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Epidemiology of Work-Related Traumatic Spinal Cord Injury

An Analysis of Workers' Compensation Claims in Korea, 2011–2019

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Objective: We aimed to identify the incidence and burden of work-related traumatic spinal cord injury (wrTSCI) in Korea in the 10-year period from 2010 to 2019. **Methods:** We used nationwide workers' compensation insurance data. The study population comprised industrially injured workers with TSCI diagnosis codes. The annual incidence of wrTSCI (number per million workers) was calculated. **Results:** The mean annual incidence of wrTSCI was 22.8/1,000,000 (95% confidence interval, 20.5 to 25.0), and the mean total cost per claim was 231.40 million KRW. The incidence of TSCI in the cervical region was the highest (13.1/1,000,000; 95% confidence interval, 11.4 to 14.9), and most cases were in the construction industry (47.3%). **Conclusion:** These findings can help identify specific at-risk groups and facilitate the development of prevention strategies.

Keywords: epidemiology, incidence, occupational injuries, spinal cord injuries, worker's compensation

LEARNING OUTCOMES

- To ascertain the incidence of work-related traumatic spinal cord injury by injury level and industry sector using Korean workers' compensation insurance data over a 10-year period from 2010 to 2019.
- To identify the claims characteristics based on the level of injury.
- To identify specific at-risk groups and understand the important implications for developing prevention strategies for these devastating injuries.

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Ethical considerations and disclosures: This study was exempt from ethical approval by the institutional review board (IRB) of Seoul National University Hospital (IRB no. E-2207-149-1342) because the data in the KCOMWEL were anonymized and deidentified. Therefore, the need for informed consent was also waived.

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Traumatic spinal cord injury (TSCI) occurs when an external physical impact acutely damages the spinal cord.¹ Although rare, TSCI is a major cause of global disability.² The annual global incidence of spinal cord injury (SCI) is 40 to 80 per million population,³ and TSCI accounts for approximately 90%. The incidence of TSCI is 39, 16, and 15 per million population in North America, Australia, and Western Europe, respectively.^{1,4}

Because TSCI can have devastating physical, occupational, and sociopsychological impacts,^{5–7} their management requires significant resources, and they place a substantial burden on not only the individual and his/her family, but also the community as a whole.^{5,8} As there is currently no cure for SCI, and most cases do not show significant improvement even after rehabilitation therapy, the healthcare cost of TSCI is considerable.⁹ In the United States, the cost of SCI-related hospitalizations was estimated at approximately US \$1.7 billion in 2009.¹⁰ A recent systematic review reported that direct healthcare costs in the first year after TSCI ranged from US \$32,240 to \$1,156,400 per patient globally.¹¹

Occupational accidents are one of the major causes of TSCI. In Australia and Chile, work-related TSCI (wrTSCI) accounts for 12% to 18% of all TSCI cases.^{9,12} The epidemiologic characteristics of wrTSCI differ from those of general TSCI.¹³ For example, patients with non-work-related TSCI may commonly experience incomplete tetraplegia,^{1,2,14} whereas the most common type of wrTSCI is complete paraplegia.^{9,12} Because these differences can affect healthcare policy, the epidemiology of wrTSCI needs to be analyzed independently of general TSCI.¹² However, the epidemiology of wrTSCI has been seldom reported, and in South Korea, no official reports on the overall incidence of wrTSCI exist.

Therefore, this study aimed to identify the incidence trend and burden of wrTSCI in Korea in a 10-year period between 2010 and 2019, focusing on the level of injury from workers' compensation insurance (WCI) data, which are large-scale nationwide data.

MATERIALS AND METHODS

Data Source

The Industrial Accident Compensation Insurance Act was enacted in 1964 as the first social insurance system in Korea. Since then, insurance coverage and compensation have continued to increase. In Korea, workers who require at least 4 days of medical care services or suffer death due to a work-related injury or disease are eligible for compensation. Data on those who are industrially injured are collected by the Korean Ministry of Employment and Labor; WCI data are managed by the Korea Workers' Compensation and Welfare Service. These data include information related to injury and workplace at the time of the work-related accident, as well as information related to medical care and compensation. For this study, we obtained anonymized WCI data from 2010 to 2019 from the Korea Workers' Compensation and Welfare Service.

