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Original article

Association Between Initiation of Rehabilitation and Length of Hospital Stay for Workers with Moderate to Severe Work-Related Traumatic Brain Injury

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ABSTRACT

Background: In workers with moderate to severe work-related traumatic brain injury (wrTBI), this study aimed to investigate the effect of the timing of rehabilitation therapy initiation on the length of hospital stay and the factors that can influence this timing.
Methods: We used data obtained from the Republic of Korea's nationwide Workers' Compensation Insurance. In the Republic of Korea, between the years 2010 and 2019, a total of 26,324 workers filed a claim for compensation for moderate to severe wrTBI. Multiple regression modeling was performed to compare the length of hospital stay according to the timing of rehabilitation therapy initiation following wrTBI. According to the timing of the initiation of rehabilitation therapy following TBI, the proportions of healthcare institutions that provided medical care during each admission step were compared.
Results: The length of hospital stay for workers who started rehabilitation therapy within 90 days was significantly shorter than that for workers who started rehabilitationment were first admitted to tertiary hospitals. Approximately 39% of patients who received delayed rehabilitation treatment were first admitted to general hospitals, and 28.5% were first admitted to primary hospitals.
Conclusions: Our findings demonstrate the importance of early rehabilitation initiation and that the type of healthcare institution that the patient is first admitted to after wrTBI may influence the timing of rehabilitation initiation. The results of this study also emphasize the need to establish a Worker's Compensation Insurance–specialized rehabilitation healthcare delivery system.

1. Introduction

Traumatic brain injury (TBI), defined as "acute brain injury resulting from mechanical energy to the head from external physical forces," [1] is a leading cause of death globally [2,3]. Furthermore, the morbidity of TBI is considerable [4]. Moderate or severe TBI is more likely to cause persistent impairment than mild TBI and places a significant burden on healthcare services [3,5–9].

Patients with TBI gain substantial benefits from acute treatment and rehabilitation programs [10]. Early initiation of the rehabilitation process for TBI patients can facilitate functional recovery. Previous studies have reported that transferring patients directly to a rehabilitation ward after acute treatment greatly improves cognitive and physical functions, and the length of hospital stay is reduced [11,12]. In contrast, delayed rehabilitation negatively affects the rehabilitation process and patient outcomes. Therefore, the timing of rehabilitation is important [3,13]. Accordingly, to optimize treatment and accelerate recovery in patients with TBI, rehabilitation therapy should be initiated as early as possible [14].

Work-related TBI (wrTBI) is a type of industrial injury most likely to cause impairment [5–7,15] and requires a considerably longer period of medical care than other types of injury [16]. Non-wrTBI and wrTBI may seem similar, but they have several differences in characteristics, insurance coverage, and compensation, among others. Therefore, research on wrTBI specifically is of importance [9,17].

However, studies on the rehabilitation of patients with wrTBI are limited. The effect of early initiation of rehabilitation for

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patients with wrTBI is not well known [16]. In addition, studies on the factors that influence the timing of rehabilitation initiation in patients with wrTBI are lacking. In the Republic of Korea, few studies have investigated the use of rehabilitation for TBI patients [18]. Indeed, to the best of our knowledge, there are no published reports in the literature on rehabilitation for wrTBI.

Therefore, in the present study, we aimed to investigate (i) the effect of the timing of rehabilitation therapy initiation on the length of hospital stay and (ii) factors that can influence the timing of rehabilitation initiation in workers with moderate to severe wrTBI by analyzing large-scale administrative data, specifically the Republic of Korea Workers' Compensation Insurance (WCI) data collected over 10 years (2010–2019).

2. Materials and methods

2.1. Ethical considerations

This study was exempt from ethics approval by the institutional review board (IRB No. E-2201–107–1291) because the Republic of Korea Workers' Compensation and Welfare Service data were anonymized and deidentified. Accordingly, the requirement for informed consent was also waived.

