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ORIGINAL RESEARCH

Impact of Postoperative Chronic Back Pain Syndrome on the Incidence of Psychiatric and Brain Disorders, and All-Cause Mortality

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Purpose: Postoperative chronic back pain syndrome (PCBPS) is characterized by persistent or recurrent symptoms following lumbar spine surgery. This study aimed to investigate its long-term associations with psychiatric and brain disorders, and mortality outcomes.

Patients and Methods: This retrospective cohort study utilized the Korean National Health Insurance Service database. Patients who underwent lumbar spinal surgery between 2009 and 2023 were included (n= 603,272). PCBPS was operationally defined using three criteria: diagnosis code for post-laminectomy syndrome (PCBPS-D group), prolonged gabapentinoid prescription (≥12 weeks) (PCBPS-G group), and reoperation (PCBPS-R group). Psychiatric disorders (anxiety, depression, and insomnia), brain disorders (stroke, Parkinson's disease, and dementia), and all-cause mortality were assessed as outcomes.

Results: Among the cohort, 169,796 patients (28.1%) met at least one PCBPS definition. PCBPS was significantly associated with psychiatric disorders (aHR 1.15; 95% CI, 1.13–1.17), including anxiety (aHR 1.15; 95% CI, 1.11–1.19), depression (aHR 1.20; 95% CI, 1.15–1.24), and insomnia (aHR 1.14; 95% CI, 1.11–1.18). PCBPS was also linked to increased risk of brain disorders (aHR 1.09; 95% CI, 1.07–1.11), including stroke (aHR 1.15; 95% CI, 1.12–1.19), Parkinson's disease (aHR 1.40; 95% CI, 1.27–1.55), and dementia (aHR 1.07; 95% CI, 1.05–1.09). Moreover, PCBPS was associated with higher all-cause mortality (aHR 1.10; 95% CI, 1.07–1.12). These associations remained robust across PCBPS sub-definitions and stratified analyses.

Conclusion: PCBPS is associated with increased risks of psychiatric disorders, brain diseases, and mortality. These findings emphasize the need for early identification and integrative management in patients with chronic postsurgical pain.

Keywords: mental disorders, mortality, neurodegenerative diseases, low back pain, postoperative complications, stroke

Introduction

Chronic pain has been associated with maladaptive behaviors, physical inactivity, and poor health status, which are well-known risk factors for adverse mental and cerebrovascular health outcomes.[1,2] In particular, chronic low back pain is one of the most common causes of disability worldwide and is often refractory to treatment, even after surgical intervention.[3,4] Postoperative chronic back pain syndrome (PCBPS), also known as failed back surgery syndrome, refers to the continuation or recurrence of symptoms following lumbar spine surgery, including chronic back pain, leg pain, or numbness; this condition affects 10–40% of patients undergoing spinal procedures,[5] and has a substantial impact, encompassing not only physical suffering but also emotional distress, reduced quality of life, and socioeconomic burden.[6,7] Despite growing awareness of these associations, existing literature has primarily focused on the clinical

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efficacy of spinal surgery or short-term pain management. There is a critical lack of large-scale, longitudinal studies that comprehensively investigate the long-term systemic consequences of PCBPS, particularly its association with psychiatric and brain disorders, as well as overall survival rates. Therefore, addressing this gap by leveraging a longitudinal nationwide database to provide a multi-faceted analysis of these long-term impacts is needed.

We also consider the specific situation of South Korea in this study's hypothesis. South Korea is one of the fastest aging countries, and the rate of general spinal surgeries is quite high; a report showed that 206,785 spinal surgeries were performed in 2023, second only to cataract surgeries.[8,9] The Korean National Health Insurance Service (NHIS) database offers a significant opportunity to address the prevailing knowledge gaps.[10] Large -scale epidemiological investigations of PCBPS-related outcomes such as psychiatric and brain disorders, and even mortality can be conducted because the NHIS database is able to provide comprehensive medical information regarding degenerative spinal surgeries and relevant outcome events longitudinally in a large scale.

In this context, we utilized the Korean NHIS database in this study to investigate whether 1) PCBPS increases the risk of psychiatric and brain disorders and 2) this would ultimately be associated with increased all-cause mortality.

