathology, and laboratory medicine. The tertiary hospital was a general hospital with more than 20 specialty departments that serve as a teaching hospital for medical students and nurses. Departments were classified as medical and surgical. Medical departments included general medicine, internal medicine, neurology, psychiatry, pediatrics, dermatology, radiology, radiation oncology, clinical pathology, tuberculosis, rehabilitation medicine, family medicine, emergency medicine, industrial medicine, preventive medicine, and conservative dentistry. Surgical departments included general surgery, orthopedic surgery, neurosurgery, thoracic and cardiovascular surgery, plastic surgery, anesthesiology, obstetrics and gynecology, ophthalmology, otorhinolaryngology, urology, and oral surgery. The total cost of hospitalization, including ICU stay, was the amount of money reimbursed by KNHI to the hospitals and patients for medical services endorsed by HIRA.

Statistical analysis

Mean and standard deviation or median and interquartile range were used to describe the distribution of continuous variables. We used the χ^2 test and Student's *t*-test to compare categorical and continuous variables, respectively. We calculated hazard ratios (HRs) with 95% confidence intervals (CIs) using a proportional hazards regression model for ER visits and ICU readmissions. In the model, we adjusted for age, gender, CCI, type of hospital, type of admission, and use of mechanical ventilation, ECMO, or vasopressor drugs to account for potential confounding factors between patients with and without rehabilitation. We examined the proportional hazards assumption using plots of the log (-log) survival function and Schoenfeld residuals. All statistical analyses were performed using SAS Visual Analytics (SAS Institute INC, Cary, NC, USA).

Ethics statement

The study was reviewed by the Institutional Review Board (IRB) of Samsung Medical Center (IRB No. 2015-11-017), and exempted because we only accessed de-identified, previously collected administrative data.

RESULTS

Among the 1,465,776 patients, 249,918 (17.1%) received rehabilitation therapy during their hospital stay that included an ICU admission (**Table 1**). Compared to patients without rehabilitation therapy, those who received rehabilitation therapy were older, had a higher CCI, were more likely to be admitted to a tertiary hospital and surgical department via the ER, and were more likely to receive major treatments (mechanical ventilation, intermittent hemodialysis, peritoneal dialysis, CRRT, or ECMO) during their hospital admission (**Table 2**). The mean ICU (median 8 vs. 2 days, $P < 0.001$) and hospital length of stay (median 33 vs. 11 days, $P < 0.001$) was longer in participants who received rehabilitation therapy than in patients without rehabilitation. In addition, the total hospitalization cost was higher in participants who underwent rehabilitation therapy than in those who did not (median 8,859 vs. 4,640 dollars, $P < 0.001$).

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Table 1. Characteristics of surviving ICU patients according to rehabilitation therapy in Korea, January 2008 to May 2015