2.2. Study design

This was a nationwide longitudinal study that analyzed the compensation claims of workers with moderate to severe wrTBI, which were lodged over a 10-year period between 2010 and 2019.

2.3. Data source

We used the Republic of Korea's nationwide WCI data for this study. The Industrial Accident Compensation Insurance Act was first enacted in the Republic of Korea over 50 years ago, and policymakers have continually made amendments to improve access and coverage to promote the broad use of compensations and medical care services after industrial injury [9,19]. Compensations are paid to workers for work-related injuries and illnesses that require medical care services for 4 days or more. The Korean Ministry of Employment and Labor collects data regarding industrial injuries occurring in the country. The data include information regarding preinjury demographic characteristics, injury-related characteristics, and medical care use [9]. The WCI data are managed by the Republic of Korea Workers' Compensation and Welfare Service. For the current study, anonymized data collected between 2010 and 2019 were obtained.

2.4. Study population

The study population comprised a total of 48,166 workers who filed a claim for compensation for wrTBI between January 1, 2010, and December 31, 2019. To specifically investigate the use of specialized rehabilitation therapy, workers with mild TBI (concussion) were excluded from the study. Workers with moderate to severe TBI were included in this study. To determine the severity of TBI, the International Classification of Diseases (10th revision) was used. Patients with one of the following diagnostic codes for a main diagnosis or subdiagnosis were deemed to have moderate to severe TBI: cranial fracture (i.e., S02.0, S02.1, S02.7, S02.8, S02.9, S07.1, and T90.2) and intracranial injury (i.e., S06.1–S06.9, and T90.5) [9,20,21]. Patients with these diagnostic codes were selected, and the final number of study participants was 26,324.

2.5. Variables

The study variables included workers' preinjury demographic characteristics, work-related injury characteristics, and the pattern of medical care use following industrial injury.

The workers were classified into one of the following age groups: less than 30, 30–39, 40–49, 50–59, and 60 and more years.

The work-related injury characteristics included the type of injury, occupation, industry, and location of the workplace at the time of the industrial injury. Work-related injury was classified into 2 categories: injury and commuting injury. The occupations were classified into 9 categories according to the Korean Standard Classification of Occupations (7th version). The industries were classified into 21 categories according to the Korean Standard Industrial Classification (10th version). The location of the workplace was classified into metropolitan (which included the capital [Seoul] and the surrounding area of Incheon/Gyeonggi-do) or regional for all other areas.

The healthcare institutions where the workers received medical care after a wrTBI included tertiary hospitals, general hospitals, primary hospitals, clinics, and dentistry/oriental medicine hospitals. The surgical interventions included craniotomy and craniectomy during the period of medical care. Intensive care unit (ICU) admission history was specified as "Yes" or "No" according to whether the worker was admitted to the ICU while receiving medical care. In this study, workers with an ICU admission history were considered to have severe injuries (a high severity level), while those without an ICU admission history were considered to have nonserious injuries.

Rehabilitation during the medical care period was investigated; the two types of rehabilitation services considered were physiotherapy and occupational therapy. A previous study suggested that recovery was most rapid during the first 3 months after a TBI [22]. Based on this study, workers were categorized according to whether rehabilitation therapy was initiated within 90 days of the TBI or after 90 days. In this study, rehabilitation therapy initiated within 90 days was regarded as early.

The length of hospital stay was determined by calculating the total number of days during which the worker was treated as an inpatient after wrTBI. The number of days for outpatient treatment was not included.

2.6. Statistical analyses

The general characteristics of workers who received and did not receive rehabilitation therapy were compared using the χ^2 test and t-test. This was used to investigate the reasons workers with moderate to severe wrTBI did not receive rehabilitation therapy. In workers who received rehabilitation therapy, the $\chi 2$ test and t-test were used to compare the general characteristics according to the timing (early vs. delayed) of rehabilitation therapy initiation. Multiple regression modeling was performed to compare the length of hospital stay according to the timing of rehabilitation therapy initiation following TBI. Additional modeling was performed using ICU admission as a stratification variable to examine the effect on the length of hospital stay. Finally, the proportions of various healthcare institutions that provided medical care during each admission step were compared to the timing of the initiation of rehabilitation therapy following TBI.

All analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC, USA).

Table 1
General characteristics of workers with moderate to severe work-related traumatic brain injury stratified by receipt of rehabilitation therapy

Characteristics	Total (n = 26,324)		Rehabilitation therapy after TBI				p
			Yes (n = 5062)		No (n = 21,262)		
Age at injury							
Mean ± SD	51.2 ± 13.1		53.0 ± 12.4		50.7 ± 13.2		<0.001
Median (IQR)	53 (44–60)		55 (46–62)		53 (43–60)		
Age group, years							<0.001
<30	2016	7.7	268	5.3	1748	8.2	
30–39	2777	10.6	447	8.8	2330	11.0	
40–49	5572	21.2	1003	19.8	4569	21.5	
50–59	8643	32.8	1730	34.2	6913	32.5	
≥60	7316	27.8	1614	31.9	5702	26.8	
Sex							<0.001
Male	24,260	92.2	4791	94.7	19,469	91.6	
Female	2064	7.8	271	5.4	1793	8.4	
Work-related injury type							0.024
Injury	25,382	96.4	4854	95.9	20,528	96.6	
Commuting injury	942	3.6	208	4.1	734	3.5	
Occupation							<0.001
Managers	2213	8.4	435	8.6	1778	8.4	
Professionals and related workers	1183	4.5	207	4.1	976	4.6	
Clerks	635	2.4	106	2.1	529	2.5	
Service workers	815	3.1	108	2.1	707	3.3	
Sales workers	203	0.8	29	0.6	174	0.8	
Skilled agricultural, forestry, and fishery workers	466	1.8	62	1.2	404	1.9	
Craft and related trades workers	7028	26.7	1455	28.7	5573	26.2	
Equipment, machine operating, and assembling workers	2511	9.5	438	8.7	2073	9.8	
Elementary workers	11,270	42.8	2222	43.9	9048	42.6	
Industry							<0.001
Agriculture, forestry, and fishing	655	2.5	69	1.4	586	2.8	
Mining and quarrying	104	0.4	12	0.2	92	0.4	
Manufacturing	5802	22.0	1066	21.1	4736	22.3	
Electricity, gas, steam, and air conditioning supply	30	0.1	5	0.1	25	0.1	
Water supply; sewage, waste management, materials recovery	7	0.0	1	0.0	6	0.0	
Construction	11,143	42.3	2420	47.8	8723	41.0	
Wholesale and retail trade	2	0.0	1	0.0	1	0.0	
Transportation and storage	1385	5.3	240	4.7	1145	5.4	
Accommodation and food service activities	1712	6.5	263	5.2	1449	6.8	
Information and communication	114	0.4	17	0.3	97	0.5	
Financial and insurance activities	96	0.4	23	0.5	73	0.3	
Real estate activities	55	0.2	16	0.3	39	0.2	
Professional, scientific, and technical activities	160	0.6	31	0.6	129	0.6	
Business facilities management and business support services; rental and leasing activities	2642	10.0	488	9.6	2154	10.1	
Public administration and defense; compulsory social security	231	0.9	49	1.0	182	0.9	
Education	119	0.5	21	0.4	98	0.5	
Human health and social work activities	357	1.4	51	1.0	306	1.4	
Arts, sports, and recreation-related services	258	1.0	45	0.9	213	1.0	
Membership organizations, repair, and other personal services	1351	5.1	228	4.5	1123	5.3	
Activities of households as employers; undifferentiated goods-and services-producing activities of households for own use	94	0.4	14	0.3	80	0.4	
Activities of extraterritorial organizations and bodies	7	0.0	2	0.0	5	0.0	
Location of the workplace							0.992
Metropolitan	12,245	46.5	2355	46.5	9890	46.5	
Regional	14,079	53.5	2707	53.5	11,372	53.5	
First inpatient hospital							<0.001
Tertiary hospital	4342	16.5	1951	38.5	2391	11.3	
General hospital	7483	28.4	1985	39.2	5498	25.9	