Materials and Methods

Study Population

This retrospective cohort study analyzed data from the NHIS claims data spanning 2002 to 2023 in South Korea. In South Korea, the national health insurance system is operated by a single insurer, the NHIS. Since 1989, the NHIS has provided universal health coverage to the entire population. All citizens are required to pay a monthly insurance premium to the NHIS, which is determined based on their income level. When patients utilize medical services, healthcare costs are shared between the NHIS and the patient: the NHIS reimburses healthcare providers for the insured portion of the expenses, while beneficiaries pay the remaining out-of-pocket costs. After providing medical services, healthcare institutions claim reimbursement from the NHIS for the insured portion of the medical costs. Consequently, the NHIS maintains and manages comprehensive data on healthcare utilization and medical services for the entire Korean population, thereby constituting a nationally representative database.

The initial cohort included 2,346,164 individuals. A wash-out period was applied from 2002 through 2008 to exclude prior cases. Subsequently, patients who underwent lumbar spinal surgery between 2009 and 2023 were identified and enrolled. Index lumbar surgeries for the cohort definition are shown in Supplementary Table 1. The detailed exclusion criteria and the number of exclusions at each stage are summarized in Figure 1. Ultimately, 603,272 patients were included in the final analysis.

As this study utilized anonymized secondary data, the Institutional Review Board of the National Health Insurance Service Ilsan Hospital (NHIMC 2024–08-002-001) waived the requirement for ethical approval. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki.

Definition

PCBPS was operationally defined using three criteria: 1) Patients with a diagnosis code for post-lumbar surgery syndrome (International Classification of Diseases [ICD]-10 code M96.1) recorded after their initial lumbar spine surgery (Diagnosis-based, PCBPS-D group); 2) Patients prescribed gabapentinoids for a continuous duration of 12 weeks or longer following surgery (Gabapentinoid usage, PCBPS-G group); and 3) Patients who underwent at least one additional lumbar spine surgery procedure after the index surgery (reoperation-based, PCBPS-R group). We defined each PCBPS group in detail and defined the cases that correspond to at least one of the three as the entire PCBPS group (PCBPS-E group). In order to avoid overlapping classifications among sub-definitions during the follow-up period, surgical claim codes were initially used to define the PCBPS-R group, followed sequentially by the identification of diagnostic codes and relevant drug prescriptions. Finally, the use of ≥12 weeks of gabapentinoid prescriptions as a proxy for chronic postsurgical pain is grounded in previous studies.[8,11]