Characteristics	Overall (n = 1,465,776)	No rehabilitation (n = 1,215,858)	Rehabilitation (n = 249,918)	*P* value
Gender				< 0.001
Men	836,584 (57.1)	705,739 (58.0)	130,845 (52.4)	
Women	629,192 (42.9)	510,119 (42.0)	119,073 (47.6)	
Age, yr	63.1 (15.6)	62.6 (15.7)	65.7 (14.8)	< 0.001
CCI	3.0 (3.1)	2.8 (3)	4.2 (3.4)	< 0.001
Comorbidity				
Myocardial infarction	152,987 (10.4)	140,725 (11.6)	12,262 (4.9)	< 0.001
Congestive heart failure	172,031 (11.7)	145,207 (11.9)	26,824 (10.7)	< 0.001
Peripheral vascular disease	71,069 (4.9)	59,430 (4.9)	11,639 (4.7)	< 0.001
CVD only	300,567 (20.5)	221,216 (18.2)	79,351 (31.8)	< 0.001
CVD and hemiplegia	75,897 (5.2)	18,206 (1.5)	57,691 (23.1)	< 0.001
Hemiplegia only	11,002 (0.8)	3,437 (0.3)	7,565 (3.0)	< 0.001
Paraplegia only	7,850 (0.5)	2,342 (0.2)	5,508 (2.2)	< 0.001
Dementia	80,141 (5.5)	45,658 (3.8)	34,483 (13.8)	< 0.001
Chronic pulmonary disease	324,745 (22.2)	243,928 (20.1)	80,817 (32.3)	< 0.001
Connective tissue disease	20,288 (1.4)	13,636 (1.1)	6,652 (2.7)	< 0.001
Peptic ulcer disease	229,385 (15.7)	188,550 (15.5)	40,835 (16.3)	< 0.001
Liver disease	290,214 (19.8)	236,024 (19.4)	54,190 (21.7)	< 0.001
Diabetes mellitus	617,598 (42.1)	495,772 (40.8)	121,826 (48.8)	< 0.001
Renal disease	71,395 (4.9)	59,171 (4.9)	12,224 (4.9)	0.603
Cancer	264,585 (18.1)	230,831 (19.0)	33,754 (13.5)	< 0.001
AIDS/HIV	832 (0.1)	614 (0.1)	218 (0.1)	< 0.001
Type of hospital				< 0.001
Tertiary hospital	585,892 (40.0)	481,571 (39.6)	104,321 (41.7)	
General hospital	834,910 (57.0)	697,700 (57.4)	137,210 (54.9)	
Hospital	44,118 (3.0)	36,000 (3.0)	8,118 (3.3)	
Nursing care hospital	699 (0.1)	449 (0.0)	250 (0.1)	
Clinic	157 (0.0)	138 (0.0)	19 (0.0)	
Route of hospital admission				< 0.001
Emergency room	804,104 (54.9)	644,189 (53.0)	159,915 (64.0)	
Outpatient department	659,993 (45.0)	570,394 (46.9)	89,599 (35.9)	
Department[a]				< 0.001
Medical	807,916 (55.1)	709,965 (58.4)	97,951 (39.2)	
Surgical	657,838 (44.9)	505,872 (41.6)	151,966 (60.8)	

Values are presented as frequency (%), except for age and CCI (mean [standard deviation]).
ICU = intensive care unit, CCI = Charlson Comorbidity Index, CVD = cerebrovascular disease, AIDS = acquired immune deficiency syndrome, HIV human immunodeficiency virus.
[a]Medical includes general medicine, internal medicine, neurology, psychiatry, pediatrics, dermatology, radiology, radiation oncology, clinical pathology, tuberculosis, rehabilitation medicine, family medicine, emergency medicine, industrial medicine, preventive medicine, and conservative dentistry. Surgical includes general surgery, orthopedic surgery, neurosurgery, thoracic and cardiovascular surgery, plastic surgery, anesthesiology, obstetrics and gynecology, ophthalmology, otorhinolaryngology, urology, and oral surgery.

The percentage of patients receiving any rehabilitation therapy increased annually, from 14% in 2008 to 20% in 2014 (**Fig. 2A**). Physical therapy was received by 16% of all ICU patients, whereas other types of rehabilitation therapy were received by 5% or less of patients. Among patients receiving rehabilitation therapy, 41.5% underwent two or more different types of therapy (**Supplementary Table 1**). Physical therapy was received by 91.9% of patients who underwent rehabilitation therapy. A lower percentage of patients received occupational therapy (28.6%), but patients received more sessions of occupational therapy than respiratory therapy (32.1 vs. 24.8 treatments per patient) (**Supplementary Table 2**). Among the types of therapies, respiratory therapy was the lowest percentage in 2008, but increased during the study period. The percentage of patients receiving all other individual types of rehabilitation therapy also increased over time. In patients without neurologic or

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Table 2. Management procedures and outcomes of surviving ICU patients according to rehabilitation therapy in Korea, January 2008 to May 2015

