

Limited Utility of PHQ-2 Depression Screening for Early Postoperative Outcomes After Spine Tumor Surgery

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Abstract

Introduction

Depression has been associated with adverse postoperative outcomes across multiple surgical subspecialties, particularly in lumbar fusion populations. However, the prognostic value of depression screening tools in spine tumor surgery remains unclear.

Methods

We conducted a retrospective cohort study of 906 adult patients undergoing spine tumor resection with available preoperative Patient Health Questionnaire-2 (PHQ-2) data. Outcomes included hospital length of stay, discharge disposition, and 30- and 90-day emergency department (ED) visits and readmissions. Univariate analyses were conducted in the unmatched cohort, with PHQ-2 modeled both categorically (PHQ-2 = 0 vs. 3–6) and as a continuous variable. Coarsened exact matching was subsequently performed to control for demographic and clinical confounders, and outcome associations were reassessed in the matched cohort.

Results

In the unmatched cohort, a positive preoperative PHQ-2 screen was not associated with increased length of stay, non-home discharge, or 30- or 90-day ED visits or readmissions (all $p > 0.05$). Similarly, when PHQ-2 was analyzed as a continuous variable, no significant associations were identified. After coarsened exact matching, patients with a positive depression screen continued to demonstrate no significant associations with adverse early outcomes (all $p > 0.05$).

Conclusions

Preoperative depressive symptom burden, as assessed by PHQ-2, was not associated with short-term outcomes following spine tumor surgery. Unlike findings in elective degenerative spine populations, PHQ-2 screening did not predict early healthcare utilization or discharge outcomes in spine oncology populations. The low prevalence of positive screens suggests that PHQ-2 may under-detect depression in this population. These results suggest that the prognostic utility of depression screening may be context dependent and that PHQ-2 may not adequately capture depression symptoms in this patient population.

Introduction

Surgical management of spinal tumors remains one of the most complex and resource-intensive areas within spine surgery, often involving prolonged inpatient stay and coordinated care across multiple

specialties.¹⁻⁴ Despite advances in surgical technique and operative management, there continues to be a high prevalence of complications,¹ and clinicians lack scalable markers that reliably identify patients at risk for adverse outcomes.

In recent years, psychosocial factors, particularly depression, have gained increasing attention as contributors to postoperative outcomes across diverse surgical populations.⁵⁻¹⁰ Depressive symptoms have been associated with heightened pain perception,¹¹ impaired functional recovery,¹² and increased postoperative healthcare utilization.^{6,7} Within spine surgery, this relationship has been most extensively studied in patients undergoing elective procedures for degenerative disease, where depression and anxiety have been linked to longer hospital stays, higher rates of emergency department (ED) visits, and hospital readmissions.^{6,7,13} These findings have supported the incorporation of depression screening tools into preoperative evaluation pathways.

The Patient Health Questionnaire-2 (PHQ-2) is a widely used rapid screening tool for depression.¹⁴ Positive PHQ-2 screening has been shown to be associated with increased postoperative healthcare utilization⁶ and poor patient-reported outcomes¹⁵ in lumbar fusion patients. However, the relevance of depression screening in the spine oncology population remains unclear. To date, no studies have specifically evaluated whether preoperative PHQ-2 screening is associated with early postoperative outcomes following spine tumor surgery. Understanding whether depression screening is informative in spine oncology is critical for designing risk stratification approaches for oncologic populations.

In this study, we assessed the relationship between preoperative PHQ-2 scores and early postoperative outcomes in patients undergoing spine tumor resection. We evaluate relationships with hospital length of stay, discharge disposition, and 30- and 90-day ED visits using a rigorous coarsened exact matching (CEM) method. Through this analysis, we aim to clarify whether brief depression screening provides meaningful risk stratification utility in spine oncology patients.

Methods

Study Design and Patient Selection

We performed a retrospective cohort study of adult patients who underwent surgical resection of spinal tumors between 2013 and 2024 at a large, multihospital academic health system. An initial cohort of 1,841 patients was identified (Fig. 1).

Patients were eligible for inclusion if they had inpatient spine tumor resection under general anesthesia and had histopathologic confirmation of neoplastic involvement of the spine, including primary spinal tumors and metastatic disease. Though these tumor categories differ in underlying pathology and long-term survival, prior evidence indicates that short-term postoperative outcomes are primarily determined by patients' preoperative clinical condition and perioperative factors rather than by tumor origin.¹⁶⁻¹⁹ Thus, patients with primary and metastatic spinal tumors were evaluated together within a single

analytic cohort. To account for surgical complexity, operative duration (cut time), defined as the time in minutes from skin incision to wound closure, was included as a covariate for matching. In addition, as preoperative opioid use reflects baseline pain²⁰ and is associated with depressive symptoms,^{6,21–23} preoperative morphine equivalent dose (MED) was also incorporated in our analysis.

