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Retrospective Study

Prevalence and Risk Factors for Persistent Spinal Pain Syndrome Type II Following Spinal Surgery: A Nationwide Retrospective Cohort Study

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Background: Persistent Spinal Pain Syndrome Type II (PSPS II) is a major health concern in patients undergoing spinal surgery. However, there are little data on the prevalence and risk factors of PSPS II post spinal surgery.

Objectives: We examined the prevalence and factors associated with diagnosing PSPS II post spinal surgery using a nationwide database in the Republic of Korea.

Study Design: A retrospective, population-based cohort study.

Setting: Nationwide cohort study in the Republic of Korea.

Methods: Adult patients who underwent spinal surgery under general anesthesia from January 1, 2016 through December 31, 2020 were included. Patients previously diagnosed with PSPS II were excluded from the study in order to focus only on patients who were newly diagnosed post spinal surgery. We determined that a PSPS II diagnosis must be made within one year of the date of spinal surgery, with an additional evaluation for diagnoses occurring within 2 years to capture longer-term cases. A multivariate logistic regression model was developed to identify the factors associated with diagnosing PSPS II post spinal surgery.

Results: In total, 530,644 patients who underwent spinal surgery were included. Of these, 25.6% and 31.5% were diagnosed with PSPS II within one and 2 years post spinal surgery, respectively. The multivariate logistic regression model indicated that being a woman, old age, being a member of a medical aid program group, an increased Charlson Comorbidity Index score, discectomy, laminectomy, and lumbar level surgery were associated with an increased prevalence of PSPS II within one year post spinal surgery. Similar results were observed in the multivariate logistic regression model for PSPS II within 2 years post spinal surgery.

Limitation: Our study's retrospective cohort design is a limitation.

Conclusions: This population-based cohort analysis found a 25.6% prevalence of PSPS II within one year post spinal surgery and 31.5% within two years post spinal surgery. Identified risk factors include old age, being a woman, economic poverty, comorbid status, underlying disability, type of surgery, and lumbar-level surgery. A large dataset was used to document the prevalence and risk factors for PSPS II post spinal surgery.

Key words: Pain, spine, surgery, prevalence, cohort study

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Persistent Spinal Pain Syndrome Type II (PSPS II) is a disorder characterized by persistent pain that has a significant influence on both the patient and the health care system (1). PSPS II is defined as chronic or recurring pain in the back, neck, or limbs that persists despite surgery or treatment expected to alleviate discomfort (2).

Despite advances in spinal surgery, the prevalence of PSPS II has not declined (3). According to a recent cohort analysis, 5.4% of patients had a PSPS II diagnosis within 6 months of the initial procedure and 8.4% received a PSPS II diagnosis within a year of decompression surgery (4). These authors also revealed that old age and multilevel surgery were risk factors for PSPS II (4). The overall prevalence of PSPS II post spinal surgery ranges from 20% to 40% (2). A recent cohort study found that significant symptoms of lumbar degenerative disease at presurgery were risk factors for PSPS II, with 16.8% of patients diagnosed with PSPS II post lumbar surgery (5). Nevertheless, there are little data on the prevalence and risk factors of PSPS II post spinal surgery. Therefore, we aimed to examine the prevalence of and associated factors for diagnosing PSPS II post spinal surgery using a nationwide database in the Republic of Korea (South Korea).

Methods

Study Design, Setting, and Ethical Declarations

This retrospective population-based cohort study was approved by the Institutional Review Board of Seoul National University Bundang Hospital (IRB approval number: X-2304-821-901). The Big Data Center of the National Health Insurance Service (NHIS) authorized data sharing (NHIS-2023-1-525). The requirement for informed consent in the data analyses was waived as the analyses were carried out retrospectively, and anonymized data were acquired from the South Korean NHIS database.

Data Source

The information utilized in this research was acquired from the NHIS, which is the sole public insurance system and health care system administered by South Korea. By law, the NHIS database must include complete disease diagnoses and prescription information for any medication, procedure, or both. Individuals are authorized to receive government-sponsored health insurance benefits upon enrollment. The diagnostic process was conducted in accordance with the guidelines specified in the 10th Revision of the International Classification of Diseases (ICD-10). Foreign residents utilizing the NHIS are obligated to undergo registration if their stay in the country surpasses 6 months. The NHIS database contains supplementary data pertaining to the socioeconomic status and date of mortality for each individual (6).

Study Population

Adult patients who underwent spinal surgery under general anesthesia from January 1, 2016 through December 31, 2020 were initially screened. In addition to procedures performed in the lumbar, cervical, and thoracic regions, spinal surgery involves procedures performed in unspecified regions. The codes corresponding to the various forms of spinal surgery are detailed in Table S1. Patients younger than 18 years were excluded. Patients who underwent multiple spinal surgeries during the designated research period were restricted to the initial operation. Patients who underwent subsequent surgery or those who had previously been diagnosed with PSPS II were excluded in order to focus on newly diagnosed cases of PSPS II post spinal surgery.

Diagnosis of PSPS II Within 1 or 2 Years (Study Endpoint)

The ICD-10 was used to extract PSPS II scores from the study population. In a previous investigation, the diagnostic criterion for PSPS II was back pain that persisted or recurred within a year of spinal surgery (7). Using this definition, we determined that a post spinal surgical PSPS II diagnosis must be made within one year of the date of spinal surgery. Patients who were diagnosed with PSPS II within one year post spinal surgery were classified into the PSPS II group; those who were not diagnosed with PSPS II within one year post spinal surgery were classified into the non-PSPS II group. However, considering that 5–36% of PSPS II cases are reported 2 years after discectomy for disc herniation (8), we also aimed to evaluate the diagnosis of PSPS II within 2 years post spinal surgery.