Variables	Overall (n = 1,465,776)	No rehabilitation (n = 1,215,858)	Rehabilitation (n = 249,918)	*P* value
Procedures during hospital admission[a]				
Mechanical ventilation[b]	264,266 (18.0)	175,250 (14.4)	89,016 (35.6)	< 0.001
ECMO	1,809 (0.1)	1,048 (0.1)	761 (0.3)	< 0.001
Hemodialysis	55,483 (3.8)	43,605 (3.6)	11,878 (4.8)	< 0.001
CRRT	23,409 (1.6)	16,315 (1.3)	7,094 (2.8)	< 0.001
IHD	43,278 (3.0)	34,560 (2.8)	8,718 (3.5)	< 0.001
PD	185 (0.0)	156 (0.0)	29 (0.0)	0.619
Vasopressor drugs	117,276 (8.0)	85,673 (7.1)	31,603 (12.7)	< 0.001
At the discharge hospital admission[c]				
ICU length of stay, day	2 (3-7)	2 (2-6)	8 (3-21)	< 0.001
Hospital length of stay, day	13 (7-24)	11 (6-19)	33 (19-58)	< 0.001
Total cost, USD[d]	5,097 (2,527-8,543)	4,640 (2,196-7,474)	8,859 (5,265-15,518)	< 0.001

ICU = intensive care unit, ECMO = extracorporeal membrane oxygenation, CRRT = continuous renal replacement therapy, IHD = intermittent hemodialysis, PD = peritoneal dialysis.
[a]Values are presented as frequency (%); [b]Mechanical ventilation was defined that using for more than 3 hours; [c]Values are presented as median (interquartile range); [d]1 USD=1,158 Korean won (exchange rate as of December 1, 2015).

neuromuscular disorders, the percentage of patients receiving any form of rehabilitation therapy was < 10%, but the percentage of patients in this group receiving respiratory therapy increased during the study period (**Fig. 2B**). And, in patients with neurologic or neuromuscular disorders, the percentage of patients receiving any form of rehabilitation therapy was > 30%, indicating that rehabilitation therapy is concentrated in neurologic or neuromuscular patients (**Fig. 2C**). Detailed trends in rehabilitation therapy for central nerve system disease and spinal cord disease are shown in **Supplementary Fig. 1**.

During the 30-day post-discharge follow-up period, 80,416 patients readmitted to the ICU and 138,766 patients revisited to the ER. Of patients who readmitted to the ICU, 13,250 (5.4%) had received rehabilitation therapy during their initial admission, whereas 67,166 (5.7%) had no rehabilitation therapy (**Table 3**). Of patients who revisited to the ER, 23,622 (9.6%) had received rehabilitation therapy during their initial admission, whereas 115,144