To assess the full spectrum of scores, PHQ-2 was modeled as a continuous variable in all patients with a recorded preoperative PHQ-2 and complete demographic and outcome data (n = 906). Patients were subsequently stratified into those who reported no depressive symptoms (PHQ-2 = 0) and those with a positive depression screen (PHQ-2 = 3–6).¹⁴ Patients with intermediate scores were excluded. After applying these criteria, 794 patients were included in the final study cohort.

Data Collection and Extraction

The PHQ-2 survey was prospectively administered at a preoperative outpatient visit. This brief two-item screening assesses depressive symptoms by asking about the frequency of depressed mood and anhedonia over the preceding 2 weeks.¹⁴ Response options are scored on a four-point scale ranging from 0 (“not at all”) to 3 (“nearly every day”). Scores from both items are summed to generate a total PHQ-2 score, with higher values indicating greater depressive symptom burden. Consistent with established screening thresholds, a total score of 3 or greater was used to define a positive screen for depression.¹⁴

Patient data were obtained from the electronic health record using EpiLog, an internally developed platform that captures perioperative information.²⁴ Variables collected for analysis included patient age, gender, race, body mass index (BMI), tobacco use history, prior operative history, American Society of Anesthesiologists (ASA) classification, Charlson Comorbidity Index (CCI), minutes cut time, and preoperative MED. Primary outcomes included postoperative length of hospital stay and discharge disposition, with secondary outcomes comprising emergency department (ED) encounters and hospital readmissions within 30 and 90 days following surgery. Postoperative events occurring at outside healthcare systems were identified through review of documented follow-up encounters and incorporated into the analytic dataset.

Statistical Analysis and Coarsened Exact Matching

Patients with no depressive symptoms (PHQ-2 score = 0; n = 753) were compared with those positive for depression (PHQ-2 score = 3–6; n = 41), consistent with established screening cutoffs.¹⁴ Baseline demographics were compared using Wilcoxon rank-sum tests for continuous variables and chi-square or Fisher’s exact tests for categorical variables, as appropriate. Unadjusted associations between PHQ-2 status and early postoperative outcomes were first evaluated in the unmatched cohort using univariate logistic regression models. PHQ-2 was additionally modeled as a continuous variable to assess for

dose-response relationships. This analysis included all patients with recorded PHQ-2 scores (n = 906), including those with intermediate scores of 1–2.

To account for confounding, coarsened exact matching (CEM) was performed to balance baseline characteristics known to influence surgical outcomes. Matching variables included age (grouped by decade),²⁵ gender (binary),²⁶ BMI (< 18.5, 18.5–29.9, and ≥ 30 kg/m²),²⁷ prior surgery (yes vs. no),^{28,29} ASA status (exact),³⁰ and operative duration (binary; below vs. above the cohort median of 155 minutes).^{31–33} Patients were matched 1:1 across these covariates, resulting in 37 matched pairs. Logistic regression analyses were subsequently repeated in the matched cohort.

Coarsened exact matching was performed using the MatchIt package in R (R Core Team, 2017). All remaining data processing and statistical analyses were conducted in SAS Version 9.4 (SAS Institute Inc., Cary, North Carolina). Associations for categorical postoperative outcomes are presented as odds ratios (OR) with corresponding 95% confidence intervals (CI), while results for continuous outcomes are reported as β coefficients with 95% CI. A p-value < 0.05 was considered statistically significant.

Results

Patient Demographics

Among the 794 patients included in the final analytic cohort, 753 (94.8%) patients had no evidence of depressive symptoms on preoperative screening, while 41 (5.2%) screened positive. Compared with patients with PHQ-2 scores of 0, those who had scores of 3–6 were more likely to report tobacco use (17.07% vs. 8.23%, p = 0.013) and had longer operative durations, as measured by cut time (233.85 minutes vs. 179.96 minutes, p = 0.0045) (Table 1). No significant differences were observed between groups with respect to age, sex, race, BMI, ASA classification, CCI, or prior surgical history. Preoperative MED was also similar between groups (2014.44 vs. 2859.09, p = 0.76), indicating comparable baseline opioid exposure. After matching, 37 pairs were retained for analysis. The matched cohort was well balanced across all matching variables, with no significant differences in age, gender, BMI, prior surgery, ASA status, or minutes cut time (all p-value > 0.05).

Table 1

Patient demographic and clinical characteristics stratified by preoperative PHQ-2 before and after CEM. Statistical comparisons between patients with positive (PHQ-2 = 3–6) and negative (PHQ-2 = 0) depression screens were performed using Wilcoxon rank-sum tests for continuous variables and chi-square or Fisher's exact tests for categorical variables. Significant p-values are bolded.