Analyzed Variables

Data on gender and age were obtained. The patient's place of residence, employment status (including self-employment), and household income were covariates of socioeconomic status. Household income levels were represented by 5 categories, one of which included a 4-quartile ratio and a medical aid program for those unable to pay for insurance. Seoul and other major cities were considered urban areas, whereas the remaining areas were considered rural. We collected information on the various treatments performed and the degree of spinal surgery. Arthrodesis, corpectomy, spine fracture surgery, discectomy, spine tumor surgery, laminectomy, and other spinal procedures belong to different categories of spinal surgery. We also collected data regarding intraoperative neurophysiological monitoring. Propofol-based total intravenous or inhalation anesthesia has also been used as an anesthetic technique for spine surgery.

The Charlson Comorbidity Index (CCI) and underlying disability were used to consider the coexisting conditions of the patients. ICD-10 codes added to the NHIS database were used to calculate the CCI scores at the time of hospital admission (Table S2). All persons with disabilities in South Korea must be registered in the NHIS database to be eligible for the benefits provided by social welfare programs. Every disability must be formally identified by a medical expert, who assesses the challenges encountered while performing regular duties. Table S3 provides a comprehensive classification of disabilities.

The patients in our study were categorized into one of 6 severity levels (1st: most severe; 6th: least severe) based on disease severity. A "severe" level was assigned to classes 1–3, and a "light to moderate" level to grades 4–6. Data on the type of spinal surgery, surgical spine level, and year of surgery were also collected.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows 27.0 (IBM Corp.). A *P* value significance was set at $P < 0.05$.

The normality of the distribution of continuous data, such as age and CCI score, was assessed using the Kolmogorov–Smirnov test. Continuous variables were not normally distributed. For continuous variables, baseline characteristics are expressed as median values with interquartile ranges (IQR) and categorical variables are expressed as percentages. The Mann–Whitney U test and χ^2 test for continuous and categorical variables were used to compare clinicopathological characteristics between the PSPS II and non-PSPS II groups.

In order to identify the factors associated with diagnosing PSPS II within one year of spinal surgery, we developed a multivariate logistic regression model. Additionally, a multivariable logistic regression model was used to predict diagnosing PSPS II within one year post spinal surgery, excluding patients who died within that time frame. This exclusion was necessary because certain patient deaths occurred before the PSPS II diagnosis, rendering them undiagnosable.

In addition, a multivariate logistic regression model was constructed to ascertain the factors correlated with PSPS II occuring within 2 years of spinal surgery. PSPS II diagnoses within 2 years of spinal surgery were incorporated into this model for the 2-year follow-up of patients who underwent spinal surgery from 2016 through 2019. Furthermore, to predict the PSPS II occuring within a 2-year period post spinal surgery, a multivariate logistic regression model was implemented; patients who died during that period were excluded from the model. Due to the death of specific patients preceding a diagnosis of PSPS II, they were rendered undiagnosable and were excluded from the analysis.

For adjustment purposes, every covariate was incorporated into each model, and outcomes were displayed as odds ratios (ORs) with 95% CIs. Hosmer-Lemeshow statistics were used to validate the appropriateness of the model's goodness of fit. Multicollinearity among the variables was not an issue, as evidenced by the inflation factors for which the criterion of variance was less than 2.0.

Results

Study Population

From January 1, 2016 through December 31, 2020 there were 642,151 spinal surgery cases in South Korea. A total of 55,722 patients underwent more than one spinal surgery during the study period; 3,137 children younger than 18 years were excluded. After excluding 52,648 patients diagnosed with PSPS II at presurgery, 530,644 patients who underwent spinal surgery were included in the study. Of these, 25.6% (135,636/530,644) were diagnosed with PSPS II within one year of their spinal surgery. Furthermore, 31.5% (133,811/425,394) of patients who underwent spinal surgery from 2016 through 2019 were diagnosed with PSPS II within 2 years of their spinal surgery. Figure 1 shows a flowchart of the patient selection procedure. The clinicopathological features of the study population are shown in Table 1. The median age was 63.0 years (IQR, 52.0-72.0); the proportion of men was 51.5% (273,121/530,644). The clinicopathological characteristics of the PSPS II and non-PSPS II groups are shown in Table 2.

PSPS II Within One Year

The findings of the multivariate logistic regression model for PSPS II within one year of spinal surgery are shown in Table 3. An increased prevalence of PSPS II within a year post spinal surgery was linked to several factors, including old age (OR, 1.02; 95% CI, 1.02-1.02; $P < 0.001$), medical aid program group (vs Q1 [the lowest] in household income, OR, 1.25; 95% CI, 1.21-1.30; $P < 0.001$), increased CCI (OR, 1.01; 95% CI,: 1.01-1.02; $P < 0.001$), discectomy (vs arthrodesis, OR, 1.12; 95% CI, 1.09-1.14; $P < 0.001$), laminectomy (vs arthrodesis, OR, 1.21; 95% CI,

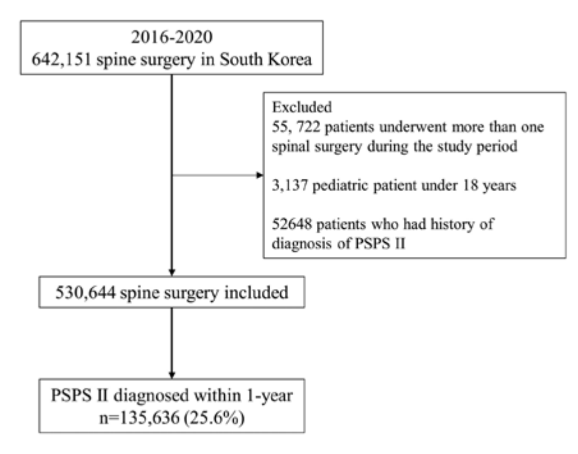

Fig. 1. *Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) flow chart of the patient selection process.*