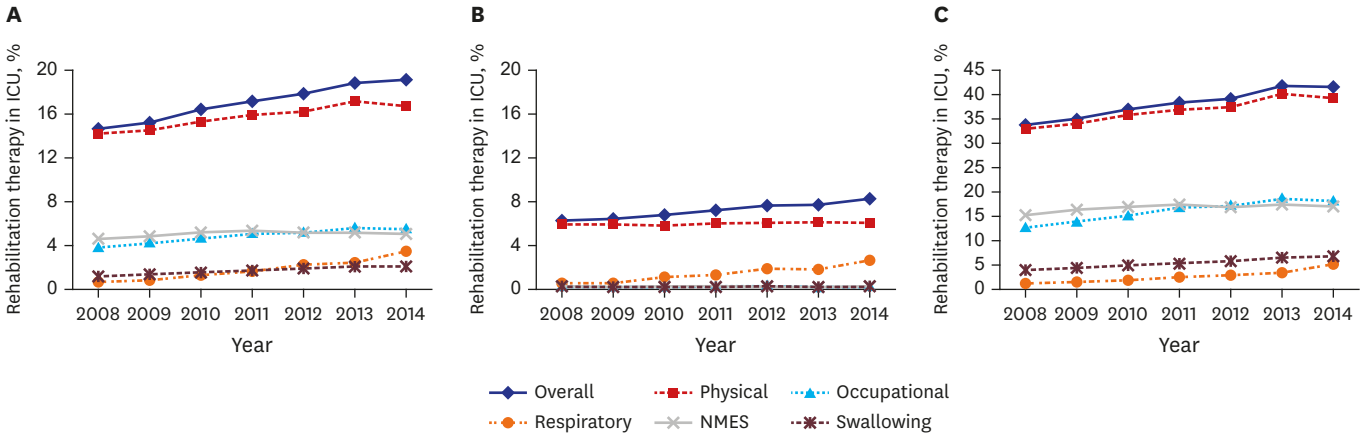

Fig. 2. Trends in rehabilitation therapy in patients admitted to ICUs for the first time in Korea between January 2008 and May 2015. (**A**) Group 1 = all patients admitted to the ICU during the time period. (**B**) Group 2 = patients admitted to the ICU during the time period who had no neurologic or neuromuscular disorder during hospitalization or the first year after discharge. (**C**) Group 3 = patients admitted to the ICU during the time period who had cerebrovascular disease, paraplegia/hemiplegia, or brain/spinal cord tumor during hospitalization or the first year after discharge.
ICU = intensive care unit, NMES = neuromuscular electrical stimulation.

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Table 3. HRs (95% CIs) for post-discharge 30-day outcomes associated with rehabilitation among patients who survive in ICU (n =1,418,811)[a]

Outcomes	No Rehabilitation (n = 1,183,678)[a]	Rehabilitation (n = 245,133)[a]	Univariable Cox regression		Multivariable Cox regression[b]	
	No. (%)	No. (%)	HR (95% CI)	*P* value	HR (95% CI)	*P* value
Overall						
Readmission to the ICU (any cause)	67,166 (5.7)	13,250 (5.4)	0.95 (0.97–1.04)	0.281	0.70 (0.65–0.75)	< 0.001
Revisit to the emergency room	115,144 (9.7)	23,622 (9.6)	0.99 (0.91–1.07)	0.768	0.83 (0.77–0.88)	< 0.001
No neurologic or neuromuscular disorder	(n = 585,051)	(n = 45,173)				
Readmission to the ICU (any cause)	21,592 (3.7)	1,574 (3.5)	0.95 (0.80–1.12)	0.519	0.86 (0.76–0.98)	0.022
Revisit to the emergency room	44,367 (7.6)	3,594 (8)	1.05 (0.90–1.23)	0.519	0.95 (0.86–1.06)	0.371

HR = hazard ratio, CI = confidence interval, ICU = intensive care unit.
[a]No insurance claim records were available after discharge for 36,965 patients (32,180 in the no rehabilitation group and 4,785 in the rehabilitation group); [b]Adjusted for age, gender, comorbidities (myocardial infarction, congestive heart failure, peripheral vascular disease, cerebrovascular disease, dementia, chronic pulmonary disease, connective tissue disease, peptic ulcer disease, liver disease, diabetes, renal disease, and cancer), tertiary hospital, admission type, mechanical ventilation, extracorporeal membrane oxygenation, and vasopressor drugs.

(9.7%) had no rehabilitation therapy. After adjusting for confounding variables, the risk of ICU readmission (adjusted HR, 0.70; 95% CI, 0.65–0.75) and revisit to the ER (adjusted HR, 0.83; 95% CI, 0.77–0.88) were significantly lower in patients who received rehabilitation therapy than in patients without rehabilitation. In addition, we analyzed readmission to the ICU and revisit to the ER in patients without neurologic or neuromuscular disorder. After adjusting for confounding variables, the risk of ICU readmission (adjusted HR, 0.86; 95% CI, 0.76–0.98) was significantly lower in patients who received rehabilitation therapy than in patients without rehabilitation.

DISCUSSION

This study showed that in-hospital rehabilitation for critically ill patients was associated with an 30% reduction in risk of ICU readmission, and 17% reduction in risk of ER visit within the 30-day following discharge. However, only approximately 17% of our ICU survivors received any type of rehabilitation therapy during their hospital stay, and they were more likely to be older and in poorer physiological condition than those who did not undergo rehabilitation therapy. From 2008 to 2014, the overall percentage of patients receiving rehabilitation therapy steadily increased, and the percentages for each rehabilitation therapy also increased over time.