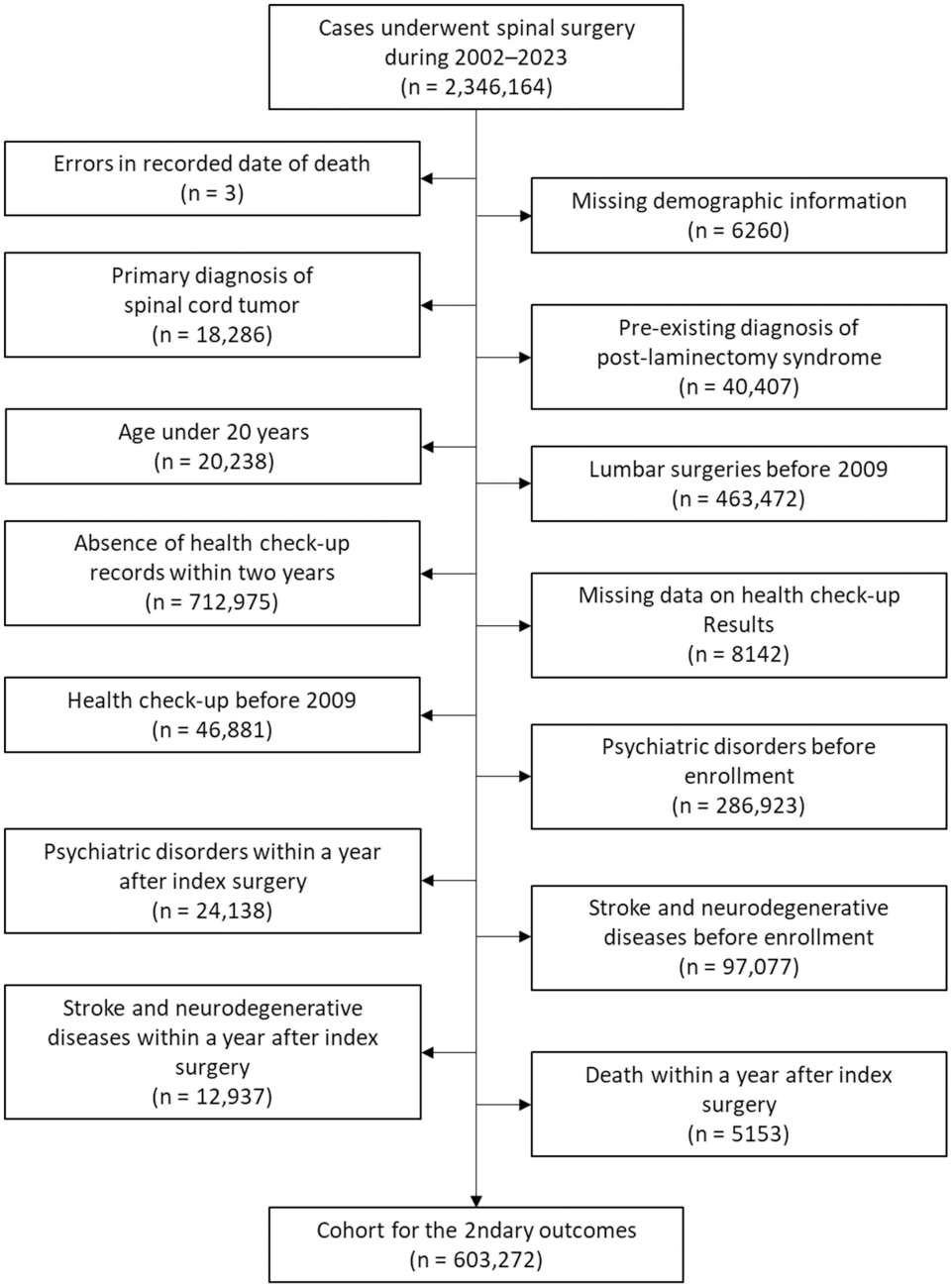

Figure 1 Flowchart of this study.

Outcomes

We defined outcomes of interest according to the relevant ICD-10 codes. Psychiatric disorders and brain disorders are the primary outcomes of this study. Psychiatric disorders were defined based on the presence of the following diagnostic codes: anxiety (F41), depression (F32.9), and insomnia (F51.0, G47.0). Brain disorders were identified using the following operational definitions: Parkinson's disease (PD) was defined by a primary diagnosis code of G20 and concurrent prescription of anti-parkinsonian medications. Stroke was defined as hospitalization following a diagnosis of ischemic or hemorrhagic stroke (ICD-10 codes I60–I64) confirmed by brain CT or MRI. Dementia was defined by the presence of relevant diagnostic codes (F00, F01, F02, G30, F067, G3100, and G3182) in combination with a prescription for donepezil or memantine. Additionally, we identified all-cause mortality as a secondary outcome.

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Covariates

Age and sex were extracted as demographic variables, and income level was defined using five quartiles of national health insurance premiums. In addition, insurance eligibility was categorized into three groups: medical aid, self-employed, and employee. Seoul, Gyeonggi province (surrounding Seoul), metropolitan cities, and other regions were identified to be the residential areas.

Lifestyle and behavioral factors, such as alcohol consumption, smoking status, physical activity level (metabolic equivalents task [MET]), and body mass index, were acquired from health checkup cohort data. Furthermore, the presence of the following comorbidities was evaluated for each participant: hypertension (ICD-10 codes: I10–I15), diabetes mellitus (ICD-10 codes: E10–E14), chronic kidney disease (ICD-10 codes: N18 or dialysis claim codes: O2013 and O2016), and peripheral polyneuropathy (ICD-10 codes: G61–63). Osteoporosis was identified based on prescription records of relevant medications, such as bisphosphonates, selective estrogen receptor modulators, and denosumab.

The principal diagnoses were categorized as disc herniation, spinal canal stenosis, spondylolisthesis, low back pain, compression fracture, spondylosis, infection, scoliosis, other fractures, multiple fractures, and others according to the ICD-10 principal diagnosis codes (Supplementary Table 1). Preoperative electrodiagnosis was based on relevant claim codes (F6123, F6124, E6501, E6502, E6503, E6507, E6508, E6509, F6111, F6112, F6113, F6114, F6116, FA111, FA112, FA116, and FY681).