Table 1. *Clinicopathological features of the study population.*

Variable	Median (IQR)]	n (%)
Age, years	63.0 (52.0-72.0)	
Gender, men		273,121 (51.5)
Having a job		339,818 (64.0)
Residence at surgery		
Urban area		206,273 (38.9)
Rural area		324,371 (61.1)
Household income level		
Q1 (lowest)		92,555 (17.4)
Q2		95,615 (18.0)
Q3		130,410 (24.6)
Q4 (highest)		177,628 (33.5)
Medical aid program group		25,761 (4.9)
Unknown		8,675 (1.6)
CCI	1.0 (0.0-1.1)	
Myocardial infarction		7,988 (1.5)
Congestive heart failure		13,228 (2.5)
Peripheral vascular disease		4,251 (0.8)
Cerebrovascular disease		16,116 (3.0)
Dementia		6,212 (1.2)
Chronic pulmonary disease		63,570 (12.0)
Rheumatic disease		16,704 (3.1)
Peptic ulcer disease		57,282 (10.8)
Mild liver disease		110,478 (20.8)
DM without chronic complication		116,937 (22.0)

1.18-1.23; P < 0.001), and lumbar level (vs cervical level, OR, 1.13; 95% CI, 1.10-1.16; *P* < 0.001). Men (OR, 0.90; 95% CI, 0.89-0.92; *P* < 0.001) and those with jobs (OR: 0.97; 95% CI, 0.96-0.99; *P* < 0.001) showed a decreased prevalence of PSPS II at one year post spinal surgery. After excluding patients who died within one year of their spinal surgery, Table S4 displays the results of the multivariate logistic regression model for PSPS II within one year postprocedure.

Table 1 cont. *Clinicopathological features of the study population.*

Variable	Median (IQR)]	n (%)
DM with chronic complication		12,687 (2.4)
Hemiplegia or paraplegia		17,334 (3.3)
Renal disease		6,478 (1.2)
Cancer		11,430 (2.2)
Moderate and severe liver disease		679 (0.1)
Metastatic cancer		4,769 (0.9)
AIDS/HIV		229 (0.0)
Underlying disability		
Mild to moderate disability		61,581 (11.6)
Severe disability		15,360 (2.9)
IOM		20,831 (3.9)
Propofol-based TIVA		208,244 (39.2)
Type of spine surgery		
Arthrodesis		67,978 (12.8)
Corpectomy		634 (0.1)
Spine fracture		5,857 (1.1)
Discectomy		297,422 (56.0)
Spine tumor		8,358 (1.6)
Laminectomy		134,640 (25.4)
Other spine surgery		15,755 (3.0)
Type of surgical spine level		
Cervical		69,721 (13.1)
Thoracic		18,932 (3.6)
Lumbar		428,992 (80.8)
Not specified		12,999 (2.4)
Year of surgery		
2016		110,981 (20.9)
2017		106,435 (20.1)
2018		104,249 (19.6)
2019		103,729 (19.5)

IQR, interquartile range; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia

PSPS II Within 2 Years

Table 4 shows the results of the multivariate logistic regression model for PSPS II within 2 years of spinal surgery. An increased prevalence of PSPS II within 2 years post spinal surgery was linked to several factors, including old age (OR, 1.02; 95% CI, 1.02-1.02; *P* < 0.001), medical aid program group (vs Q1 in household income, OR, 1.29; 95% CI, 1.25-1.34; *P* < 0.001), increased CCI (OR, 1.01; 95% CI, 1.01-1.02; *P* < 0.001), discectomy (vs arthrodesis, OR, 1.12; 95% CI, 1.09-1.16; *P* < 0.001), laminectomy (OR, 1.24; 95% CI, 1.20-1.28; *P* < 0.001), and lumbar level (vs cervical level, OR, 1.14; 95% CI, 1.11-1.17; *P* < 0.001).

Men (OR, 0.82; 95% CI, 0.81-0.83; *P* < 0.001) and those with jobs (OR, 0.98; 95% CI, 0.96-0.99; *P* = 0.001) had a decreased prevalence of PSPS II at 2 years post spinal surgery. After excluding patients who died within 2 years of their spinal surgery, Table S5 displays the results of the multivariate logistic regression model for PSPS II within one year of the procedure.

Discussion

Within one and 2 years post spinal surgery, the prevalence of PSPS II was 25.6% and 31.5%, respectively, in this population-based cohort study. Factors such as old age, women, economic poverty, comorbid status, underlying dis-

Table 2. *Findings of comparing the clinicopathological characteristics of the PSPS II and non-PSPS II groups.*

Variable		PSPS II group n = 135,636	Non-PSPS II group n = 395,008	*P* value
Age, years		66.0 (57.0, 74.0)	62.0 (51.0, 71.0)	< 0.001
Gender, men		64,719 (47.7)	208,402 (52.8)	< 0.001
Having a job		85,374 (62.9)	254,444 (64.4)	< 0.001
Residence at surgery				0.483
	Urban area	52,616 (38.8)	153,657 (38.9)	
	Rural area	83,020 (61.2)	241,351 (61.1)	
Household income level				< 0.001
	Q1 (lowest)	23,507 (17.3)	69,048 (17.5)	
	Q2	23,816 (17.6)	71,799 (18.2)	
	Q3	32,804 (24.2)	97,606 (24.7)	
	Q4 (highest)	44,947 (33.1)	132,681 (33.6)	
	Medical aid program group	8,373 (6.2)	17,388 (4.4)	
	Unknown	2,189 (1.6)	6,486 (1.6)	
CCI		1.0 [0.0, 2.0]	1.0 [0.0, 1.0]	< 0.001
	Myocardial infarction	2,081 (1.5)	5,907 (1.5)	0.311
	Congestive heart failure	3,625 (2.7)	9,603 (2.4)	< 0.001
	Peripheral vascular disease	1,219 (0.9)	3,032 (0.8)	< 0.001
	Cerebrovascular disease	4,662 (3.4)	11,454 (2.9)	< 0.001
	Dementia	1,651 (1.2)	4,561 (1.2)	0.065
	Chronic pulmonary disease	17,731 (13.1)	45,839 (11.6)	< 0.001
	Rheumatic disease	4,866 (3.6)	11,838 (3.0)	< 0.001
	Peptic ulcer disease	14,705 (10.8)	42,577 (10.8)	0.521
	Mild liver disease	27,777 (20.5)	82,701 (20.9)	< 0.001
	DM without chronic complication	31,666 (23.3)	85,271 (21.6)	< 0.001
	DM with chronic complication	4,091 (3.0)	8,596 (2.2)	< 0.001
	Hemiplegia or paraplegia	4,539 (3.3)	12,795 (3.2)	0.055
	Renal disease	1,625 (1.2)	4,853 (1.2)	0.377
	Cancer	2,061 (1.5)	9,369 (2.4)	< 0.001
	Moderate and severe liver disease	135 (0.1)	544 (0.1)	0.001
	Metastatic cancer	377 (0.3)	4,392 (1.1)	< 0.001
	AIDS/HIV	65 (0.0)	164 (0.0)	0.327
Underlying disability				< 0.001
	Mild to moderate disability	18,722 (13.8)	42,859 (10.9)	
	Severe disability	4,131 (3.0)	11,229 (2.8)	
IOM		5,033 (3.7)	15,798 (4.0)	< 0.001
Propofol-based TIVA		50,777 (37.4)	157,467 (39.9)	< 0.001
Type of spine surgery				< 0.001
	Arthrodesis	15,053 (11.1)	52,925 (13.4)	
	Corpectomy	148 (0.1)	486 (0.1)	
	Spine fracture	117 (0.1)	5,740 (1.5)	