Study Population

The study population comprised industrially injured workers (IIWs) with TSCI diagnosis codes as the main diagnosis or subdiagnosis during the 10-year period from 2010 to 2019. The *International*

TABLE 1. Preinjury Demographic Characteristics of Claimants With Work-Related Traumatic Spinal Cord Injury, Korea, 2010–2019

Characteristics	Total (n = 3855)	
Age at injury, y		
Mean (SD)	51.8	11.3
Median (IQR)	53	45–60
Age group, n (%)		
<30	163	4.2
30–39	394	10.2
40–49	890	23.1
50–59	1409	36.6
≥60	999	25.9
Sex, n (%)		
Male	3644	94.5
Female	211	5.5
Work-related injury type, n (%)		
Injury	3692	95.8
Commuting injury	163	4.2
Occupation, n (%)		
Managers	324	8.4
Professionals and related workers	164	4.3
Clerks	81	2.1
Service workers	140	3.6
Sales workers	43	1.1
Skilled agricultural, forestry, and fishery workers	109	2.8
Craft and related trades workers	1091	28.3
Equipment, machine operating, and assembling workers	430	11.2
Elementary workers	1473	38.2
Industry, n (%)		
Mining	20	0.5
Manufacturing	749	19.4
Electricity, gas, steam, air conditioning, and water supply	9	0.2
Construction	1824	47.3
Transportation, storage, information, and communication	281	7.3
Forestry	99	2.6
Fishing	4	0.1
Agriculture	33	0.9
Financial and insurance activities	15	0.4
Other	821	21.3

IQR, interquartile range.

Classification of Diseases, Tenth Revision diagnostic codes for TSCI used in this study were as follows: cervical: G82.5, S14.0, S14.1, and T06.0; thoracic: S24.0 and S24.1; lumbar: G83.4, S34.0, S34.1, and S34.3; and “unspecified”: G82, G82.2, T06.1, T09.3, and T91.3. The patients were defined by priority in the order of cervical, thoracic, lumbar, and “unspecified.” The final study population included 3855 workers.

Variables

The included variables were age, sex, work-related injury type, occupation sector, industry sector, and compensation.

Age was categorized into five groups in increments of 10 years from <30 to ≥60 years. Work-related injuries were divided into two groups: injury and commuting injury. Occupational classifications followed the Korean Standard Classification of Occupations, based on the International Standard Classification of Occupations, and industrial classifications followed the Korean Standard Industrial Classification based on the International Standard Industrial Classification.

The total cost per claim refers to the total compensation paid to each worker owing to a work-related injury or disease, including medical care, temporary disability, and permanent disability benefits. The cost of medical and similar services refers to medical care benefits, including medical service fees, medication costs, and nursing expenses. Claimants with time lost from work referred to workers who were paid the cost of income replacement. The cost of income replacement refers to the benefits paid to an eligible worker or his/her dependents owing to the worker's temporary disability resulting from a work-related injury or disease. The duration of work disability was estimated by adding the number of inpatient and outpatient days of the IIW.

Statistical Analyses

The annual incidence of wrTSCI (number per million workers) was calculated by dividing the number of workers with TSCI diagnosis codes as the main or subdiagnosis by the total number of workers. Moreover, the incidence was calculated by stratifying TSCI by body region. Incidence by industry sector (number per million workers) was calculated by dividing the number of TSCI cases in the industry by the number of workers in each industry. The denominator used to calculate the incidence rate was derived from data on the number of workers provided by the Korean Ministry of Employment and Labor. In addition, the 10-year trends were assessed using Poisson regression analysis.

The mean and SD values for the continuous variables of the entire study population and classification by body regions were calculated using analysis of variance, whereas the frequency distribution of categorical variables was calculated using the χ^2 test.

All analyses were performed using the Statistical Analysis System statistical package (version 9.4; SAS Institute, Cary, NC), with the statistical significance level set at $P < 0.05$.