Statistical Analysis

This study conducted analyses in five steps. First, we performed chi-squared tests to evaluate the relationships between outcome measures and covariates. Statistical significance was assessed at a two-sided p-value threshold of <0.05. Second, we analyzed the differences in survival time and incidence rates according to covariates. Differences in survival time were assessed using t-tests and analysis of variance, with statistical significance was assessed at a two-sided p-value threshold of <0.05. The incidence rate was calculated as the number of outcome measurement's event cases per 100,000 person-days. Third, to explore the association between PCBPS and outcome measures, survival analyses were performed. The proportional hazards assumption was assessed using Kaplan–Meier survival curves, and differences in survival rates were examined using the Log rank test (p <0.05). Cox proportional hazards regression models were employed to estimate the association, and the results were expressed as adjusted hazard ratios (aHRs) with 95% confidence intervals (CIs). Fourth, to enhance the robustness of the findings, sensitivity analyses were conducted. These included subtype analyses of PCBPS and subgroup analyses according to health behaviors. All regression models were adjusted for the covariates included in the study. Statistical significance was defined as a two-sided p-value <0.05. All statistical analyses were performed using SAS software version 9.4 (SAS Institute, Cary, NC, USA) and R software version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Baseline Characteristics

A total of 603,272 patients who underwent lumbar spinal surgery between 2009 and 2023 were included in the final analysis. Among them, 169,796 (28.1%) met at least one of the criteria for PCBPS. The distribution of PCBPS groups is presented in Table 1, and the entire participants' characteristics are provided in Supplementary Table 2. Compared to the non-PCBPS group, those with PCBPS were more likely to be female, older, have lower physical activity levels, and present with higher prevalence of comorbidities such as hypertension, diabetes, and peripheral polyneuropathy.

PCBPS and Psychiatric Disorders

Patients with PCBPS had a significantly increased risk of developing psychiatric disorders (Log-rank p <0.001) (Supplementary Figure 1A and Supplementary Table 3). In the entire PCBPS group (PCBPS-E), the aHR for psychiatric disorders was 1.15 (95% CI, 1.13–1.17; p <0.001), compared to the non-PCBPS group. For each sub-outcome, anxiety (aHR 1.15; 95% CI, 1.11–1.19; p <0.001), depression (aHR 1.20; 95% CI, 1.15–1.24; p <0.001), and insomnia (aHR 1.14; 95% CI, 1.11–1.18; p <0.001) were all significantly associated with PCBPS. Sub-defined PCPBS groups

Table 1 Distribution of PCBPS According to Each Outcome

Variables	Total	Psychiatric Disorders				Brain Disorders				All-Cause Mortality
		Total	Subtypes			Total	Subtypes			
		Yes	Anxiety	Depression	Insomnia	Yes	PD	Stroke	Dementia	Died
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Total	603,272	69,558 (11.5)	22,751 (3.8)	17,484 (2.9)	29,323 (4.9)	76,409 (12.7)	2091 (0.3)	22,620 (3.7)	51,698 (8.6)	44,865 (7.4)
PCBPS										
No	433,476	44,173 (10.2)	14,328 (3.3)	10,972 (2.5)	18,873 (4.4)	40,546 (9.4)	1,111 (0.3)	13,519 (3.1)	25,916 (6.0)	23,730 (5.5)
Yes	169,796	25,385 (15.0)	8423 (5.0)	6512 (3.8)	10,450 (6.2)	35,863 (21.1)	980 (0.6)	9101 (5.4)	25,782 (15.2)	21,135 (12.4)
PCBPS sub-definitions										
No	433,476	44,173 (10.2)	14,328 (3.3)	10,972 (2.5)	18,873 (4.4)	40,546 (9.4)	1111 (0.3)	13,519 (3.1)	25,916 (6.0)	23,730 (5.5)
PCBPS-D	22,004	3,445 (15.7)	1091 (5.0)	897 (4.1)	1457 (6.6)	3109 (14.1)	95 (0.4)	999 (4.5)	2015 (9.2)	1678 (7.6)
PCBPS-G	121,674	18,542 (15.2)	6318 (5.2)	4748 (3.9)	7476 (6.1)	28,433 (23.4)	765 (0.6)	6909 (5.7)	20,759 (17.1)	16,097 (13.2)
PCBPS-R	26,118	3398 (13.0)	1014 (3.9)	867 (3.3)	1517 (5.8)	4321 (16.5)	120 (0.5)	1193 (4.6)	3008 (11.5)	3360 (12.9)

Abbreviation: PCBPS, postoperative chronic back pain syndrome.

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consistently demonstrated elevated risks of psychiatric disorders: the aHRs were 1.29 (95% CI, 1.25–1.34; p <0.001) in the PCBPS-D group, 1.08 (95% CI, 1.06–1.11; p <0.001) in the PCBPS-G group, and 1.25 (95% CI, 1.20–1.29; p <0.001) in the PCBPS-R group. These findings were statistically significant and consistent across all PCBPS definitions (Figure 2, Supplementary Tables 4 and 5).