In a prospective, cohort study (the Improving Care of Acute Lung Injury [ALI] Patients study) conducted between 2004 and 2007 in the United States, 36% of mechanically ventilated patients with ALI received physical therapy in the ICU.[26] In recent multicenter studies, physical therapy services provided by dedicated staff were available to all ICU patients as part of standard ICU care.[14,18,27] By contrast, the percentage of critically ill patients who received any type of in-hospital rehabilitation in our current study was low (17%) and consisted primarily of physical therapy. Our results, therefore, demonstrated a paucity of rehabilitation resources or comprehensive rehabilitation management in critical care facilities in Korea. Indeed, the availability of physical and occupational therapists represented a major barrier to the delivery of therapy in earlier studies.[10,28] Previous implementing projects also considered the lack of staff, equipment, and physician referrals for physical therapy as barriers to ICU rehabilitation therapy.[5,9,29]

After adjusting for confounding factors, we found that the percentage of ICU readmissions during 1-year follow-up was significantly lower in patients receiving rehabilitation therapy.

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In a recent meta-analysis, active mobilization and rehabilitation in the ICU were associated with more days alive and out-of-hospital up to day 180.[30] Since patients admitted to an ICU are more likely than non-ICU patients to visit the ER and be readmitted to the hospital and ICU,[31] these results suggest that ICU or overall in-hospital rehabilitation therapy can provide meaningful benefits to ICU survivors concerning healthcare utilization after discharge. However, the percentage of ER visits was similar in our two patient groups. Considering that our overall ER visit rate of 22.8% was much lower than that of previous reports (e.g., 46% within the first 6 months post-discharge, as per Hill et al.[31]), but our overall ICU readmission rate (13.9%) was similar to previously reported rates (e.g., 10% within the first year post-discharge, as per Garland et al.[32]), we assume that ER visits are more likely than ICU admissions to be influenced by various healthcare system factors or patient factors not directly related to health status.

Compared to patients without rehabilitation therapy, those who received rehabilitation therapy were older, had a higher CCI, were more likely to be admitted a tertiary hospital and surgical department via the ER, were more likely to receive major life-sustaining treatments, and stayed longer in the ICU and hospital. These results reflect the actual situation of ICU rehabilitation in Korea. Under the Korean health system, therefore, rehabilitation prescribed for patients who can charge medical insurance cost of rehabilitation therapy rather than medical needs for rehabilitation. Increased rehabilitation therapy in patients with CVD in this study might be related with the Korean insurance systems.

In the current study, marked differences in rates of neurologic comorbidities, including CVD, dementia and paraplegia/hemiplegia, existed between patients who did and did not receive rehabilitation therapy. Indeed, this preferential use of rehabilitation therapy in patients with neurologic disorders is not unusual. In a national survey of physical therapists in the United States using six different ICU patient scenarios, physical therapy was more likely to be routinely and intensively provided for the two neurologic patient scenarios than for three medical patient scenarios.[16] In a nationwide cohort study in Taiwan, ICU survivors receiving post-discharge rehabilitation therapy were more likely to exhibit neurologic comorbidities than those without rehabilitation, despite only patients with sepsis being included in the study.[33] Rehabilitation therapy may be more common in patients with neurologic disorders because many of these patients have a physical disability, which is one of the most common indications for rehabilitation. However, the preferential use of rehabilitation therapy in patients with neurologic conditions was more pronounced than in previous studies, like CVD, dementia, and paraplegia/hemiplegia was 2.8, 3.6, and 14.9 fold more common, respectively, in patients who received rehabilitation therapy compared with patients who did not undergo rehabilitation. In addition, utilization rates of rehabilitation therapy and each type of therapy when excluding patients with neurologic or neuromuscular disorders more clearly demonstrated the priority for neurorehabilitation (**Fig. 2**). In Korea, early rehabilitation in acute stroke patients is encouraged as a part of the Value Incentive Program of HIRA. In addition, KNHI guarantees a wider range of therapies and higher reimbursement costs for rehabilitation therapies for patients with neurologic disorders than for patients with other medical disorders. It is possible that these healthcare system factors influenced the preferential use of in-hospital rehabilitation in neurology patients.