Table 2 cont. *Findings of comparing the clinicopathological characteristics of the PSPS II and non-PSPS II groups.*

Variable		PSPS II group n = 135,636	Non-PSPS II group n = 395,008	*P* value
	Discectomy	75,485 (55.7)	221,937 (56.2)	
	Spine tumor	1,106 (0.8)	7,252 (1.8)	
	Laminectomy	40,281 (29.7)	94,359 (23.9)	
	Other spine surgery	3,446 (2.5)	12,309 (3.1)	
Type of surgical spine level				< 0.001
	Cervical	15,618 (11.5)	54,103 (13.7)	
	Thoracic	4,113 (3.0)	14,819 (3.8)	
	Lumbar	115,124 (84.9)	313,868 (79.5)	
	Not specified	781 (0.6)	12,218 (3.1)	
Year				< 0.001
	2016	26,748 (19.7)	84,233 (21.3)	
	2017	26,351 (19.4)	80,084 (20.3)	
	2018	26,855 (19.8)	77,394 (19.6)	
	2019	27,047 (19.9)	76,682 (19.4)	
	2020	28,635 (21.1)	76,615 (19.4)	

PSPS II, Persistent Spinal Pain Syndrome Type II; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia

Table 3. *Multivariate logistic regression model for PSPS II within a year post spinal surgery.*

Variable		OR (95% CI)	*P* < 0.001
Age, years		1.02 (1.02-1.02)	< 0.001
Gender, men		0.90 (0.89-0.92)	< 0.001
Having a job		0.97 (0.96-0.99)	< 0.001
Residence at surgery			
	Urban area	1	
	Rural area	1.00 (0.99-1.02)	0.611
Household income level			
	Q1 (lowest)	1	
	Q2	1.01 (0.99-1.03)	0.334
	Q3	1.00 (0.98-1.02)	0.939
	Q4 (highest)	0.92 (0.91-0.94)	< 0.001
	Medical aid program group	1.25 (1.21-1.30)	< 0.001
	Unknown	1.01 (0.96-1.06)	0.724
CCI*		1.01 (1.01-1.02)	< 0.001
	Myocardial infarction	0.93 (0.88-0.98)	0.003
	Congestive heart failure	0.94 (0.90-0.98)	0.002
	Peripheral vascular disease	1.00 (0.94-1.08)	0.901
	Cerebrovascular disease	1.01 (0.97-1.05)	0.660
	Dementia	0.82 (0.78-0.87)	< 0.001
	Chronic pulmonary disease	1.06 (1.04-1.08)	< 0.001
	Rheumatic disease	1.16 (1.12-1.20)	< 0.001
	Peptic ulcer disease	1.00 (0.98-1.02)	0.918

ability, surgery type (discectomy or laminectomy), and lumbar-level surgery were identified as risk factors for a PSPS II diagnosis post spinal surgery. Our study is noteworthy because it reports, using big data, the prevalence and risk factors for PSPS II that may develop post spinal surgery.

In general, PSPS II has been evaluated for one year post the date of spinal surgery in previous studies (7,9,10). However, data on the prevalence of PSPS II are limited. In Japan, among 1,842 patients who underwent lumbar surgery, the prevalence of PSPS II was reported to be 20.6% (95% CI, 18.8-22.6%) using survey data (11). In the United States, among 28,426 patients who underwent back surgery, the prevalence of PSPS II was reported to be 8% (12). Another cohort study in the United States using a population of 333 patients reported that the prevalence of PSPS II was 16.8% (5). Using a large sample size from the national database of South Korea, we report a 25.6% prevalence of PSPS II within a year post spinal surgery in this study. Furthermore, we found that 31.5% of PSPS II cases occurred within 2-year period. This is noteworthy because there are insufficient reports on the prevalence of PSPS II within the 2-year period post spinal surgery.

In our study, being a woman was a significant factor in PSPS II. Previous studies have reported that PSPS II is more commonly observed in women patients post spinal surgery (12,13). It is generally known that approximately half of chronic pain disorders are more common in women due to major gender variations in the physiological mechanisms underlying pain (14). PSPS II is considered a chronic pain disorder that can be influenced by differences in the gender-associated physiological mechanisms underlying pain.

Comorbid status, including CCI, was also a risk factor for PSPS II post spinal surgery. In India, approximately two-thirds of patients with chronic pain report chronic mental or physical illness (15). In Canada, patients with chronic pain have a higher prevalence of comorbidities than those without pain (16). Medical history was identified as a risk factor for PSPS II in a previous review article (1); our findings corroborate this finding.