PCBPS and Brain Disorders

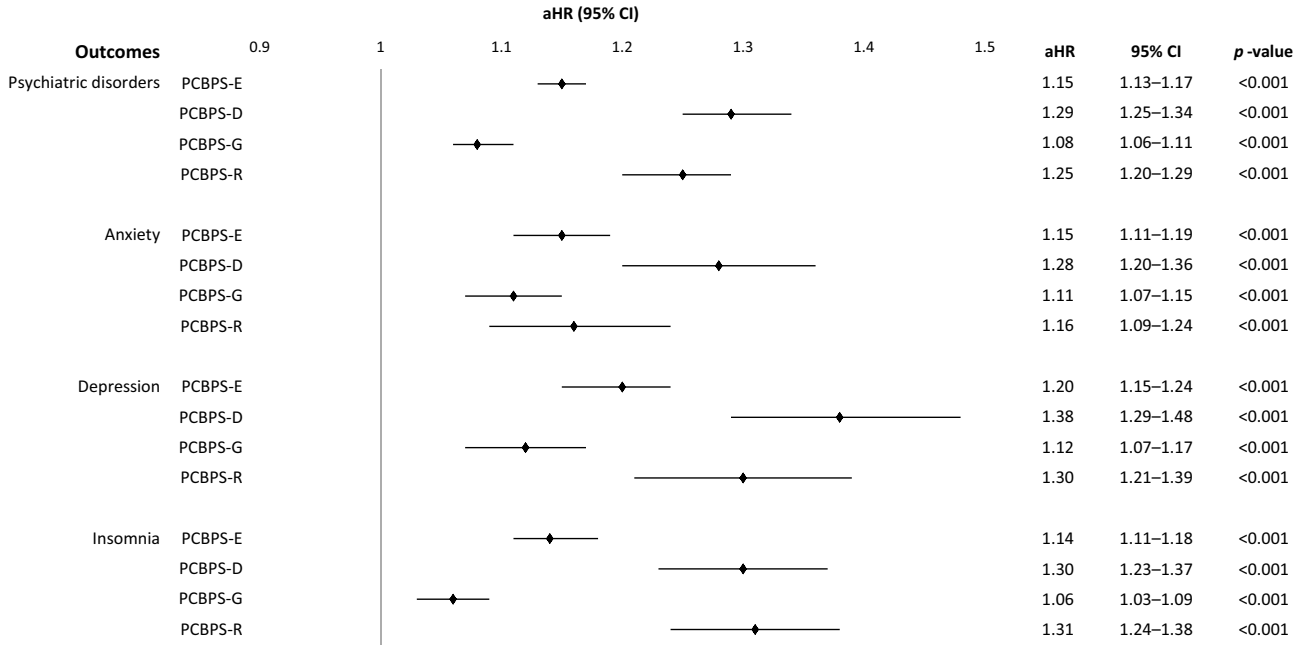
Patients with PCBPS had a significantly increased risk of developing brain disorders (Log-rank p <0.001) (Supplementary Figure 1B and Supplementary Table 3). In the PCBPS-E group, the aHR for entire brain disorders was 1.09 (95% CI, 1.07–1.11; p <0.001), compared to the non-PCBPS group. For each sub-outcome, stroke (aHR 1.15; 95% CI, 1.12–1.19; p <0.001), PD (aHR 1.40; 95% CI, 1.27–1.55; p <0.001), and dementia (aHR 1.07; 95% CI, 1.05–1.09; p <0.001) were all significantly associated with PCBPS. Sub-defined PCPBS groups consistently demonstrated elevated risks of brain disorders: the aHRs were 1.15 (95% CI, 1.11–1.20; p <0.001) in the PCBPS-D group, 1.05 (95% CI, 1.03–1.07; p <0.001) in the PCBPS-G group, and 1.25 (95% CI, 1.21–1.29; p <0.001) in the PCBPS-R group. These associations remained statistically significant and robust across all PCBPS definitions except between the PCBPS-G group and dementia (Figure 3,Supplementary Tables 4 and 5).