	Before CEM			After CEM		
	PHQ-2 Score	PHQ-2 Score	p-value	PHQ-2 Score	PHQ-2 Score	p-value
	0 (n = 753)	3–6 (n = 41)		0 (n = 37)	3–6 (n = 37)	
Age (mean, range)	57.84 (16–88)	57.1 (21–84)	0.310	56.1 (24–81)	55.5 (21–84)	0.690
Gender (n, %)	380 (50.46%)	19 (46.34%)	0.610	17 (45.95%)	17 (45.95%)	1.000
Male		22 (53.66%)				
Female	373 (49.54%)			20 (54.05%)	20 (54.05%)	
Race (n,%)	548 (72.78%)	30 (73.17%)	1.000	29 (78.38%)	26 (70.27%)	0.790
White		10 (24.39%)				
Not White	185 (24.57%)	1 (2.44%)		7 (18.92%)	10 (27.03%)	
Unknown	20 (2.66%)			1 (2.70%)	1 (2.70%)	
BMI (mean, range)	27.02 (12.37–57.47)	28.38 (16.01–55.79)	0.947	28.8 (18.2–49.6)	28.6 (16.0–55.8)	0.820
Tobacco Use (n, %)	62 (8.23%)	7 (17.07%)	0.013	2 (5.41%)	7 (18.92%)	0.150
ASA Grade (mean, range)	2.74 (2–4)	2.85 (2–4)	0.190	2.86 (2–4)	2.86 (2–4)	1.000
CCI Score (n, %)	297 (39.44%)	20 (48.78%)	0.490	17 (45.95%)	19 (51.35%)	0.260
0–4		4 (9.76%)				
5–6	90 (11.95%)	17 (41.46%)		8 (21.62%)	3 (8.11%)	
7–33	366 (48.61%)			12 (32.43%)	15 (40.54%)	
Prior Surgery (n, %)	334 (44.36%)	16 (39.02%)	0.500	16 (43.24)	16 (43.24)	1.000
Prior Surgery in past 30 days (n, %)	99 (13.15%)	3 (7.32%)	0.280	3 (8.11%)	3 (8.11%)	1.000
Minutes Cut Time (mean, range)	179.96 (6–897)	233.85 (61–737)	0.005	194.22 (30–429)	138.51 (61–737)	0.400

	Before CEM			After CEM		
	PHQ-2 Score	PHQ-2 Score	p-value	PHQ-2 Score	PHQ-2 Score	p-value
	0 (n = 753)	3–6 (n = 41)		0 (n = 37)	3–6 (n = 37)	
Preoperative Morphine Equivalent Dose (mean, range)	2014.44 (30-17100)	2859.09 (270-16488)	0.760	2004.30 (135–7440)	2947.00 (270-16488)	0.710

Association with Outcomes

In the unmatched cohort, univariate analysis comparing patients with PHQ-2 scores of 0 and 3–6 demonstrated no significant associations between depressive symptom status and early postoperative outcomes, with odds ratios ranging from 0.53 to 1.15 and all p-values exceeding 0.05 (Table 2; Fig. 2). A positive pre-procedure depression screen was not associated with increased odds of prolonged hospital length of stay, non-home discharge, ED visits, or hospital readmissions. Similarly, when PHQ-2 scores were analyzed as a continuous variable, no significant associations were identified across the assessed outcomes (OR ranging from 0.88 to 1.03; all p-values > 0.05) (Table 3). After matching, patients with a positive depression screen continued to have no significant association with any of the outcomes of interest (OR ranging from 0.83 to 2.25; all p-values > 0.05) (Table 2; Fig. 2). Taken together, these analyses did not demonstrate an association between preoperative PHQ-2 and early postoperative outcomes in this cohort.

Table 2

Association between preoperative PHQ-2 score (3–6 vs. 0) and early postoperative outcomes. Odds ratios (OR) with 95% confidence intervals (CI) are reported for categorical outcomes, and β coefficients with 95% CI are reported for log-transformed length of stay.

Outcome	Before CEM		After CEM	
	β (95% CI) or	p-value	β (95% CI) or	p-value
	OR (95% CI)		OR (95% CI)	
Log-transformed Length of Stay	0.16 (-0.09-0.40)	0.20	0.066 (-0.23-0.47)	0.69
Non-Home Discharge	1.15 (0.58–2.29)	0.69	1.50 (0.53–4.31)	0.61
30D ED Visit	0.66 (0.25–1.71)	0.39	2.25 (0.69–7.31)	0.27
90D ED Visit	0.73 (0.33–1.61)	0.43	2.00 (0.68–5.85)	0.30
30D Readmission	0.54 (0.23–1.23)	0.14	1.00 (0.25-4.00)	1.00
90D Readmission	0.79 (0.39–1.56)	0.49	0.83 (0.25–2.73)	1.00

Table 3

Association between continuous PHQ-2 score and early postoperative outcomes. Preoperative PHQ-2 score was modeled as a continuous variable in univariate analyses of outcomes in the full unmatched cohort, including all PHQ-2 scores (n = 906). Odds ratios (OR) with 95% confidence intervals (CI) are reported for categorical outcomes, and β coefficients with 95% CI are reported for log-transformed length of stay.