This is the first Korean nationwide cohort study to investigate actual clinical practice related to the use of rehabilitation therapy in critical care, including 1,465,776 adult ICU survivors. In Korea, rehabilitation has not yet become standard practice in critical care because of its

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relatively recent implementation.[34] In addition, most ICUs do not have dedicated therapists, and use of rehabilitation therapy depends on consultation because of its expense and restricted institutional prescription authority (related to the physician's specialty). Most previous studies used a controlled design and thereby potentially deviated from usual clinical practice because of their focus on short-term, intensive administration of resources and early rehabilitation in the ICU.[5,7,10] Although some nationwide surveys of rehabilitation practice in other countries have been published, it is possible that only ICUs with sufficient resources or interest in early mobilization participated in these studies.[14-18] By contrast, our HIRA database is more likely to provide comprehensive, unbiased, and objective information regarding the epidemiology of rehabilitation. It did not restrict study participants to a specific disease group and did not rely on observations or responses of particular examiners for data acquisition. The large sample size and an extended follow-up period were additional strengths of our study.

This study has limitations. First, the amount and timing of rehabilitation therapies were not clearly determined. The HIRA only reviews claims for the entire hospital admission period and does not distinguish between time in the ICU or on the general ward. Second, the HIRA database consists of claims for reimbursement and, therefore, does not provide information regarding behavioral factors, psychosocial status, laboratory results, or mortality. Also, the effects of activities that do not incur direct costs, such as basic nursing care, were not excluded. Finally, although a single payer national health system with largely private provision of healthcare in Korea has made this comprehensive analysis possible, our results may not be generalizable to other countries with different healthcare systems.

In conclusion, this study identified increasing, but still insufficient, utilization of rehabilitation resources in critical care in Korea. Nonetheless, rehabilitation therapy during hospitalizations including an ICU admission appears to positively impact outcomes in ICU survivors—the rate of ICU readmission and ER visit. Despite the effectiveness of rehabilitation therapy for critically ill patients, there are practical limitations due to insufficient medical resources for ICU rehabilitation. To overcome practical limitations, sufficient medical insurance cost of rehabilitation for critically ill patients should be needed. Although future prospective studies will be needed to verify the effectiveness of rehabilitation therapy for critically ill patients, our results underline the potential importance of rehabilitation therapy for critically ill patients. To implement rehabilitation as routine practice, and thereby improvement outcomes, overall consideration should be given to various factors, including those related to physicians and specific healthcare systems.

SUPPLEMENTARY MATERIALS

Supplementary Table 1

Number of different types of rehabilitation therapy

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Supplementary Table 2

Usage of each type of therapy in patients receiving rehabilitation therapy

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Supplementary Fig. 1

Trends in rehabilitation therapy. (**A**) Group 1 = patients admitted to the ICU during the time period who had central nerve system disease. (**B**) Group 2 = patients admitted to the ICU during the time period who had spinal cord disease.