PCBPS and All-Cause Mortality

Patients with PCBPS had a significantly increased risk of all-cause mortality (Log-rank p <0.001) (Supplementary Figure 1C and Supplementary Table 3). In the PCBPS-E group, the aHR for mortality was 1.10 (95% CI, 1.07–1.12; p <0.001), compared to the non-PCBPS group. Sub-defined PCPBS groups consistently demonstrated elevated risks of mortality: the aHRs were 1.11 (95% CI, 1.06–1.17; p <0.001) in the PCBPS-D group, 1.03 (95% CI, 1.00–1.05; p = 0.029) in the PCBPS-G group, and 1.42 (95% CI, 1.37–1.47; p <0.001) in the PCBPS-R group (Figure 4, Supplementary Tables 4 and 5).

Stratified Cox-Proportional Hazard Models

Supplementary Table 6 presents the results of stratified Cox regression analyses. The increased risks of psychiatric disorders, brain disorders, and all-cause mortality associated with PCBPS remained consistent across all subgroups—



Outcomes		aHR	95% CI	p -value
Psychiatric disorders	PCBPS-E	1.15	1.13–1.17	<0.001
	PCBPS-D	1.29	1.25–1.34	<0.001
	PCBPS-G	1.08	1.06–1.11	<0.001
	PCBPS-R	1.25	1.20–1.29	<0.001
Anxiety	PCBPS-E	1.15	1.11–1.19	<0.001
	PCBPS-D	1.28	1.20–1.36	<0.001
	PCBPS-G	1.11	1.07–1.15	<0.001
	PCBPS-R	1.16	1.09–1.24	<0.001
Depression	PCBPS-E	1.20	1.15–1.24	<0.001
	PCBPS-D	1.38	1.29–1.48	<0.001
	PCBPS-G	1.12	1.07–1.17	<0.001
	PCBPS-R	1.30	1.21–1.39	<0.001
Insomnia	PCBPS-E	1.14	1.11–1.18	<0.001
	PCBPS-D	1.30	1.23–1.37	<0.001
	PCBPS-G	1.06	1.03–1.09	<0.001
	PCBPS-R	1.31	1.24–1.38	<0.001

Figure 2 Forest plot depicting the adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) for the association between postoperative chronic back pain syndrome (PCBPS) and various psychiatric disorder outcomes. Different operational definitions of PCBPS are shown for each psychiatric disorder outcome category. Multiple definitions of PCBPS are consistently associated with psychiatric disorders.