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Table 1 (*continued*)

Characteristics	Total (n = 26,324)		Rehabilitation therapy after TBI				p
			Yes (n = 5062)		No (n = 21,262)		
Primary hospital	2594	9.9	891	17.6	1703	8.0	
Clinic	1110	4.2	53	1.1	1057	5.0	
Dentistry, oriental medicine hospital	99	0.4	24	0.5	75	0.4	
Not hospitalized	10,696	40.6	158	3.1	10,538	49.6	
Operation							<0.001
Yes	583	2.2	377	7.5	206	1.0	
No	25,741	97.8	4685	92.6	21,056	99.0	
Intensive care unit admission history							<0.001
Yes	7068	26.9	3311	65.4	3757	17.7	
No	19,256	73.2	1751	34.6	17,505	82.3	
Death							<0.001
Yes	4632	17.6	361	7.1	4271	20.1	
No	21,692	82.4	4701	92.9	16,991	79.9	

lQR, interquartile range; SD, standard deviation; TBI, traumatic brain injury.

3. Results

Of all the workers with moderate to severe wrTBI, 5,062 received rehabilitation therapy and 21,262 did not (Table 1). Of those who received rehabilitation therapy, 3.1% were not treated as inpatients while receiving medical care. On the other hand, 49.6% of the workers who did not receive rehabilitation therapy were not treated as inpatients ($p < 0.001$). Approximately 65.4% of those who received rehabilitation therapy and 17.7% of those who did not receive rehabilitation therapy had a history of admission to the ICU ($p < 0.001$). Of the workers who received rehabilitation therapy, 7.1% died, whereas 20.1% of the workers who did not receive rehabilitation therapy died ($p < 0.001$).

Table 2 shows the general characteristics of workers who received rehabilitation therapy, stratified by the timing of rehabilitation therapy initiation. The mean age at the time of wrTBI was 52.4 years, and more than half of the workers were 50 years or older ($p = 0.001$ and $p = 0.005$, respectively). Most of the workers with the "work-related injury type" were categorized as those with "injury" (96.1%) and those without craniotomy/craniectomy (92.8%) ($p < 0.001$ and $p = 0.011$, respectively). By occupation, elementary workers accounted for 43.3% of all workers, while by industry, construction workers accounted for 48.6% of all workers ($p < 0.001$ and $p < 0.001$, respectively). Regarding the type of healthcare institution first visited for inpatient treatment following TBI, the proportion of admissions at the tertiary hospitals was the highest for those who received early rehabilitation therapy (42.8%), whereas in those who received rehabilitation therapy after 90 days, the proportion of admissions to general hospitals was the highest (38.5%, $p < 0.001$). Approximately 70.2% of the workers who received rehabilitation therapy within 90 days had an ICU admission history compared with 49.7% of those who received rehabilitation therapy after 90 days ($p < 0.001$).

The average length of hospital stay was 488.2 days for workers who received rehabilitation therapy within 90 days and 855.5 days for workers who received rehabilitation therapy after 90 days (Supplementary Table 1). The results of multiple regression models conducted on the timing of rehabilitation therapy initiation and the length of hospital stay are shown in Table 3. The length of hospital stay of workers who received rehabilitation therapy within 90 days was significantly shorter than that of workers who received rehabilitation therapy after 90 days ($p < 0.001$). According to ICU admission history, the length of hospital stay was significantly shorter for workers who received rehabilitation therapy within 90 days ($p < 0.001$ and $p < 0.001$, respectively). The length of inpatient hospital stay and medical care period according to the patients' general characteristics are provided in Supplementary Table 1.