Outcome	β (95% CI) or OR (95% CI)	p-value
Log-transformed Length of Stay	0.04 (-0.01-0.09)	0.09
Non-Home Discharge	1.03 (0.90–1.18)	0.63
30D ED Visit	1.00 (0.86–1.18)	0.95
90D ED Visit	1.02 (0.89–1.17)	0.80
30D Readmission	0.88 (0.75–1.03)	0.12
90D Readmission	0.97 (0.85–1.11)	0.63

Discussion

In this retrospective study of patients undergoing spine tumor surgery, we found that positive PHQ-2 screening was not associated with adverse early postoperative outcomes. Specifically, patients with a positive preoperative depression screen (PHQ-2 score = 3–6) did not demonstrate increased odds of prolonged hospital length of stay, non-home discharge, ED visits, or hospital readmissions within 30 or 90 days. These findings were consistent across multiple analytic approaches, including unmatched analyses, modeling PHQ-2 as a continuous variable, and coarsened exact matching to control for clinical and demographic differences.

Our findings contrast with prior literature demonstrating an association between depression and adverse outcomes across multiple surgical populations.^{5,8} Within spine surgery, depression and anxiety symptoms have been linked to higher rates of readmission, infection, ED utilization, and worse patient reported recovery, especially in degenerative lumbar cohorts.^{6,9,13,34} Notably, Xu et al. applied a similar rigorous CEM approach and demonstrated that a positive PHQ-2 screen was associated with increased 90-day postoperative ED visits following single-level posterior lumbar fusion.⁶ The absence of associations in our spine oncology cohort suggests that the prognostic relevance of preoperative depression screening may be highly dependent on disease context.

In degenerative spine surgery, outcomes are strongly influenced by pain perception and functional recovery, which are highly sensitive to affective state.^{35–37} As these procedures are typically elective,³⁸ depressive symptoms may amplify pain experience and dissatisfaction, increasing postoperative healthcare utilization. In contrast, early postoperative outcomes in the spinal oncology population may

be more strongly driven by perioperative complexity and systemic disease burden. These factors may overshadow the influence of depressive symptoms on short-term outcomes. However, depressive symptoms may exert a more meaningful influence on longer-term recovery trajectories in this patient population, including functional recovery and quality of life. Our focus on early outcomes may, therefore, underestimate the relevance of psychosocial factors that emerge over longer recovery periods.

An additional consideration is the relatively low prevalence of positive PHQ-2 screening observed in this cohort (5.2%), which is substantially lower than rates of depression previously reported in the spinal oncology population (20–30%).^{39,40} Given the psychological burden associated with cancer diagnosis and treatment, this low prevalence is unlikely to reflect a true absence of depressive symptoms among spine tumor patients, raising the possibility that the PHQ-2 underestimates depression in the population. As a brief screening instrument, PHQ-2 may lack sufficient granularity to capture clinically meaningful variation in depression symptom severity among spine oncology patients. While the PHQ-2 is widely used for rapid screening and has demonstrated utility in other surgical populations,^{6,10,15} it may not adequately distinguish between transient mood symptoms related to cancer diagnosis and major depressive disorder. In patients with spinal tumors, emotional distress may reflect situational factors such as prognostic uncertainty and treatment fatigue. More comprehensive assessments, such as the PHQ-9,^{41,42} may better capture dimensions of depression that are more relevant to postoperative risk in this population.

While prior work supports the value of PHQ-2 screening in identifying patients at risk for adverse postoperative events,^{6,13} our findings indicate that its prognostic relevance may be limited in patients undergoing surgery for spinal tumors. Ultimately, this study underscores the importance of contextualizing psychosocial risk factors with the underlying disease process when developing risk stratification frameworks.

This study should be interpreted in the context of several limitations. First, the retrospective design introduces the potential for confounding and selection bias. To minimize these effects, CEM was used to balance demographic and clinical characteristics known to influence early postoperative outcomes. Although the overall number of patients with positive PHQ-2 screens was small, matching was successful for the majority of eligible cases, with 37 of 41 patients included in the matched analysis. Nevertheless, the limited size of the matched cohort may have reduced statistical power to detect modest effect sizes. Importantly, effects were similar across multiple analytic approaches, including unmatched analyses, continuous modeling of PHQ-2, and matched comparisons, suggesting that any true associations, if present, are likely small. In addition, detailed operative variables, such as surgical approach or tumor location, were not included in our analysis. To partially address this limitation, we included operative cut time as a proxy measure for surgical complexity.

Future studies should explore whether more detailed depression assessments or composite risk models that integrate physiological and psychosocial factors can better predict postoperative outcomes in spine tumor patients. Understanding which dimensions of patient vulnerability meaningfully influence recovery

will be essential for tailoring preoperative screening strategies and optimizing perioperative care in this complex population.

Conclusion

Preoperative depressive symptom burden, as assessed by PHQ-2, was not associated with adverse short-term postoperative outcomes following spine tumor surgery. Unlike findings in elective degenerative spine surgery, PHQ-2 screening did not predict length of stay, discharge disposition, or short-term healthcare utilization. The low prevalence of positive screens suggests that the PHQ-2 may not fully capture depressive symptoms in spine oncology patients. Ultimately, these findings suggest that the prognostic relevance of brief depression screening tools may be highly context dependent and that more nuanced assessments may be required to identify meaningful risk in this complex population.