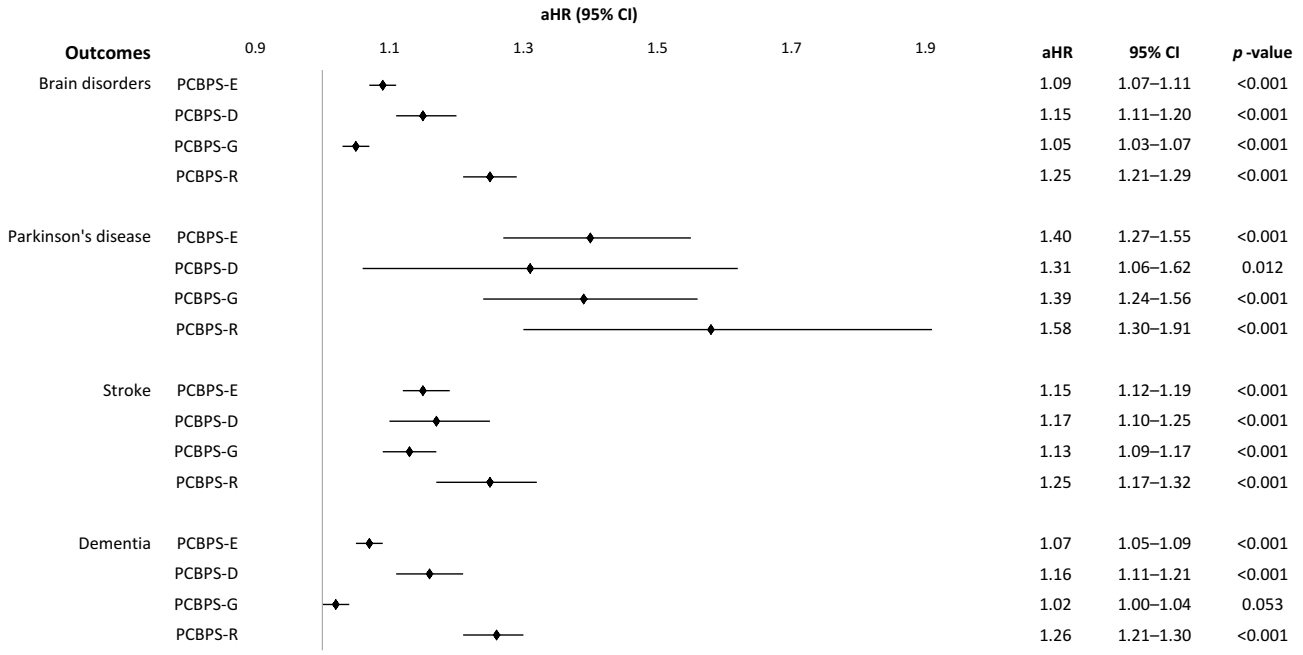


Figure 3 Forest plot depicting the adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) for the association between postoperative chronic back pain syndrome (PCBPS) and various brain disorders outcomes. Different operational definitions of PCBPS are shown for each brain disorder outcome category. Multiple definitions of PCBPS are consistently associated with brain disorders.

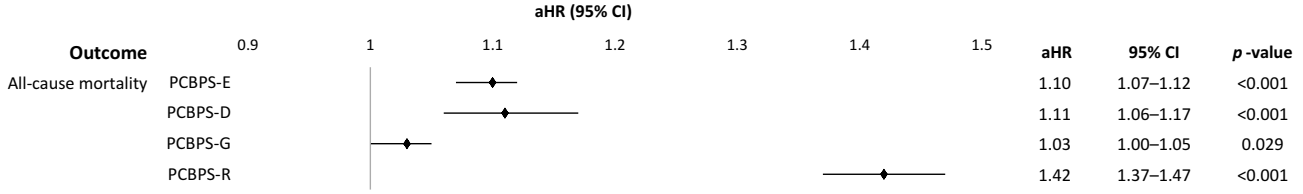


Figure 4 Forest plot depicting the adjusted hazard ratios (aHRs) and 95% confidence intervals (CIs) for the association between postoperative chronic back pain syndrome (PCBPS) and all-cause mortality. PCBPS is significantly associated with all-cause mortality.

including smoking status, alcohol use, physical activity, and BMI—and across all PCBPS sub-definitions. Notably, the hazard ratios for psychiatric and brain disorders tended to be more pronounced in subgroups with current smoking, low physical activity (<500 METs), and BMI ≥30; however, this trend was not observed in all-cause mortality.

Discussion

This study demonstrated that PCBPS increased the risk of several subsequent primary outcomes, such as psychiatric and brain disorders, and even all-cause mortality. We applied several sub-definitions of PCBPS to refine the diagnostic ambiguity of PCBPS and validated statistical significance across a variety of cases. We observed consistent results across most sub-definition groups. Furthermore, we further demonstrated the robustness of our results through stratified analysis. This study has the advantage of being validated with a large sample size using NHIS data. Further, we were able to identify various variables and outcomes robustly and longitudinally, without losing data due to the nature of health insurance claim data, which enables us to get a multi-faceted insight regarding PCBPS's long-term impact on such outcomes.

Several mechanisms contributing PCBPS-related psychiatric disorders can be explained as follows. Persistent nociceptive signaling after surgery can lead to central sensitization, resulting in hyperresponsiveness of the central nervous system to pain stimuli;[12,13] this heightened sensitivity is closely associated with increased risks of depression, anxiety, and sleep disturbances. Chronic pain is also known to induce structural and functional alterations in key brain regions involved in pain modulation and emotional regulation, including the prefrontal cortex, limbic system, and

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thalamus;[14,15] these changes may manifest as emotional instability, and reorganization of brain networks, contributing to neuropsychiatric vulnerability.[16] Furthermore, chronic pain and mental health disorders share overlapping neurobiological mechanisms, including neuroinflammation, microglial activation, and dysregulation of neurotransmitter systems.[13] These shared pathways may underlie the observed comorbidity of chronic pain with depression and anxiety.[17] Taken together, these findings highlight the need for comprehensive mental health evaluation and interdisciplinary treatment approaches in patients with PCBPS.