RESULTS

Table 1 shows the preinjury demographic characteristics of workers with wrTSCI. The mean and median age was 51.8 and 53 years, respectively, at the time of work-related injury. Work-related TSCI occurred most commonly among those aged 50 to 59 years, with workers 50 years or older accounting for more than half of the cases. Most cases involved men (94.5%) and “injury” as the type of work-related injury (95.8%). With respect to the occupation sector, elementary workers (38.2%) and craft and related trade workers (28.3%) accounted for more than half of the cases. With respect to the industry sector, construction (47.3%) accounted for approximately half of the cases, followed by other sectors (21.3%) and manufacturing (19.4%).

During 2010 to 2019, 3855 workers filed claims for wrTSCI (Table 2), which accounted for approximately 0.4% of all claims during that period. With respect to the TSCI region, most cases occurred at the

TABLE 2. Number of Work-Related Traumatic Spinal Cord Injury Claims, Korea, 2010–2019

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Total	Incidence*
Cervical	159	188	199	205	193	238	266	260	266	251	2225	13.1 (11.4–14.9)
Thoracic	27	14	22	23	16	22	25	20	21	30	220	1.3 (0.8–1.8)
Lumbar	83	52	74	56	58	61	49	68	63	77	641	3.8 (2.9–4.7)
Unspecified	64	73	64	74	55	64	82	92	104	97	769	4.5 (3.5–5.6)
Total	333	327	359	358	322	385	422	440	454	455	3855	22.8 (20.5–25.0)

*Rates are presented as an average over the 10-year period (rate per 1,000,000).

cervical region, followed (in order) by “unspecified,” lumbar, and thoracic regions.

Figure 1 shows the 10-year trend in wrTSCI incidence. The mean incidence of wrTSCI was 22.8/1,000,000 (95% confidence interval [CI], 20.5 to 25.0), which remained steady from 2010 to 2013, decreased sharply in 2014, and increased again in 2015 ($P = 0.320$). The incidence of TSCI in the cervical region (13.1/1,000,000; 95% CI, 11.4 to 14.9) accounted for more than half of all TSCIs. With respect to the 10-year trend by region, only “unspecified” showed a repeating pattern of statistically significant increase and decrease up to 2014, followed by an increasing trend starting from 2015 ($P = 0.002$). The mean mortality rate associated with wrTSCI was 1.7/1,000,000 (95% CI, 1.1 to 2.3), with most cases involving an injury in the cervical region (Supplementary Table 1, <http://links.lww.com/JOM/B325>).

The three industry sectors with the highest number of wrTSCI cases were construction (47.3%); manufacturing (19.4%); and transportation, storage, information, and communication (7.3%). Industry sectors with the highest mean incidence of TSCI were mining (169.6/1,000,000; 95% CI, 95.3 to 244.0), forestry (117.7/1,000,000; 95% CI, 94.5 to 140.9), and fishing (83.7/1,000,000; 95% CI, 1.7 to 165.8). The mean incidence within the construction industry was 61.0/1,000,000 (95% CI, 58.2 to 63.8) (Table 3).

Table 4 shows the claims characteristics of wrTSCI. Among all the workers with TSCI, 97.3% experienced time lost from work, whereas 98.7% received inpatient hospital treatment. The mean duration of disability for workers with TSCI was 838.3 days, and the mean total cost per claim was 231.40 million KRW. Workers with injuries in “unspecified” regions had the longest mean duration of work disability and the highest mean total cost per claim ($P < 0.001$ and $P < 0.001$, respectively).

DISCUSSION

This is the first epidemiological study on wrTSCI in Korea, comprising an in-depth analysis focusing on body regions. Our data show the overall absolute number of cases of acute wrTSCI. We calculated the incidence of wrTSCI by injury level and industry sector using Korean WCI data over a 10-year period from 2010 to 2019. We also reported the claims characteristics based on the level of injury.