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REFERENCES

1. Needham DM, Davidson J, Cohen H, Hopkins RO, Weinert C, Wunsch H, et al. Improving long-term outcomes after discharge from intensive care unit: report from a stakeholders' conference. *Crit Care Med* 2012;40(2):502-9.
PUBMED | CROSSREF
2. Herridge MS, Cheung AM, Tansey CM, Matte-Martyn A, Diaz-Granados N, Al-Saidi F, et al. One-year outcomes in survivors of the acute respiratory distress syndrome. *N Engl J Med* 2003;348(8):683-93.
PUBMED | CROSSREF
3. Herridge MS, Tansey CM, Matté A, Tomlinson G, Diaz-Granados N, Cooper A, et al. Functional disability 5 years after acute respiratory distress syndrome. *N Engl J Med* 2011;364(14):1293-304.
PUBMED | CROSSREF
4. Bailey P, Thomsen GE, Spuhler VJ, Blair R, Jewkes J, Bezdjian L, et al. Early activity is feasible and safe in respiratory failure patients. *Crit Care Med* 2007;35(1):139-45.
PUBMED | CROSSREF
5. Morris PE, Goad A, Thompson C, Taylor K, Harry B, Passmore L, et al. Early intensive care unit mobility therapy in the treatment of acute respiratory failure. *Crit Care Med* 2008;36(8):2238-43.
PUBMED | CROSSREF
6. Thomsen GE, Snow GL, Rodriguez L, Hopkins RO. Patients with respiratory failure increase ambulation after transfer to an intensive care unit where early activity is a priority. *Crit Care Med* 2008;36(4):1119-24.
PUBMED | CROSSREF
7. Burtin C, Clerckx B, Robbeets C, Ferdinande P, Langer D, Troosters T, et al. Early exercise in critically ill patients enhances short-term functional recovery. *Crit Care Med* 2009;37(9):2499-505.
PUBMED | CROSSREF
8. Lord RK, Mayhew CR, Korupolu R, Mantheiy EC, Friedman MA, Palmer JB, et al. ICU early physical rehabilitation programs: financial modeling of cost savings. *Crit Care Med* 2013;41(3):717-24.
PUBMED | CROSSREF
9. Needham DM, Korupolu R, Zanni JM, Pradhan P, Colantuoni E, Palmer JB, et al. Early physical medicine and rehabilitation for patients with acute respiratory failure: a quality improvement project. *Arch Phys Med Rehabil* 2010;91(4):536-42.
PUBMED | CROSSREF
10. Schweickert WD, Pohlman MC, Pohlman AS, Nigos C, Pawlik AJ, Esbrook CL, et al. Early physical and occupational therapy in mechanically ventilated, critically ill patients: a randomised controlled trial. *Lancet* 2009;373(9678):1874-82.
PUBMED | CROSSREF
11. Hashem MD, Parker AM, Needham DM. Early mobilization and rehabilitation of patients who are critically ill. *Chest* 2016;150(3):722-31.
PUBMED | CROSSREF
12. Sommers J, Engelbert RH, Dettling-Ihnenfeldt D, Gosselink R, Spronk PE, Nollet F, et al. Physiotherapy in the intensive care unit: an evidence-based, expert driven, practical statement and rehabilitation recommendations. *Clin Rehabil* 2015;29(11):1051-63.
PUBMED | CROSSREF
13. Morris PE, Griffin L, Berry M, Thompson C, Hite RD, Winkelman C, et al. Receiving early mobility during an intensive care unit admission is a predictor of improved outcomes in acute respiratory failure. *Am J Med Sci* 2011;341(5):373-7.
PUBMED | CROSSREF
14. Berney SC, Harrold M, Webb SA, Seppelt I, Patman S, Thomas PJ, et al. Intensive care unit mobility practices in Australia and New Zealand: a point prevalence study. *Crit Care Resusc* 2013;15(4):260-5.
PUBMED

15. Chaboyer W, Gass E, Foster M. Patterns of chest physiotherapy in Australian Intensive Care Units. *J Crit Care* 2004;19(3):145-51.
PUBMED | CROSSREF

16. Hodgin KE, Nordon-Craft A, McFann KK, Mealer ML, Moss M. Physical therapy utilization in intensive care units: results from a national survey. *Crit Care Med* 2009;37(2):561-6.
PUBMED | CROSSREF

17. Norrenberg M, Vincent JL; European Society of Intensive Care Medicine. A profile of European intensive care unit physiotherapists. *Intensive Care Med* 2000;26(7):988-94.
PUBMED | CROSSREF

18. Nydahl P, Ruhl AP, Bartoszek G, Dubb R, Filipovic S, Flohr HJ, et al. Early mobilization of mechanically ventilated patients: a 1-day point-prevalence study in Germany. *Crit Care Med* 2014;42(5):1178-86.
PUBMED | CROSSREF

19. Korean National Health Insurance Cooperation. *Annual Report of National Health Insurance Statistics. 2007*. Seoul: Division of Statistical Analysis, Korean National Health Insurance Cooperation; 2007.