Abbreviations

Patient Health Questionnaire-2 (PHQ-2); Coarsened exact matching (CEM); Emergency Department (ED); body mass index (BMI); American Society of Anesthesiologists (ASA) grade; Charlson Comorbidity Index (CCI)

Declarations

Ethics approval and consent to participate

This study was approved by the Institutional Review Board of the Hospital of the University of Pennsylvania (IRB #825431). All methods were performed in accordance with relevant guidelines and regulations. The requirement for informed consent was waived due to the retrospective nature of the study.

Consent for publication

Not applicable. This study used retrospective, deidentified patient data and did not include any identifiable individual information requiring consent for publication.

Availability of data and material

The datasets generated and analyzed during the current study are not publicly available due to institutional and patient privacy restrictions but are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' Contributions

K.H.P., J.L.G., and N.R.M. wrote the main manuscript text. J.C. and S.D.M. performed the statistical analyses. E.X. and I.M. curated the data. K.H.P. prepared all figures and tables. A.B., G.W.P., A.H., H.M.K., J.S., C.W.F., and N.R.M. provided resources and project supervision. K.H.P. and N.R.M. conceptualized the study. All authors reviewed and approved the final manuscript.

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Authors' information (optional)

Not applicable.

References

1. Luksanapruk P, Buchowski JM, Zebala LP, Kepler CK, Singhatanadgige W, Bumpass DB (2017) Perioperative Complications of Spinal Metastases Surgery. *Clin Spine Surg* 30(1):4–13. 10.1097/BSD.0000000000000484
2. Walha S, Fairbanks SL (2021) Spinal Cord Tumor Surgery. *Anesthesiol Clin* 39(1):139–149. 10.1016/j.anclin.2020.11.012
3. Furlan JC, Wilson JR, Massicotte EM, Sahgal A, Fehlings MG (2022) Recent advances and new discoveries in the pipeline of the treatment of primary spinal tumors and spinal metastases: a scoping review of registered clinical studies from 2000 to 2020. *Neuro Oncol* 24(1):1–13. 10.1093/neuonc/noab214
4. Dunbar EM (2020) Multidisciplinary spine oncology care across the disease continuum. *Neurooncol Pract* 7(Suppl 1):i1–i4. 10.1093/nop/npaa071
5. Geoffrion R, Koenig NA, Zheng M et al (2021) Preoperative Depression and Anxiety Impact on Inpatient Surgery Outcomes. *Ann Surg Open* 2(1):e049. 10.1097/AS9.0000000000000049
6. Xu E, Karsalia R, Arena J et al (2025) Positive Preprocedure Depression Screening Is Associated With Worse Outcomes After Single-Level Posterior-Only Lumbar Fusion: A Retrospective Cohort Analysis. *Neurosurgery*. Published online July 18, :10.1227/neu.00000000000003644. doi:10.1227/neu.00000000000003644
7. Karsalia R, Xu E, Malhotra RD et al (2025) Markers of preoperative depression and anxiety as predictors of increased short-term healthcare utilization after lumbar fusion surgery. *J Neurosurgery: Spine* 44(1):118–125. 10.3171/2025.5.SPINE241512

8. Chen A, An E, Yan E et al (2024) Prevalence of preoperative depression and adverse outcomes in older patients undergoing elective surgery: A systematic review and meta-analysis. *J Clin Anesth* 97:111532. 10.1016/j.jclinane.2024.111532
9. Aghajanian S, Shafiee A, Teymouri Athar MM et al (2024) Impact of Depression on Postoperative Medical and Surgical Outcomes in Spine Surgeries: A Systematic Review and Meta-Analysis. *J Clin Med* 13(11):3247. 10.3390/jcm13113247
10. Castle JP, Gaudiani MA, Abbas MJ et al (2025) Preoperative depression screening using PHQ-2 is associated with worse outcomes after ACL reconstruction. *J Orthop* 70:63–69. 10.1016/j.jor.2025.03.006
11. Lee S, Xue Y, Petricca J et al (2024) The impact of pre-operative depression on pain outcomes after major surgery: a systematic review and meta-analysis. *Anaesthesia* 79(4):423–434. 10.1111/anae.16188
12. Tang V, Cenzer I, McCulloch CE et al (2020) Preoperative Depressive Symptoms associated with Poor Functional Recovery after Surgery. *J Am Geriatr Soc* 68(12):2814–2821. 10.1111/jgs.16781
13. Deshpande N, Hadi M, Mansour TR et al (2024) The impact of anxiety and depression on lumbar spine surgical outcomes: a Michigan Spine Surgery Improvement Collaborative study. *J Neurosurgery: Spine* 40(6):741–750. 10.3171/2023.12.SPINE23860
14. Kroenke K, Spitzer RL, Williams JBW (2003) The Patient Health Questionnaire-2: Validity of a Two-Item Depression Screener. *Med Care* 41(11):1284. 10.1097/01.MLR.0000093487.78664.3C
15. Zakaria HM, Mansour TR, Telemi E et al (2019) Use of Patient Health Questionnaire–2 scoring to predict patient satisfaction and return to work up to 1 year after lumbar fusion: a 2-year analysis from the Michigan Spine Surgery Improvement Collaborative: Presented at the 2019 AANS/CNS Joint Section on Disorders of the Spine and Peripheral Nerves. *J Neurosurgery: Spine* 31(6):794–801. 10.3171/2019.6.SPINE1963
16. De la Garza Ramos R, Goodwin CR, Jain A et al (2016) Development of a Metastatic Spinal Tumor Frailty Index (MSTFI) Using a Nationwide Database and Its Association with Inpatient Morbidity, Mortality, and Length of Stay After Spine Surgery. *World Neurosurg* 95:548–555e4. 10.1016/j.wneu.2016.08.029
17. Verlaan JJ, Choi D, Versteeg A et al (2016) Characteristics of Patients Who Survived < 3 Months or > 2 Years After Surgery for Spinal Metastases: Can We Avoid Inappropriate Patient Selection? *J Clin Oncol* 34(25):3054–3061. 10.1200/JCO.2015.65.1497
18. Schoenfeld AJ, Ochoa LM, Bader JO, Belmont PJ (2011) Risk factors for immediate postoperative complications and mortality following spine surgery: a study of 3475 patients from the National Surgical Quality Improvement Program. *J Bone Joint Surg Am* 93(17):1577–1582. 10.2106/JBJS.J.01048
19. Schoenfeld AJ, Le HV, Marjoua Y et al (2016) Assessing the utility of a clinical prediction score regarding 30-day morbidity and mortality following metastatic spinal surgery: the New England Spinal Metastasis Score (NESMS). *Spine J* 16(4):482–490. 10.1016/j.spinee.2015.09.043