Our study is one of few to examine the incidence of wrTSCI. Work-related TSCI comprised approximately 20% of all TSCI cases

in Korea.⁵ Our findings were similar to those of other studies reporting that wrTSCI accounted for 12% to 18% of all TSCI cases.^{9,12} The mean incidence of wrTSCI was 22.8 per million workers, which was higher than that reported in Australia and Chile.^{9,12} The mean incidence of wrTSCI was 4 per million workers in Australia (1986 to 1997), whereas that in Chile (1986 to 2005) was 7.8 per million workers.^{9,12} Although the study conducted in Chile included only 25% of the country's active working population, the incidence in Korea was higher. However, we analyzed nationwide WCI data, which included almost all workers in the country. These differences in the methodology may have minimized the risk of underestimation in this study.

The incidence of wrTSCI was relatively stable between 2010 and 2013 but decreased sharply in 2014 and gradually increased again from 2015. The decrease in incidence in 2014 can be viewed not as a decrease in the number of IIWs but as an expansion of coverage through the application of WCI.^{15,16} The number of workplaces covered by the WCI increased significantly in 2014; hence, the number of workers covered by insurance increased significantly (10.4%) compared with that in the previous year.¹⁷ This could have contributed to the temporary decrease in incidence. Therefore, the expanded WCI coverage could have influenced the incidence rate. Moreover, the subsequent increase in incidence could be attributed to the increased number of IIWs due to the abolition of the employer confirmation system for improved accessibility, which enabled workers to file for claims due to industrial injuries.^{16,18}

The incidence of TSCI in the cervical region was the highest, accounting for more than half of all TSCI cases (approximately 57%). This finding is similar to that of the epidemiology of the whole TSCI. In Europe, the proportion of cases of cervical TSCI ranged from 40% to 60%, whereas in the United States, 55.7% of new TSCI cases since 2000 were cervical injuries.¹⁹ Meanwhile, our results contradicted those of an Australian study on workers with TSCI who reported paraplegia and tetraplegia in 68% and 32% of cases, respectively.⁹ This difference may be attributable to the composition of the study population. In an Australian study, 75% of the study population was aged 25 to 54 years; however, in our study, more than half (64.5%) of the study population consisted of older workers 50 years or older. Cervical TSCI is often caused by relatively minor trauma, such as a fall on a level surface in patients with degenerative spinal conditions, including spondylosis and ossification of the posterior longitudinal ligament.²⁰ Actually, cervical

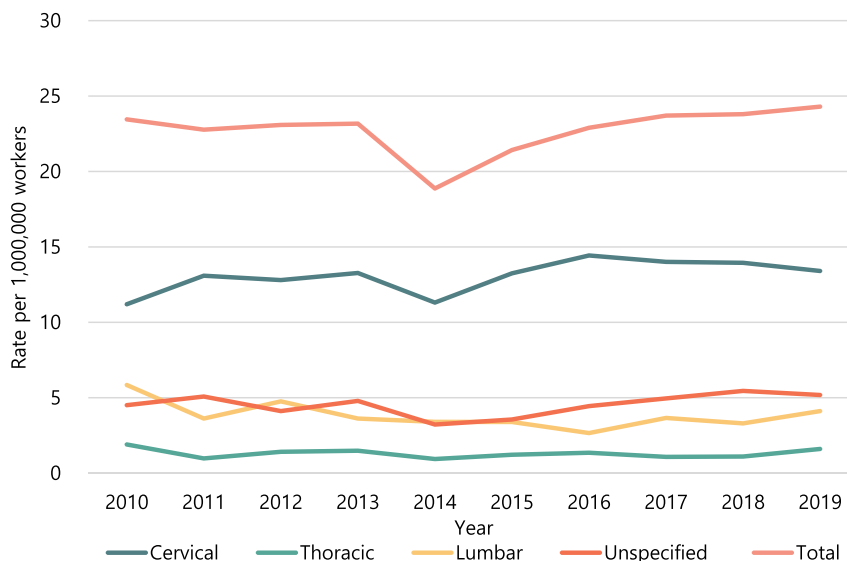


FIGURE 1. Incidence of work-related traumatic spinal cord injury among all workers, Korea, 2010–2019.