Fig. 1 shows the proportion of healthcare institutions visited according to the number of admissions (1st, 2nd, 3rd, 4th, and 5th admission). The workers who received rehabilitation therapy within 90 days were most likely to be first admitted to a tertiary hospital after TBI (42.8% of the total cases). In subsequent admissions, the proportion of visits to tertiary hospitals was approximately 20%. Workers who received rehabilitation therapy after 90 days were most likely to be first admitted to a general hospital and, for subsequent admissions, to a primary hospital. Regardless of the timing of rehabilitation therapy initiation, the length of inpatient hospital stay increased as the number of admissions increased (Table 4).

4. Discussion

This is the first study conducted in the Republic of Korea to examine the relationship between the timing of rehabilitation therapy initiation and the length of hospital stay among workers with moderate to severe wrTBI. This study involved analysis of data obtained from the Republic of Korea WCI from 2010 to 2019, and we found that the length of hospital stay was shorter for workers who started rehabilitation therapy early than those who received it after 90 days, regardless of disease severity. An important difference between the two groups was whether a tertiary hospital was the first healthcare institution to which the patient was admitted.

In the period of data collection (2010 to 2019), from a total of 26,324 workers with moderate to severe wrTBI, 21,262 (80.8%) workers did not receive rehabilitation therapy, whereas 5,062 (19.2%) patients received rehabilitation therapy. In a study that reported on the functional outcomes in the first year after moderate and severe TBI, the proportion of patients with Glasgow Outcome Scale-Extended of 3–6 was more than 40% [23]. These patients with Glasgow Outcome Scale-Extended score 3–6 a year after injury may have required rehabilitation treatment. In addition, in a study that examined rehabilitation utilization following a wrTBI in Australia, 28.5% of all patients with wrTBIs, including concussion, received rehabilitation treatment [16]. Considering these studies, the proportion of patients who received rehabilitation therapy in this study is relatively low. The patients in this study may not have received the correct rehabilitation treatment, or their condition

Table 2
General characteristics of workers with moderate to severe work-related traumatic brain injury who received rehabilitation stratified by the time of initiating rehabilitation therapy

Characteristics	Total ($n = 4555$)		Initiating rehabilitation therapy after TBI				p
			≤90 days ($n = 3558$)		>90 days ($n = 997$)		
Age at injury							
Mean ± SD	52.4 ± 12.3		52.8 ± 12.2		51.2 ± 12.4		0.001
Median (IQR)	54 (45-61)		54 (46-61)		53 (44-60)		
Age group, years							0.005
<30	252	5.5	188	5.3	64	6.4	
30–39	414	9.1	305	8.6	109	10.9	
40–49	943	20.7	738	20.7	205	20.6	
50–59	1586	34.8	1223	34.4	363	36.4	
≥60	1360	29.9	1104	31.0	256	25.7	
Sex							0.367
Male	4307	94.6	3370	94.7	937	94.0	
Female	248	5.4	188	5.3	60	6.0	
Work-related injury type							<0.001
Injury	4376	96.1	3448	96.9	928	93.1	
Commuting injury	179	3.9	110	3.1	69	6.9	
Occupation							<0.001
Managers	390	8.6	294	8.3	96	9.6	
Professionals and related workers	189	4.2	140	3.9	49	4.9	
Clerks	95	2.1	60	1.7	35	3.5	
Service workers	95	2.1	67	1.9	28	2.8	
Sales workers	28	0.6	18	0.5	10	1.0	
Skilled agricultural, forestry, and fishery workers	58	1.3	54	1.5	4	0.4	
Craft and related trades workers	1336	29.3	1084	30.5	252	25.3	
Equipment, machine operating, and assembling workers	392	8.6	304	8.5	88	8.8	
Elementary workers	1972	43.3	1537	43.2	435	43.6	
Industry							<0.001
Agriculture, forestry, and fishing	62	1.4	53	1.5	9	0.9	
Mining and quarrying	10	0.2	9	0.3	1	0.1	
Manufacturing	978	21.5	775	21.8	203	20.4	
Electricity, gas, steam, and air conditioning supply	5	0.1	5	0.1	0	0.0	
Water supply, sewage, waste management, materials recovery	1	0.0	1	0.0	0	0.0	
Construction	2214	48.6	1766	49.6	448	44.9	
Wholesale and retail trade	1	0.0	1	0.0	0	0.0	
Transportation and storage	205	4.5	146	4.1	59	5.9	
Accommodation and food service activities	235	5.2	158	4.4	77	7.7	
Information and communication	13	0.3	7	0.2	6	0.6	
Financial and insurance activities	20	0.4	11	0.3	9	0.9	
Real estate activities	15	0.3	11	0.3	4	0.4	
Professional, scientific, and technical activities	27	0.6	15	0.4	12	1.2	
Business facilities management and business support services; rental and leasing activities	409	9.0	332	9.3	77	7.7	
Public administration and defense; compulsory social security	41	0.9	31	0.9	10	1.0	
Education	21	0.5	19	0.5	2	0.2	
Human health and social work activities	48	1.1	37	1.0	11	1.1	
Arts, sports, and recreation-related services	36	0.8	28	0.8	8	0.8	
Membership organizations, repair, and other personal services	202	4.4	144	4.1	58	5.8	