20. Lui B, Weinberg R, Milewski AR et al (2021) Impact of preoperative opioid use disorder on outcomes following lumbar-spine surgery. *Clin Neurol Neurosurg* 208:106865. 10.1016/j.clineuro.2021.106865
21. Carey ET, Moore KJ, Young JC et al (2021) Association of Preoperative Depression and Anxiety With Long-term Opioid Use After Hysterectomy for Benign Indications. *Obstet Gynecol* 138(5):715–724. 10.1097/AOG.0000000000004568
22. Carey E, Strassle P, Moore K, Schiff L, Louie M (2019) Associations Between Preoperative Depression, Hysterectomy, and Postoperative Opioid Use. *J Minim Invasive Gynecol* 26(7, Supplement):S71. 10.1016/j.jmig.2019.09.679
23. Armaghani SJ, Lee DS, Bible JE et al (2013) Preoperative Narcotic Use and Its Relation to Depression and Anxiety in Patients Undergoing Spine Surgery. *Spine* 38(25):2196. 10.1097/BRS.0000000000000011
24. Gawande A (2018) Why Doctors Hate Their Computers. *The New Yorker*. Published online November 5, Accessed September 9, 2025. <https://www.newyorker.com/magazine/2018/11/12/why-doctors-hate-their-computers>
25. Verla T, Adogwa O, Toche U et al (2016) Impact of Increasing Age on Outcomes of Spinal Fusion in Adult Idiopathic Scoliosis. *World Neurosurg* 87:591–597. 10.1016/j.wneu.2015.10.061
26. Karsalia R, Gallagher RS, Borja AJ et al (2025) Disparities Attributable to Sex Differences in 4680 Lumbar Fusion Outcomes. *World Neurosurg* 194:123586. 10.1016/j.wneu.2024.123586
27. Wilson JR, Tetreault LA, Schroeder G et al (2017) Impact of Elevated Body Mass Index and Obesity on Long-term Surgical Outcomes for Patients With Degenerative Cervical Myelopathy: Analysis of a Combined Prospective Dataset. *Spine* 42(3):195. 10.1097/BRS.0000000000001859
28. Zehnder P, Aghayev E, Fekete TF, Haschtmann D, Pigott T, Mannion AF (2016) Influence of previous surgery on patient-rated outcome after surgery for degenerative disorders of the lumbar spine. *Eur Spine J* 25(8):2553–2562. 10.1007/s00586-016-4383-x
29. Lau D, Chan AK, Deverin V, Ames CP (2017) Does prior spine surgery or instrumentation affect surgical outcomes following 3-column osteotomy for correction of thoracolumbar deformities? *Neurosurg Focus* 43(6):E8. 10.3171/2017.8.FOCUS17460
30. Dial BL, Esposito VR, Danilkowicz R et al (2020) Factors Associated With Extended Length of Stay and 90-Day Readmission Rates Following ACDF. *Global Spine J* 10(3):252–260. 10.1177/2192568219843111
31. Harris T, Segovia N, Koltsov J, Gardner M (2024) Association between operative duration and adverse outcomes after hip fracture surgery: A NSQIP matched cohort study. *Injury* 55(8). 10.1016/j.injury.2024.111635
32. Cheng H, Clymer JW, Po-Han Chen B et al (2018) Prolonged operative duration is associated with complications: a systematic review and meta-analysis. *J Surg Res* 229:134–144. 10.1016/j.jss.2018.03.022
33. Mao Z, Zhang J, Wang P, Zuo W (2025) The association between the duration of surgery and risks of mortality and unplanned reoperation is modulated by the surgical start time. *Sci Rep* 15(1):28057.