It is worth emphasizing that the prevalence of PSPS II was higher among the medical aid program group, which is a group that is economically disadvantaged. Lower socioeconomic status was associated with increase in the risk of chronic pain, which was defined as persistent or recurrent pain for more than 3 months (17). Moreover, a low household income (medical aid program group in South Korea) among patients with low back or neck pain increases the likelihood of chronic opioid use by 18% (18). However, information on the effect of low economic status on PSPS II risk is lacking. Our finding is important because PSPS II incurs significant therapeutic costs, both individually and socially (19). Additionally, patients with lower socioeconomic status do not have equal access to outpatient clinics or hospitals to treat chronic pain (20). Therefore, our results support the argument that socioeconomic status should be considered in the prevention and treatment of PSPS II.

In our study, among spinal surgeries, lumbar level surgery was also a risk factor for PSPS II occuring compared with surgery at other levels. Traditionally, PSPS II has been evaluated primarily as persistent or recurrent chronic pain post lumbar-level surgery (21). However, PSPS II has recently been classified as persistent or recurrent chronic neck pain post cervical-level surgery and is sometimes referred to as failed neck surgery syndrome (22). In this population-based cohort study using big data, we evaluated PSPS II after cervical-level surgery in addition to lumbar surgery. Our results suggest that the PSPS II score was higher post lumbar-level surgery than post cervical-level surgery. This suggests that caution should be exercised when performing lumbar-level surgeries in order to avoid PSPS II.

Although our study has several advantages, it has

Table 3 cont. *Multivariate logistic regression model for PSPS II within a year post spinal surgery.*

Variable		OR (95% CI)	*P* < 0.001
	Mild liver disease	0.98 (0.96-0.99)	0.032
	DM without chronic complication	0.98 (0.97-1.00)	0.052
	DM with chronic complication	1.21 (1.17-1.26)	< 0.001
	Hemiplegia or paraplegia	1.09 (1.06-1.13)	< 0.001
	Renal disease	0.79 (0.75-0.84)	< 0.001
	Cancer	0.89 (0.84-0.94)	< 0.001
	Moderate and severe liver disease	0.76 (0.63-0.84)	0.004
	Metastatic cancer	0.33 (0.30-0.38)	< 0.001
	AIDS/HIV	1.17 (0.88-1.56)	0.303
Underlying disability			
	Mild to moderate disability	1.18 (1.16-1.20)	< 0.001
	Severe disability	1.04 (1.01-1.08)	0.025
IOM		1.26 (1.22-1.31)	< 0.001
Propofol-based TIVA		0.93 (0.92-0.95)	< 0.001
Type of spine surgery			
	Arthrodesis	1	
	Corpectomy	1.08 (0.89-1.30)	0.450
	Spine fracture	0.23 (0.18-0.28)	< 0.001
	Discectomy	1.12 (1.09-1.14)	< 0.001
	Spine tumor	0.62 (0.58-0.67)	< 0.001
	Laminectomy	1.21 (1.18-1.23)	< 0.001
	Other spine surgery	1.32 (1.26-1.38)	< 0.001
Type of surgical spine level			
	Cervical	1	
	Thoracic	0.96 (0.92-0.99)	0.039
	Lumbar	1.13 (1.10-1.16)	< 0.001
	Not specified	0.29 (0.26-0.31)	< 0.001
Year of surgery			
	2016	1.01 (0.99-1.03)	0.317
	2017	1.06 (1.04-1.08)	< 0.001
	2018	1.07 (1.05-1.09)	< 0.001
	2019	1.07 (1.05-1.09)	< 0.001
	2020	1.14 (1.11-1.16)	< 0.001

PSPS II, Persistent Spinal Pain Syndrome Type II; OR, odds ratio; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia

Table 4. *Multivariate logistic regression model for PSPS II within 2 years post spinal surgery.*

Variable		OR (95% CI)	P < 0.001
Age, years		1.02 (1.02-1.02)	< 0.001
Gender, men		0.82 (0.81-0.83)	< 0.001
Having a job		0.98 (0.96-0.99)	0.001
Residence at surgery			
	Urban area	1	
	Rural area	1.01 (0.99-1.02)	0.490
Household income level			
	Q1 (lowest)	1	
	Q2	0.98 (0.96-1.01)	0.159
	Q3	0.98 (0.96-1.00)	0.102
	Q4 (highest)	0.98 (0.96-1.00)	0.050
	Medical aid program group	1.34 (1.30-1.39)	< 0.001
	Unknown	1.00 (0.95-1.06)	0.936
CCI*		1.01 (1.01-1.02)	< 0.001
	Myocardial infarction	0.92 (0.87-0.97)	0.001
	Congestive heart failure	0.94 (0.90-0.98)	0.006
	Peripheral vascular disease	1.00 (0.93-1.05)	0.929
	Cerebrovascular disease	1.01 (0.97-1.05)	0.600
	Dementia	0.83 (0.78-0.89)	< 0.001
	Chronic pulmonary disease	1.06 (1.04-1.08)	< 0.001
	Rheumatic disease	1.22 (1.17-1.26)	< 0.001
	Peptic ulcer disease	1.00 (0.98-1.02)	0.944
	Mild liver disease	0.98 (0.97-1.00)	0.097
	DM without chronic complication	0.99 (0.97-1.00)	0.091
	DM with chronic complication	1.21 (1.16-1.26)	< 0.001
	Hemiplegia or paraplegia	1.07 (1.03-1.11)	0.001
	Renal disease	0.80 (0.75-0.85)	< 0.001
	Cancer	0.87 (0.82-0.92)	< 0.001
	Moderate and severe liver disease	0.77 (0.63-0.93)	0.008
	Metastatic cancer	0.32 (0.28-0.36)	< 0.001
	AIDS/HIV	1.17 (0.86-1.58)	0.325
Underlying disability			
	Mild to moderate disability	1.35 (1.32-1.38)	< 0.001
	Severe disability	1.11 (1.07-1.16)	< 0.001
IOM		1.24 (1.19-1.29)	< 0.001
Propofol-based TIVA		0.91 (0.90-0.92)	< 0.001
Type of spine surgery			
	Arthrodesis	1	
	Corpectomy	1.15 (0.95-1.40)	0.161
	Spine fracture	0.25 (0.20-0.30)	< 0.001
	Discectomy	1.12 (1.09-1.16)	< 0.001
	Spine tumor	0.63 (0.59-0.68)	< 0.001
	Laminectomy	1.24 (1.20-1.28)	< 0.001

some limitations. First, important variables such as surgical time and body mass index as well as lifestyle factors, such as alcohol consumption and smoking history, were not adjusted for in our analysis because of insufficient data in the NHIS database. Second, the degree of back pain or neuropathic pain pre spinal surgery was not assessed. Severe symptoms pre spinal surgery could be a significant risk factor for developing PSPS II (5), which may have affected our results. Third, a PSPS II diagnosis was established solely using doctor-registered ICD-10 codes. This was based on the premise that all doctors would accurately diagnose patients and record pertinent information. Consequently, some cases may have been missed during the diagnostic process, which may have affected our findings. Finally, the generalizability of our study may be limited because the health care utilization systems of patients with PSPS II vary across countries.