TABLE 3. Number of Work-Related Traumatic Spinal Cord Injuries by Industry Sector Among All Workers in Korea, 2010–2019

Industry Sector	2010		2011		2012		2013		2014		2015		2016		2017		2018		2019		Average		Incidence*
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
Mining	2	0.6	3	0.9	3	0.8	3	0.8	2	0.6	2	0.5	4	1.0	1	0.2	0	0.0	0	0.0	2.0	0.5	169.6 (95.3–244.0)
Manufacturing	70	21.0	59	18.0	70	19.5	72	20.1	63	19.6	65	16.9	90	21.3	88	20.0	73	16.1	99	21.8	74.9	19.4	19.3 (17.9–20.7)
Electricity, gas, steam, air conditioning, and water supply	1	0.3	1	0.3	1	0.3	0	0.0	2	0.6	1	0.3	1	0.2	0	0.0	0	0.0	2	0.4	0.9	0.2	13.9 (4.8–23.0)
Construction	142	42.6	162	49.5	159	44.3	169	47.2	154	47.8	199	51.7	194	46.0	234	53.2	205	45.2	206	45.3	182.4	47.3	61.0 (58.2–63.8)
Transportation, storage, information, and communication	25	7.5	23	7.0	31	8.6	27	7.5	17	5.3	27	7.0	32	7.6	27	6.1	39	8.6	33	7.3	28.1	7.3	34.9 (30.8–39.0)
Forestry	14	4.2	10	3.1	11	3.1	13	3.6	8	2.5	9	2.3	12	2.8	5	1.1	8	1.8	9	2.0	9.9	2.6	117.7 (94.5–140.9)
Fishing	0	0.0	0	0.0	2	0.6	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	1	0.2	1	0.2	0.4	0.1	83.7 (1.7–165.8)
Agriculture	2	0.6	3	0.9	4	1.1	3	0.8	4	1.2	2	0.5	2	0.5	4	0.9	5	1.1	4	0.9	3.3	0.9	52.0 (34.3–69.8)
Financial and insurance activities	1	0.3	0	0.0	3	0.8	3	0.8	1	0.3	2	0.5	2	0.5	0	0.0	2	0.4	1	0.2	1.5	0.4	2.1 (1.1–3.2)
Other	76	22.8	66	20.2	75	20.9	68	19.0	71	22.1	78	20.3	85	20.1	81	18.4	121	26.7	100	22.0	82.1	21.3	9.8 (9.2–10.5)

*Rates are presented as an average over the 10-year period (rate per 1,000,000).

TSCI occurs more frequently in older people.²¹ Therefore, it is necessary to strengthen education on falls prevention among older workers.

Our study reveals the characteristics of wrTSCI cases by industry sector. Mining was the industry sector with the highest mean incidence of wrTSCI; however, the actual number of cases in this sector was relatively small. Most wrTSCI cases were encountered in construction (47.3%); manufacturing (19.4%); and transportation, storage, information, and communication (7.3%) industries. These industries have hazardous working conditions and require physical labor. In particular, the number of cases in the construction industry was significantly higher than those in the other industry sectors. Our results are consistent with the findings of similar studies on IIWs in the United States (1986 to 1991) and Chile (1986 to 2005), which also reported that the construction industry was most significantly associated with TSCI (41.9% and 22.0%, respectively).^{12,22} Falls are a major cause of TSCI,^{9,23–25} and the construction industry has an extremely high risk of falls.¹² In Korea, workers undergo occupational safety and health training¹⁸; however, it would be prudent to further emphasize precautionary measures against falls and the importance of wearing safety equipment at construction sites for workers.