We also demonstrated PCBPS was associated with an increased risk of developing various brain disorders, including stroke, PD, and dementia. In the context of stroke, prior large-scale cohort studies have demonstrated that individuals with chronic low back pain are at significantly elevated risk for both ischemic and hemorrhagic stroke;[18] this may be attributable to multiple factors commonly observed in chronic pain populations, such as reduced physical activity, chronic low-grade inflammation, coexisting depression, and a higher burden of cardiometabolic comorbidities—all of which are known to exacerbate cerebrovascular risk.[19] The presence of chronic pain may also contribute to hemodynamic instability and autonomic dysregulation, further increasing susceptibility to stroke.[20] The association between PCBPS and PD is also noteworthy. Chronic back pain is frequently observed in individuals with PD,[21] and recent Mendelian randomization analyses suggest that chronic low back pain may have a causal role in increasing PD risk.[22] Proposed mechanisms include sustained neuroinflammation, dysregulation of neurotransmitter systems (particularly dopaminergic pathways), and shared genetic architecture, and PCBPS may also serve as a clinical marker for early or prodromal neurodegeneration.[13,23,24] In relation to dementia, chronic postsurgical pain has been identified as an independent risk factor for cognitive decline and incident dementia, with studies showing approximately a 30% increased risk.[25] Chronic pain has been associated with microglial activation, neuroinflammatory processes, and cerebral atrophic changes in key regions involved in memory and cognition.[26,27] Longitudinal studies have reported accelerated memory decline and increased incidence of dementia in patients with chronic pain.[28] Taken together, these findings highlight the need for early evaluation of brain disorders in individuals with PCBPS.

Previous studies have reported that individuals with chronic disabling back pain exhibit significantly elevated mortality risk, and several factors may mediate this association.[29,30] The pathophysiological and psychosocial mechanisms, which we mentioned, linking PCBPS to psychiatric and brain disorders, may also contribute to increased all-cause mortality in this population.[29] Our findings support the fact that PCBPS is not only a source of prolonged pain and disability but also a marker of broader systemic vulnerability, necessitating integrated management approaches to reduce long-term mortality risk.

Our results clinically demonstrated these mechanisms in a real-world nationwide database. More than that, these findings suggest that PCBPS is not merely a persistent pain condition, but a clinically significant predictor of long-term complications and mortality. The consistent associations observed between PCBPS and increased risks of psychiatric disorders, brain diseases (including stroke, Parkinson's disease, and dementia), and all-cause mortality emphasize the need for a paradigm shift in postoperative care in patients with degenerative lumbar diseases. Given the aging population and the growing burden of degenerative spinal disorders,[31] early identification of patients at risk for PCBPS and implementation of multidisciplinary management strategies—including pain control, mental health screening, cognitive monitoring, neurologic complications, and functional rehabilitation—are getting more critical. These integrative approaches may reduce not only symptom burden but also the long-term adverse outcomes associated with social healthcare burden.

This study has several limitations. First, as a retrospective observational study, causal inferences between PCBPS and subsequent outcomes cannot be definitively established. Second, although our analysis targeted a rapidly aging population, the data were derived exclusively from the Korean NHIS, and thus the generalizability of the findings to other populations may be limited without external validation. Third, due to the inherent limitations of claims data, certain operational definitions—particularly those used to identify PCBPS and clinical outcomes—may lack granularity and fail to fully capture clinical nuances; however, to address this limitation, we applied multiple sub-definitions of PCBPS to identify it more clearly. Lastly, we were unable to determine cause-specific mortality due to data constraints, which limits further interpretation of the observed associations with all-cause mortality.

Conclusion

In this large-scale nationwide cohort study, PCBPS was significantly associated with increased risks of psychiatric and brain disorders and all-cause mortality. A key strength of this study is the application of diverse operational definitions for the exposure and the consistent confirmation of its association with various outcomes, validating the robustness of the findings. This study highlights the importance of recognizing PCBPS as a condition that extends beyond persistent pain, representing a potential risk factor for long-term neurological and systemic deterioration. In real practice, patients undergoing lumbar spine surgery should be assessed early for PCBPS risk, and clinicians should adopt comprehensive strategies for it, including psychiatric, physical, cognitive, and neurologic assessment. Future prospective studies and external validations across diverse populations are warranted to confirm these associations.

Data Sharing Statement

The data are not publicly available due to privacy and ethical restrictions of the Korean National Health Insurance data sharing system. The dataset used in this study can only be accessed by an authorized researcher through its own internal-networking system (W.-R.L.).

Ethics Approval and Informed Consent

As only secondary data with anonymized and encrypted personal information were used in the study, Ethical approval was waived by the Institutional Review Board of the National Health Insurance Service Ilsan Hospital (NHIMC 2024-08-002-001). This study adhered to the ethical standards of the Declaration of Helsinki.

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Disclosure

We certify that this article has no actual or potential conflict of interest.

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