Conclusions

In conclusion, this population-based cohort study found a prevalence of 25.6% for PSPS II within one year post spinal surgery and 31.5% within 2 years post spinal surgery. We identified several risk factors, such as older age, being a woman, economic poverty, comorbid status, underlying disability, surgery type (discectomy or laminectomy), and lumbar-level surgery. This study is significant because it documents, using big data, the frequency and potential causes of PSPS II that can occur post spinal surgery.

Author Contributions

TKO was responsible for study design, data analysis, data interpretation, and manuscript drafting. IAS contributed to the study conceptualization, data acquisition, and manuscript review. Both authors read and approved the final manuscript.

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Table 4 cont. ***Multivariate logistic regression model for PSPS II within 2 years post spinal surgery.***

Variable	OR (95% CI)	*P* < 0.001
Other spine surgery	1.29 (1.23-1.36)	< 0.001
Type of surgical spine level		
Cervical	1	
Thoracic	0.95 (0.91-0.99)	0.023
Lumbar	1.14 (1.11-1.17)	< 0.001
Not specified	0.30 (0.28-0.30)	< 0.001
Year of surgery		
2016	1	
2017	1.01 (0.99-1.03)	0.499
2018	1.03 (1.01-1.05)	0.006
2019	1.04 (1.02-1.06)	< 0.001

PSPS II, Persistent Spinal Pain Syndrome Type II; OR, odds ratio; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia

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Table S1. *Spine surgery codes used in this study.*

Op code	Op name
M5952	Emergency Spine Immobilization
N0303	Osteotomy (Spine, Pelvis)
N0444	Arthrodesis For Spinal Deformity (Anterior Technique)-7 Level Below
N0445	Arthrodesis For Spinal Deformity (Anterior Technique)-7 Level Over
N0446	Arthrodesis For Spinal Deformity (Posterior Technique)-7 Level Below
N0447	Arthrodesis For Spinal Deformity (Posterior Technique)-7 Level Over
N0451	Vertebral Corpectomy (Cervical Spine)
N0452	Vertebral Corpectomy (Thoracic Spine)
N0453	Vertebral Corpectomy (Lumbar Spine)
N0454	Surgical removal of the ossification of spinal ligament (OPLL{provide full terminology} removal-anterior approach)
N0455	Surgical removal of the ossification of spinal ligament (OLF{provide full terminology} removal-posterior approach)
N0466	Arthrodesis of Spine-Lumbar Spine-Anterior Technique
N0468	Arthrodesis of Spine-Thoracic Spine-Posterior Technique
N0469	Arthrodesis of Spine-Lumbar Spine-Posterior Technique
N0480	Operation of Spina Bifida
N0591	Open Reduction of Fracture and Dislocation of Spine or Pelvis-Spine
N0592	Open Reduction of Fracture and Dislocation of Spine or Pelvis-Acetabulum
N0593	Open Reduction of Fracture and Dislocation of Spine or Pelvis-Pelvis
N0630	Closed Reduction of Fracture And/Or Dislocated Spine
N1466	Arthrodesis of Spine-Lumbar Spine-Anterior Technique
N1469	Arthrodesis of Spine-Lumbar Spine-Posterior Technique
N1491	Diskectomy (Invasive)-Cervical Spine
N1492	Diskectomy (Invasive)-Thoracic Spine
N1493	Diskectomy (Invasive)-Lumbar Spine
N1498	Laminectomy, Thoracic Spine
N1499	Laminectomy, Lumbar Spine
N2461	Arthrodesis of Spine-Cervical Spine-Anterior Technique (Trans-Oral)
N2462	Arthrodesis of Spine-Cervical Spine-Anterior Technique (Anterior Odontoid Screw Fixation)
N2463	Arthrodesis of Spine-Cervical Spine-Anterior Technique (Others)
N2464	Arthrodesis of Spine-Thoracic Spine-Anterior Technique (Transmanubrial)
N2465	Arthrodesis of Spine-Thoracic Spine-Anterior Technique (Transsternal)
N2466	Arthrodesis of Spine-Thoracic Spine-Anterior Technique (Others)
N2467	Arthrodesis of Spine-Cervical Spine-Posterior Technique (Occipito-Cervical Fusion)
N2468	Arthrodesis of Spine-Cervical Spine-Posterior Technique (C1-2 Fixation)
N2469	Arthrodesis of Spine-Cervical Spine-Posterior Technique (Others)
N2471	Removal of Implant For Internal Fixation of Spine (Anterior)
N2472	Removal of Implant For Internal Fixation of Spine (Posterior)
N2491	Cervical Spine Laminoplasty
N2492	Cervical Spine Laminoplasty
N2497	Laminectomy, Cervical Spine
N2498	Laminectomy, Thoracic Spine
N2499	Laminectomy, Lumbar Spine
S4671	Operation of Spinal Arteriovenous Malformation
S4685	Operation of CNS Anomaly-Tethered Spinal Cord