10.1038/s41598-025-12265-3

34. Ebada A, Carron CJ, Bever N et al (2025) Propensity Score–Matched Analysis of the Association Between Depression, Anxiety, and Patient-Reported Outcomes Following Lumbar Surgery. *World Neurosurg* 201:124305. 10.1016/j.wneu.2025.124305
35. Amaral V, Marchi L, Martim H et al (2017) Influence of psychosocial distress in the results of elective lumbar spine surgery. *J Spine Surg* 3(3):371–378. 10.21037/jss.2017.08.05
36. Coronado RA, George SZ, Devin CJ, Wegener ST, Archer KR (2015) Pain Sensitivity and Pain Catastrophizing Are Associated With Persistent Pain and Disability After Lumbar Spine Surgery. *Arch Phys Med Rehabil* 96(10):1763–1770. 10.1016/j.apmr.2015.06.003
37. Pawełczyk A, Jekimov R, Lusa W et al (2025) The Preoperative Level of Pain Predicts Chronic Pain in Patients Operated on for Degenerative Disc Disease—A Prospective Study. *J Clin Med* 14(10):3467. 10.3390/jcm14103467
38. Stevens MT, Dunning CE, Oxner WM, Stewart SA, Hayden JA, Andrew Glennie R (2023) A retrospective analysis of surgical, patient, and clinical characteristics associated with length of stay following elective lumbar spine surgery. *Interdisciplinary Neurosurg* 31:101694. 10.1016/j.inat.2022.101694
39. Yeung C, Heard J, Lee Y et al (2024) The prevalence of depression and anxiety in patients with metastatic disease to the spine. *J Craniovertebr Junction Spine* 15(3):308–314. 10.4103/jcvjs.jcvjs_23_24
40. O’Callaghan E, Bello A, Rowe D et al Prevalence of Depression in Metastatic Spine Disease Patients Undergoing Surgical Intervention. *Spine*. Published online 2025:10.1097/BRS.0000000000005547. doi:10.1097/BRS.0000000000005547
41. Kroenke K, Spitzer RL, Williams JBW (2001) The PHQ-9. *J Gen Intern Med* 16(9):606–613. 10.1046/j.1525-1497.2001.016009606.x
42. Patel DV, Yoo JS, Khechen B et al (2019) PHQ-9 Score Predicts Postoperative Outcomes Following Minimally Invasive Transforaminal Lumbar Interbody Fusion. *Clin Spine Surg* 32(10):444. 10.1097/BSD.0000000000000818