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Table 2 (*continued*)

Characteristics	Total (n = 4555)		Initiating rehabilitation therapy after TBI				p
			≤90 days (n = 3558)		>90 days (n = 997)		
Activities of households as employers; undifferentiated goods-and services-producing activities of households for own use	10	0.2	8	0.2	2	0.2	
Activities of extraterritorial organizations and bodies	2	0.0	1	0.0	1	0.1	
Location of the workplace							0.650
Metropolitan	2123	46.6	1652	46.4	471	47.2	
Regional	2432	53.4	1906	53.6	526	52.8	
First inpatient hospital							<0.001
Tertiary hospital	1800	39.5	1522	42.8	278	27.9	
General hospital	1824	40.0	1440	40.5	384	38.5	
Primary hospital	855	18.8	571	16.1	284	28.5	
Clinic	53	1.2	14	0.4	39	3.9	
Dentistry, oriental medicine hospital	23	0.5	11	0.3	12	1.2	
Operation							0.011
Yes	326	7.2	273	7.7	53	5.3	
No	4229	92.8	3285	92.3	944	94.7	
Intensive care unit admission history							<0.001
Yes	2993	65.7	2498	70.2	495	49.7	
No	1562	34.3	1060	29.8	502	50.4	

Workers who did not receive rehabilitation therapy, were not treated as inpatients, or did not survive were excluded from the analysis.
IQR, interquartile range; SD, standard deviation; TBI, traumatic brain injury.

may not have been severe enough to warrant rehabilitation treatment. Further investigation is required to determine why the number of patients who received rehabilitation therapy in this study was relatively low.

Among the workers with moderate to severe wrTBI, the length of hospital stay was approximately 367.3 days shorter for those who received early rehabilitation therapy (<90 days after injury) than for those for whom rehabilitation therapy was delayed for more than 90 days after injury. This finding is consistent with trends in previous studies that explored the relationship between early rehabilitation and the length of hospital stay [11,12,24]. In a study of patients with severe TBI in Austria, the average length of hospital stay in the acute care hospital was 144.75 days for patients who received early rehabilitation and 164.67 days for patients with delayed rehabilitation [3]. Although direct comparison with the results of this study is difficult, the positive effects of early rehabilitation were verified. The length of hospital stay may decrease for patients receiving early rehabilitation therapy after an injury, owing to significant improvements in cognitive and physical functions [3,13,24–26]. Our findings suggest that rehabilitation should be initiated during the acute stage to facilitate recovery after moderate to severe TBI [26,27].