Table S1 cont. *Spine surgery codes used in this study.*

Op code	Op name
S4694	Excision of Intramedullary Tumor Or Lesion-Cervical Spine
S4695	Excision of Intramedullary Tumor Or Lesion-Thoracic Spine
S4696	Excision of Intramedullary Tumor Or Lesion-Lumbar Spine
S4704	Excision of Extradural Tumor Or Lesion-Cervical Spine-Involving Pedicle And/Or Vertebral Body
S4705	Excision of Extradural Tumor Or Lesion-Cervical Spine-Without Pedicle And Vertebral Body
S4706	Excision of Extradural Tumor Or Lesion-Thoracic Spine-Involving Pedicle And/Or Vertebral Body
S4707	Excision of Extradural Tumor Or Lesion-Thoracic Spine-Without Pedicle And Vertebral Body
S4708	Excision of Extradural Tumor Or Lesion-Lumbar Spine-Involving Pedicle And/Or Vertebral Body
S4709	Excision of Extradural Tumor Or Lesion-Lumbar Spine-Without Pedicle And Vertebral Body
S6691	Excision of Intradural Tumor Or Lesion-Cervical Spine
S6692	Excision of Intradural Tumor Or Lesion-Cervical Spine
S6693	Excision of Intradural Tumor Or Lesion-Thoracic Spine
S6694	Excision of Intradural Tumor Or Lesion-Thoracic Spine

Table S2. ***The ICD-10 codes used by comorbidity to compute the Charlson Comorbidity Index.***

o	Myocardial infarction: I21.x, I22.x, I25.2
o	Congestive heart failure: I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5 - I42.9, I43.x, I50.x, P29.0
o	Peripheral vascular disease: I70.x, I71.x, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
o	Cerebrovascular disease: G45.x, G46.x, H34.0, I60.x - I69.x
o	Dementia: F00.x - F03.x, F05.1, G30.x, G31.1
o	Chronic pulmonary disease: I27.8, I27.9, J40.x - J47.x, J60.x - J67.x, J68.4, J70.1, J70.3
o	Rheumatic disease: M05.x, M06.x, M31.5, M32.x - M34.x, M35.1, M35.3, M36.0
o	Peptic ulcer disease: K25.x - K28.x
o	Mild liver disease: B18.x, K70.0 - K70.3, K70.9, K71.3 - K71.5, K71.7, K73.x, K74.x, K76.0, K76.2 - K76.4, K76.8, K76.9, Z94.4
o	Diabetes without chronic complication: E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9
o	Diabetes with chronic complication: E10.2 - E10.5, E10.7, E11.2 - E11.5, E11.7, E12.2 - E12.5, E12.7, E13.2 - E13.5, E13.7, E14.2 - E14.5, E14.7
o	Hemiplegia or paraplegia: G04.1, G11.4, G80.1, G80.2, G81.x, G82.x, G83.0 - G83.4, G83.9
o	Renal disease: I12.0, I13.1, N03.2 - N03.7, N05.2 - N05.7, N18.x, N19.x, N25.0, Z49.0 - Z49.2, Z94.0, Z99.2
o	Any malignancy, including lymphoma and leukaemia, except malignant neoplasm of skin: C00.x - C26.x, C30.x - C34.x, C37.x - C41.x, C43.x, C45.x - C58.x, C60.x - C76.x, C81.x - C85.x, C88.x, C90.x - C97.x
o	Moderate or severe liver disease: I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5, K76.6, K76.7
o	Metastatic solid tumour: C77.x - C80.x
o	AIDS/HIV: B20.x - B22.x, B24.x

Table S3. *Classification of disabilities in the Republic of Korea.*

Type of disability	Subcategory
Physical disability	Amputation disorder, joint disorder, physical dysfunction, and deformity
Brain lesion disability	Complex disorders due to brain damage
Visual disturbance	Blindness, visual impairment
Hearing disability	Hearing impairment, equilibrium dysfunction
Speech disability	Language disorder, voice disorder, speech disorder
Intellectual disorder	IQ is below 70
Autism	Autistic disorders such as childhood autism
Mental disorder	Schizophrenia, schizoaffective disorder, bipolar affective disorder, recurrent depressive disorder
Renal disorder	Treated by dialysis or have had a kidney transplant
Heart disorder	Cardiac dysfunction that significantly restricts daily life
Respiratory disability	Chronic, severe respiratory dysfunction that significantly restricts daily life
Hepatopathy	Chronic, severe liver function abnormalities that significantly restrict daily life
Facial disfigurement	Disorders caused by deformities such as abstraction, depression, and thickening of the facial area
Intestinal and urinary fistulae	Stoma and urostomy that significantly restrict daily life
Epilepsy	Chronic, severe epilepsy that significantly restricts daily life

Table S4. *Multivariate logistic regression model for PSPS II within a year post spinal surgery after excluding patients who died within a year post spinal surgery.*

Variable		OR (95% CI)	P < 0.001
Age, years		1.02 (1.02-1.02)	< 0.001
Gender, men		0.91 (0.90-0.92)	< 0.001
Having a job		0.97 (0.96-0.99)	< 0.001
Residence at surgery			
	Urban area	1	
	Rural area	1.00 (0.99-1.02)	0.641
Household income level			
	Q1 (lowest)	1	
	Q2	1.01 (0.99-1.03)	0.319
	Q3	1.00 (0.98-1.02)	0.874
	Q4 (highest)	0.92 (0.91-0.94)	< 0.001
	Medical aid program group	1.27 (1.23-1.31)	< 0.001
	Unknown	1.01 (0.96-1.07)	0.669
CCI*		1.01 (1.01-1.02)	< 0.001
	Myocardial infarction	0.93 (0.89-0.98)	0.010
	Congestive heart failure	0.97 (0.93-1.01)	0.120
	Peripheral vascular disease	1.01 (0.95-1.09)	0.711
	Cerebrovascular disease	1.03 (0.99-1.07)	0.098
	Dementia	0.84 (0.79-0.89)	< 0.001
	Chronic pulmonary disease	1.07 (1.05-1.09)	< 0.001
	Rheumatic disease	1.16 (1.12-1.20)	< 0.001
	Peptic ulcer disease	1.00 (0.98-1.02)	0.929
	Mild liver disease	0.98 (0.96-0.99)	0.002
	DM without chronic complication	0.99 (0.97-1.00)	0.078