Figures

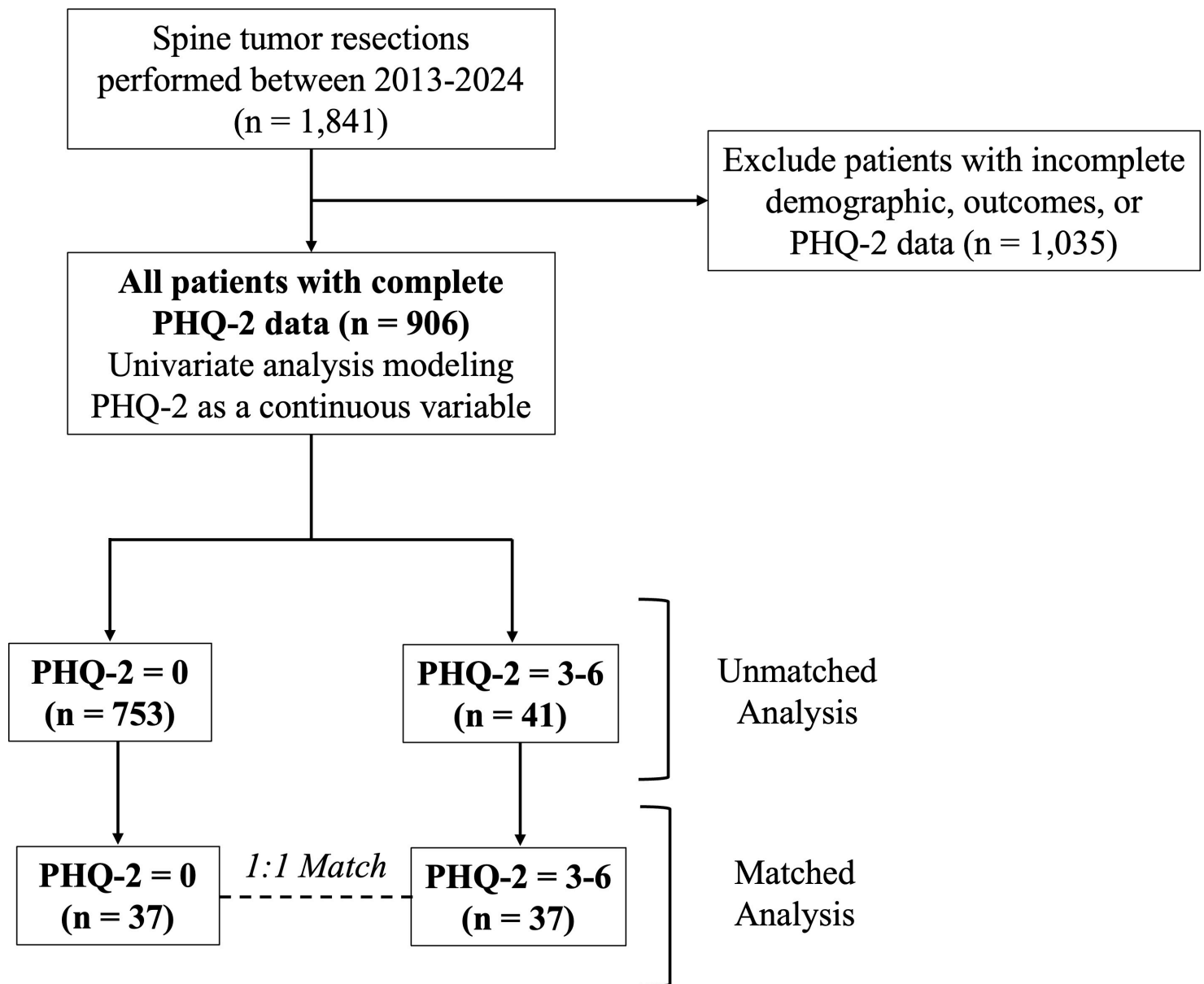


Figure 1

Patients selected for analysis and matching.

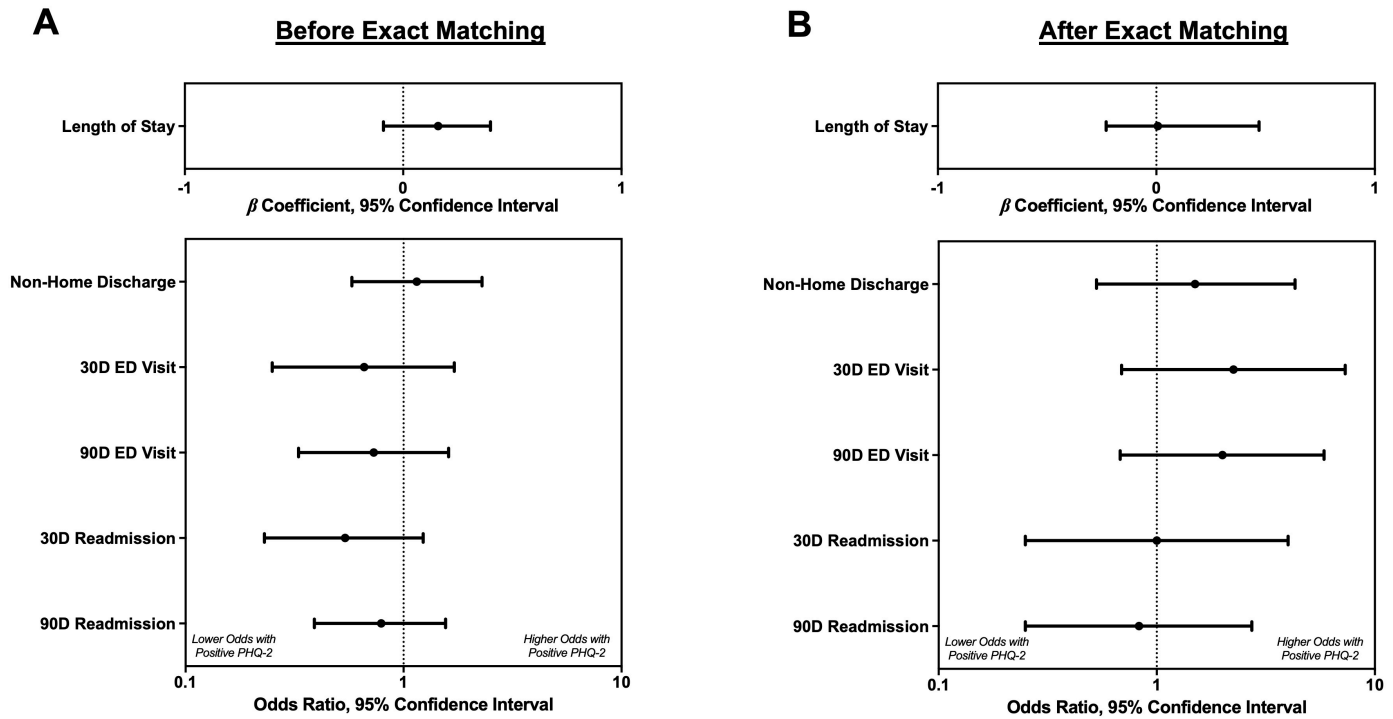


Figure 2

Association between PHQ-2 screening and postoperative outcomes. Results for before (A) and after (B) coarsened exact matching are shown as β coefficients with 95% confidence intervals (CI) for continuous outcomes and odds ratios (OR) with 95% CI for categorical outcomes.