Table 3
Multiple regression model results for the length of hospital stay stratified by intensive care unit admission

	Crude			Adjusted*		
	ß	SE	p	ß	SE	p
Total						
Initiating rehabilitation therapy after TBI						
≤90 days	-367.3	33.6	<0.001	-389.7	30.7	<0.001
>90 days	1.00			1.00		
Intensive care unit admission (Yes)						
Initiating rehabilitation therapy after TBI						
≤90 days	-543.1	54.2	<0.001	-528.0	52.6	<0.001
>90 days	1.00			1.00		
Intensive care unit admission (No)						
Initiating rehabilitation therapy after TBI						
≤90 days	-311.4	34.3	<0.001	-284.0	33.4	<0.001
>90 days	1.00			1.00		

Workers who did not receive rehabilitation therapy, were not treated as inpatients, or did not survive were excluded from the analysis.
SE, standard error; TBI, traumatic brain injury.
* Statistically estimated from multiple regression analyses adjusted for all explanatory variables.

Table 4
Length of inpatient hospital stay according to the number of admissions, stratified by the initiation of rehabilitation therapy

	Initiating rehabilitation therapy after TBI	
	≤90 days (Mean ± SD)	>90 days (Mean ± SD)
Number of admissions		
1	145.4 ± 181.6	426.3 ± 616.2
2	319.4 ± 372.4	535.9 ± 698.5
3	599.6 ± 675.7	994.2 ± 1022.5
4	813.7 ± 748.7	1038.0 ± 991.8
≥5	1352.9 ± 1037.4	1688.7 ± 1248.8

Workers who did not receive rehabilitation therapy, were not treated as inpatients, or did not survive were excluded from the analysis.
SD, standard deviation; TBI, traumatic brain injury.

However, in general, having severe injuries is associated with delayed rehabilitation treatment after TBI [28]. Therefore, we analyzed the data stratified by severity, which was classified by ICU admission history. Regardless of the severity, the length of inpatient hospital stay was short for workers who received early rehabilitation therapy (Table 3). In addition, the proportion of patients with an ICU admission history was higher for the group that received early rehabilitation than those who received delayed rehabilitation (Table 2). Thus, our findings indicate that the association between severity and the delay in rehabilitation is weak in the study cohort.

One of the causes of delayed rehabilitation is the healthcare delivery system [11,12]. In this study, approximately 80% of patients who received early rehabilitation treatment were first admitted to tertiary or general hospitals. Approximately 66% of patients who received delayed rehabilitation treatment were first admitted to tertiary or general hospitals, and 28.5% were first admitted to primary hospitals (Fig. 1). Most primary hospitals in the Republic of Korea cannot adequately provide rehabilitation therapy. This may explain why patients first admitted to primary hospitals may receive delayed rehabilitation treatment.

Rehabilitation for TBI is divided into the following three phases: early rehabilitation in acute care hospitals, specialized inpatient rehabilitation during the subacute stage, and community-based rehabilitation [26]. Some studies reported that the length of hospital stay was shorter for patients treated with intensive rehabilitation therapy immediately after the completion of acute treatment in a tertiary hospital than for the patients who received delayed rehabilitation therapy [3,12,24]. In the Republic of Korea, a healthcare delivery system targeting industrially injured workers is not well established. In 2020, a specialized rehabilitation unit or hospital system was implemented in the Republic of Korea to provide rehabilitation therapy for patients during the postacute period; however, it only treated patients covered by the national health insurance [29]. Because industrially injured workers have varying disease characteristics, insurance coverage, and compensation, the WCI-specialized rehabilitation healthcare delivery system should be established independently.

The study has the following limitations. First, the WCI data do not have information on long-term care hospitals (LTCHs). The LCTH was included as the primary hospital in this study. Occasionally, patients are transferred from acute care hospitals to LTCHs directly for rehabilitation after acute treatment, where they stay long term as inpatients. If the information on LTCHs was included, more clear conclusions on healthcare system delivery could be made. Second, the WCI data were extracted based on the year of occurrence of the industrial injury and not the year of completion of medical care for the injury. Accordingly, the length of hospital stay may be inaccurate for the workers who did not receive complete medical care for industrial injuries. Third, to ascertain the use of specialized rehabilitation therapy, the corresponding claim codes for moderate to severe TBI were used, and workers with mild TBI (concussion) were excluded from the study.