Traumatic spinal cord injury has a significant impact on individuals and has tremendous economic costs. In our study, the mean total cost per claim was 231.40 million KRW (approximately US \$160,000). This cost is more than double that of the mean total cost per claim (90.29 million KRW) in moderate to severe work-related traumatic brain injury in Korea.¹⁸ A US study of work-related tetraplegia reported that the mean first-year medical cost was US \$178,041 to \$560,524 per case, depending on the severity (1989 to 1999).¹³ In studies on the medical costs of TSCI, the mean cost for the acute phase (initial injury and recovery phase) of TSCI was US \$142,366 per case in the United States (2009),²⁶ and the total direct cost of medical services in the TSCI population was US \$108,986 per case for the first year in Ontario, Canada (2003 to 2005).²⁷ In our study, the medical cost per claim was 121.55 million KRW (approximately US \$84,000), which was rather low compared with the above results in the United States and Canada. Although a subsequent analysis of these differences is required, our findings can help raise awareness of the financial burden, provide evidence for funding of care, and design additional research.²⁷

Our study had the following strengths. This is the first study on the epidemiology of wrTSCI in Korea. Second, the WCI data used in our study were nationally representative data that included demographic information, work-related accident information, and medical care and compensation information in almost all IIW cases in Korea. Therefore, the findings of our study are representative of IIWs in Korea.

Our study had some limitations. First, the data were based on the year when the work-related accident occurred; therefore, the cost per claim may have been underreported for workers who did not complete their claims or finished receiving care, which may have affected the results. Second, because of restricted access to data on the age and sex of workers, age- and sex-standardized incidence could not be obtained. Third, the WCI data did not include information on the neurological level of SCI. Therefore, workers with G82, G82.2, T06.1, T09.3, or T91.3 as the main or subdiagnosis were classified as “unspecified.” Hence, additional data regarding the level of lesions in the early phase of work-related accidents in workers with SCI are required.

CONCLUSIONS

This is the first epidemiological study of wrTSCI in Korea. The mean incidence of wrTSCI was 22.8 per million workers. This incidence remained relatively stable between 2010 and 2013, decreased sharply in 2014, and then gradually increased from 2015 onward. The incidence of TSCI in the cervical region was the highest, accounting for more than half of all TSCIs. Moreover, the TSCI cases were concentrated in the construction industry. The mean total cost of wrTSCI per claim was 231.40 million KRW. These findings can help identify

TABLE 4. Claims Characteristics of Work-Related Traumatic Spinal Cord Injury by Body Region, Korea, 2010–2019

Claims	Total	Cervical	Thoracic	Lumbar	Unspecified	P*					
All Claimants, n	3855	2225	220	641	769						
Time lost from work, n (%)	3750	97.3	2153	96.8	216	98.2	630	98.3	751	97.7	0.124
Inpatient hospital stay, n (%)	3806	98.7	2192	98.5	215	97.7	633	98.8	766	99.6	0.063
Duration of work disability											
Mean (SD) no. days	838.3	828.4	825.9	852.1	980.1	904.7	659.2	619.8	982.7	856.4	<0.001
Median (IQR) no. days	577	276–1048	530	252–1047	725.5	310–1326.5	476	267–824	791	391–1216	
Claim costs paid, million KRW											
Mean (SD) total cost per claim	231.40	224.05	220.59	227.37	289.50	233.43	175.65	167.30	292.51	235.98	<0.001
Mean (SD) cost of medical and similar services	121.55	151.57	120.84	157.17	143.09	139.82	76.25	96.97	155.20	165.42	<0.001
Mean (SD) cost of income replacement	41.60	33.70	39.14	33.01	45.40	31.48	40.08	33.04	48.92	35.73	<0.001
Time-loss claims†											
Claim costs paid, million KRW											
Mean (SD) total cost per claim	235.22	221.57	225.67	228.93	293.21	233.85	178.09	167.43	293.88	220.01	<0.001
Mean (SD) cost of medical and similar services	146.70	61.69	124.70	158.31	145.51	139.95	77.31	97.33	154.98	138.49	<0.001
Mean (SD) cost of income replacement	42.77	33.44	40.45	32.75	46.24	31.15	40.78	32.90	50.09	35.33	<0.001

ANOVA, analysis of variance; IQR, interquartile range; KRW, Korean Won.

*P value from the χ^2 test (categorical variables) or ANOVA (continuous variable).

†Analyses restricted to claimants with >0 claim costs paid for time lost from work.

specific at-risk groups and facilitate the development of prevention strategies for these devastating injuries.

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