Table S4 cont. ***Multivariate logistic regression model for PSPS II within a year post spinal surgery after excluding patients who died within a year post spinal surgery.***

Variable		OR (95% CI)	*P* < 0.001
	DM with chronic complication	1.22 (1.18-1.27)	< 0.001
	Hemiplegia or paraplegia	1.12 (1.08-1.16)	< 0.001
	Renal disease	0.82 (0.77-0.87)	< 0.001
	Cancer	0.96 (0.90-1.01)	0.115
	Moderate and severe liver disease	0.80 (0.65-0.98)	0.028
	Metastatic cancer	0.49 (0.42-0.56)	< 0.001
	AIDS/HIV	1.15 (0.86-1.55)	0.349
Underlying disability			
	Mild to moderate disability	1.18 (1.15-1.20)	< 0.001
	Severe disability	1.06 (1.02-1.10)	0.002
IOM		1.26 (1.21-1.31)	< 0.001
Propofol-based TIVA		0.93 (0.92-0.95)	< 0.001
Type of spine surgery			
	Arthrodesis	1	
	Corpectomy	1.16 (0.96-1.41)	0.127
	Spine fracture	0.23 (0.19-0.28)	< 0.001
	Discectomy	1.12 (1.08-1.14)	< 0.001
	Spine tumor	0.63 (0.59-0.68)	< 0.001
	Laminectomy	1.21 (1.18-1.25)	< 0.001
	Other spine surgery	1.32 (1.26-1.38)	< 0.001
Type of surgical spine level			
	Cervical	1	
	Thoracic	0.98 (0.93-1.02)	0.256
	Lumbar	1.12 (1.09-1.15)	< 0.001
	Not specified	0.29 (0.27-0.32)	< 0.001
Year of surgery			
	2016	1	
	2017	1.01 (0.99-1.03)	0.234
	2018	1.06 (1.04-1.08)	< 0.001
	2019	1.07 (1.05-1.09)	< 0.001
	2020	1.14 (1.11-1.16)	< 0.001

PSPS II, Persistent Spinal Pain Syndrome Type II; OR, odds ratio; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia

Table S5. *Multivariate logistic regression model for PSPS II within two years post spinal surgery after excluding patients who died within two years post spinal surgery.*

Variable		OR (95% CI)	*P* < 0.001
Age, years		1.02 (1.02-1.02)	< 0.001
Gender, men		0.89 (0.88-0.91)	< 0.001
Having a job		0.97 (0.96-1.06)	0.840
Residence at surgery			
	Urban area	1	
	Rural area	1.00 (0.99-1.01)	0.923
Household income level			
	Q1 (lowest)	1	
	Q2	1.01 (0.98-1.03)	0.599
	Q3	0.98 (0.96-1.00)	0.085
	Q4 (highest)	0.92 (0.90-0.93)	< 0.001
	Medical aid program group	1.29 (1.25-1.34)	< 0.001
	Unknown	1.01 (0.95-1.06)	0.840
CCI*		1.01 (1.01-1.02)	< 0.001
	Myocardial infarction	0.93 (0.88-0.98)	0.006
	Congestive heart failure	0.99 (0.94-1.03)	0.535
	Peripheral vascular disease	1.00 (0.93-1.08)	0.933
	Cerebrovascular disease	1.04 (1.00-1.09)	0.035
	Dementia	0.87 (0.82-0.93)	< 0.001
	Chronic pulmonary disease	1.07 (1.05-1.09)	< 0.001
	Rheumatic disease	1.21 (1.17-1.26)	< 0.001
	Peptic ulcer disease	1.00 (0.98-1.02)	0.968
	Mild liver disease	0.98 (0.97-0.99)	0.025
	DM without chronic complication	0.99 (0.98-1.01)	0.261
	DM with chronic complication	1.23 (1.18-1.29)	< 0.001
	Hemiplegia or paraplegia	1.10 (1.06-1.14)	< 0.001
	Renal disease	0.85 (0.79-0.90)	< 0.001
	Cancer	0.97 (0.91-1.03)	0.315
	Moderate and severe liver disease	0.81 (0.66-1.00)	0.050
	Metastatic cancer	0.57 (0.49-0.67)	< 0.001
	AIDS/HIV	1.14 (0.84-1.56)	0.401
Underlying disability			
	Mild to moderate disability	1.22 (1.20-1.25)	< 0.001
	Severe disability	1.10 (1.05-1.14)	< 0.001
IOM		1.24 (1.19-1.29)	< 0.001
Propofol-based TIVA		0.91 (0.90-0.93)	< 0.001
Type of spine surgery			
	Arthrodesis	1	
	Corpectomy	1.24 (1.00-1.53)	0.046
	Spine fracture	0.25 (0.21-0.30)	< 0.001
	Discectomy	1.12 (1.08-1.15)	< 0.001
	Spine tumor	0.64 (0.59-0.69)	< 0.001

Table S5 cont. ***Multivariate logistic regression model for PSPS II within two years post spinal surgery after excluding patients who died within two years post spinal surgery.***

Variable		OR (95% CI)	*P* < 0.001
	Laminectomy	1.24 (1.20-1.27)	< 0.001
	Other spine surgery	1.30 (1.24-1.37)	< 0.001
Type of surgical spine level			
	Cervical	1	
	Thoracic	0.98 (0.94-1.03)	0.381
	Lumbar	1.13 (1.10-1.16)	< 0.001
	Not specified	0.31 (0.29-0.34)	< 0.001
Year of surgery			
	2016	1	
	2017	1.10 (0.99-1.03)	0.375
	2018	1.03 (1.01-1.05)	0.007
	2019	1.05 (1.03-1.07)	< 0.001

PSPS II, Persistent Spinal Pain Syndrome Type II; OR, odds ratio; CCI, Charlson Comorbidity Index; DM, diabetes mellitus; IOM, intraoperative neurophysiological monitoring; TIVA, total intravenous anesthesia