To the best of our knowledge, this study is the first to examine the relationship between the timing of rehabilitation therapy initiation and the length of hospital stay for workers with moderate to severe wrTBI in the Republic of Korea. This study analyzed data obtained nationwide from WCI; therefore, our findings may be

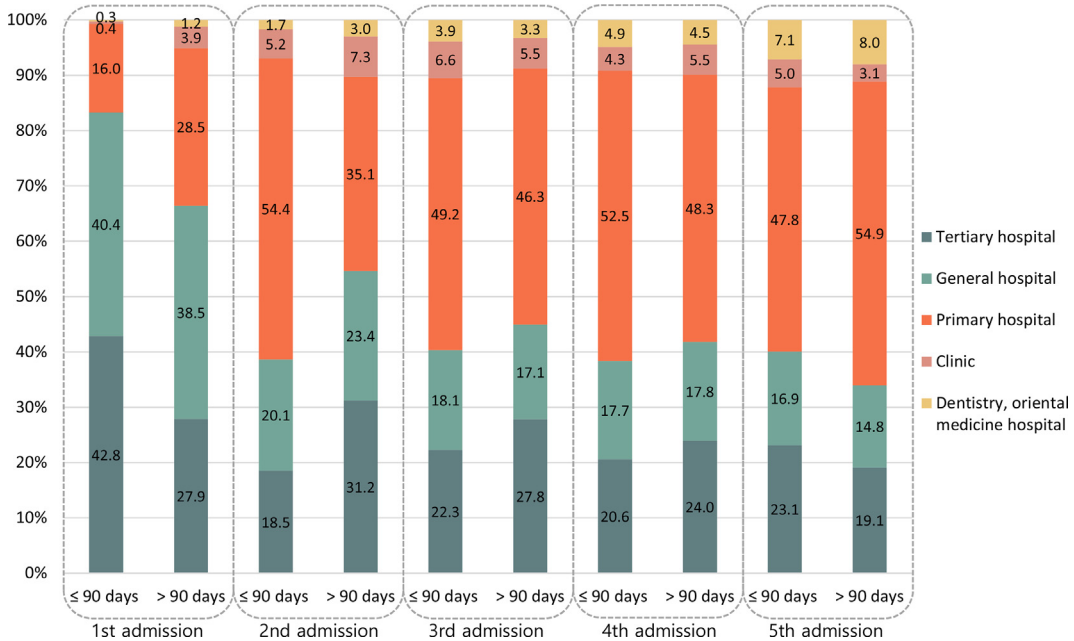

Fig. 1. Healthcare institutions stratified by admission step for workers who received rehabilitation therapy within 90 days and after 90 days.

regarded as a representation of rehabilitation therapy in the Republic of Korea.

This study reported that regardless of disease severity, the length of hospital stay was shorter for moderate to severe wrTBI patients with early initiation of rehabilitation therapy than those with delayed initiation of rehabilitation. An important difference between the two groups was the proportion of workers who were first admitted to a tertiary hospital for treatment. Our findings demonstrate the importance of early rehabilitation initiation and the choice of the first inpatient hospital after wrTBI. The results of this study also emphasize the need to establish a WCI-specialized rehabilitation healthcare delivery system.

Author contributions

SWB conceived and planned the study, performed the analysis, wrote the original draft with input from all authors, analyzed the results, validated the study, and contributed to the interpretation of the results. M-YL conceived and planned the study, validated the study, contributed to the interpretation of the results, and supervised the entire process. All authors read and approved the final manuscript.

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Ethics approval

This study was exempted from ethics approval by the institutional review board of Seoul National University Hospital (IRB No. E-2201–107–1291) because the Republic of Korea Workers' Compensation and Welfare Service data were anonymized and identified. Accordingly, the requirement for informed consent was also waived.

Conflicts of interest

The authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.shaw.2023.04.001.

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