20. Lee YS, Lee YR, Chae Y, Park SY, Oh IH, Jang BH. Translation of Korean medicine use to ICD-codes using National Health Insurance Service-National Sample Cohort. *Evid Based Complement Alternat Med* 2016;2016:8160838.
PUBMED | CROSSREF

21. Chun CB, Kim SY, Lee JY, Lee SY. Republic of Korea: health system review. *Health Syst Transit* 2009;11(7):1-184.

22. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis* 1987;40(5):373-83.
PUBMED | CROSSREF

23. Kim KH. Comparative study on three algorithms of the ICD-10 Charlson comorbidity index with myocardial infarction patients. *J Prev Med Public Health* 2010;43(1):42-9.
PUBMED | CROSSREF

24. Sagan C. *Cosmos*. New York, NY: Random House; 1980.

25. Fridkin SK, Welbel SF, Weinstein RA. Magnitude and prevention of nosocomial infections in the intensive care unit. *Infect Dis Clin North Am* 1997;11(2):479-96.
PUBMED | CROSSREF

26. Fan E, Dowdy DW, Colantuoni E, Mendez-Tellez PA, Sevransky JE, Shanholtz C, et al. Physical complications in acute lung injury survivors: a two-year longitudinal prospective study. *Crit Care Med* 2014;42(4):849-59.
PUBMED | CROSSREF

27. TEAM Study Investigators, Hodgson C, Bellomo R, Berney S, Bailey M, Buhr H, et al. Early mobilization and recovery in mechanically ventilated patients in the ICU: a bi-national, multi-centre, prospective cohort study. *Crit Care* 2015;19(1):81.
PUBMED | CROSSREF

28. Zanni JM, Korupolu R, Fan E, Pradhan P, Janjua K, Palmer JB, et al. Rehabilitation therapy and outcomes in acute respiratory failure: an observational pilot project. *J Crit Care* 2010;25(2):254-62.
PUBMED | CROSSREF

29. Engel HJ, Tatebe S, Alonzo PB, Mustille RL, Rivera MJ. Physical therapist-established intensive care unit early mobilization program: quality improvement project for critical care at the University of California San Francisco Medical Center. *Phys Ther* 2013;93(7):975-85.
PUBMED | CROSSREF

30. Tipping CJ, Harrold M, Holland A, Romero L, Nisbet T, Hodgson CL. The effects of active mobilisation and rehabilitation in ICU on mortality and function: a systematic review. *Intensive Care Med* 2017;43(2):171-83.
PUBMED | CROSSREF

31. Hill AD, Fowler RA, Pinto R, Herridge MS, Cuthbertson BH, Scales DC. Long-term outcomes and healthcare utilization following critical illness--a population-based study. *Crit Care* 2016;20(1):76.
PUBMED | CROSSREF

32. Garland A, Olafson K, Ramsey CD, Yogendran M, Fransoo R. A population-based observational study of intensive care unit-related outcomes. With emphasis on post-hospital outcomes. *Ann Am Thorac Soc* 2015;12(2):202-8.
PUBMED | CROSSREF

33. Chao PW, Shih CJ, Lee YJ, Tseng CM, Kuo SC, Shih YN, et al. Association of postdischarge rehabilitation with mortality in intensive care unit survivors of sepsis. *Am J Respir Crit Care Med* 2014;190(9):1003-11.
PUBMED | CROSSREF

34. Lee H, Ko YJ, Suh GY, Yang JH, Park CM, Jeon K, et al. Safety profile and feasibility of early physical therapy and mobility for critically ill patients in the medical intensive care unit: beginning experiences in Korea. *J Crit Care* 2015;30(4):673-7.
PUBMED | CROSSREF