

CERVICAL SPINE

Development and Validation of Cervical Prediction Models for Patient-Reported Outcomes at 1 Year After Cervical Spine Surgery for Radiculopathy and Myelopathy

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Study Design. Retrospective analysis of prospectively collected registry data.

Objective. To develop and validate prediction models for 12-month patient-reported outcomes of disability, pain, and myelopathy in patients undergoing elective cervical spine surgery.

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Acknowledgment date: February 24, 2020. First revision date: April 6, 2020. Acceptance date: May 12, 2020.

The manuscript submitted does not contain information about medical device(s)/drug(s).

NeuroPoint Alliance, Inc. funds were received in support of this work.

Relevant financial activities outside the submitted work: board membership, consultancy, grants, royalties, stocks, employment, expert testimony.

QOD Vanguard Sites: Asher AL, McGirt MJ, Devin CJ, Foley KT, Sorenson JM, Briggs TB, Kremer A, Griffitt WE, Bisson EF, Shaffrey ME, Shaffrey CI, Fassett D, Oetting G, Elowitz EH, Rumana C.

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DOI: 10.1097/BRS.0000000000003610

Summary of Background Data. Predictive models have the potential to be utilized preoperatively to set expectations, adjust modifiable characteristics, and provide a patient-centered model of care.

Methods. This study was conducted using data from the cervical module of the Quality Outcomes Database. The outcomes of interest were disability (Neck Disability Index:), pain (Numeric Rating Scale), and modified Japanese Orthopaedic Association score for myelopathy. Multivariable proportional odds ordinal regression models were developed for patients with cervical radiculopathy and myelopathy. Patient demographic, clinical, and surgical covariates as well as baseline patient-reported outcomes scores were included in all models. The models were internally validated using bootstrap resampling to estimate the likely performance on a new sample of patients.

Results. Four thousand nine hundred eighty-eight patients underwent surgery for radiculopathy and 2641 patients for myelopathy. The most important predictor of poor postoperative outcomes at 12-months was the baseline Neck Disability Index score for patients with radiculopathy and modified Japanese Orthopaedic Association score for patients with myelopathy. In addition, symptom duration, workers' compensation, age, employment, and ambulatory and smoking status had a statistically significant impact on all outcomes ($P < 0.001$). Clinical and surgical variables contributed very little to predictive models, with posterior approach being associated with higher odds of having worse 12-month outcome scores in both the radiculopathy and myelopathy cohorts ($P < 0.001$). The full models overall discriminative performance ranged from 0.654 to 0.725.

Conclusion. These predictive models provide individualized risk-adjusted estimates of 12-month disability, pain, and myelopathy outcomes for patients undergoing spine surgery for degenerative cervical disease. Predictive models have the potential to be used as a shared decision-making tool for evidence-based preoperative counselling.

Key words: arm pain, cervical spine, degenerative disease, disability, myelopathy, neck pain, patient-reported outcomes, prediction models, radiculopathy, shared-decision making.

Level of Evidence: 2

Spine 2020;45:1541–1552

Degenerative diseases of the cervical spine including radiculopathy and myelopathy are common causes of disability in our aging population.¹ Cervical radiculopathy has a reported annual incidence of 83.2/100,000 persons and a prevalence of 3.5/1000 persons, while myelopathy caused by compression of the cervical spinal cord has a lower incidence.² Over the last decade, a number of studies have reported an uptrend in the annual number of cervical spine surgeries.^{3–9}

In an era of value-based healthcare, it is imperative to identify those who will benefit from cervical spine surgery. Aggregate data analysis has demonstrated the efficacy of surgical treatment for common degenerative cervical spine pathologies.^{10–15} However, safety and efficacy vary widely at the individual patient level.^{10,11,16,17} Quantifying the variation in patient-reported outcomes will provide an individualized estimate of the risks and benefits of surgery and inform a personalized shared-decision making process. Predictive models, based on patient and clinical level factors, have the potential to be utilized preoperatively to set expectations, adjust modifiable characteristics, and provide a patient-centered model of care.¹⁸

Prospective outcome registries integrated into clinical care allow for these patient-level prognostic models.^{19–24} The primary aim of this study was to develop and validate prediction models for patient-reported disability, pain, and myelopathy outcomes at 12 months in patients undergoing cervical spine surgery.

MATERIALS AND METHODS

Patients undergoing elective spine surgery for degenerative cervical spine disease were enrolled into a multicenter prospective registry, Quality Outcomes Database (QOD). The cervical module of the QOD registry enrolls patients from over 71 participating centers across 28 US states. Within sites, patients are enrolled either continuously or on a prespecified rotating cycle ensuring unbiased enrollment into the registry.²⁵ The cervical spine module of QOD is designed to establish risk-adjusted expected morbidity rates for the most utilized surgical procedures.^{26,27} Data coordinators at each center enter data into a secure web-based portal (REDCap—Research Electronic Data Capture).²⁸

Patients undergoing cervical spine surgery for the diagnoses of disc herniation, stenosis, cervical instability, as well as patients undergoing revision surgery for same-level recurrence or adjacent-segment disease were eligible for inclusion. Exclusion criteria included spinal infection, tumor, fracture, traumatic dislocation, deformity, neurological paralysis due to pre-existing spinal disease or injury, age less than 18 years, and incarceration. Patients enrolled in the QOD registry from

April 2013 to September 2016 and who had complete follow-up data at 12-months were included in analyses.

Patient demographics were captured through patient interview and review of the electronic medical record (EMR). Clinical and surgery-specific variables were abstracted from the EMR. Surgical approach was verified for the entire cohort through an internal audit by one of the contributing authors and included anterior decompression and fusion (corpectomy or discectomy with instrumentation) and posterior decompression (foraminotomy, laminoplasty, or laminectomy) with or without fusion.

Patient-reported disability and neck and arm pain were assessed at baseline and 12-months after surgery either through phone interview or during a clinic visit. Validated questionnaires were used to assess disability [Neck Disability Index (NDI)]²⁹ and neck and arm pain [Numeric Rating Scale (NRS-NP/AP)].³⁰ In addition, the modified Japanese Orthopaedic Association (mJOA) score³¹ was collected for patients who presented with myelopathic complaints and physical exam findings.

Statistical Analysis

Two sets of multivariable proportional odds ordinal regression models were developed for patients with radiculopathy and myelopathy; the outcomes of interest were NDI, NRS-NP/AP, and mJOA scores. We fitted the models without making assumption regarding their distributions while allowing for discreteness in the outcome variables. Demographic variables of age, sex [female vs. male (reference)], body mass index, race, education [more than high school vs. high school or less (reference)], smoking status, employment, insurance [private vs. public (reference)], workers' compensation, history of diabetes, depression, and anxiety, symptom duration [> 12 months, 3–12 months vs. less than 3 months (reference)], numbness, ambulatory status [assistance vs. independent (reference)], and baseline outcome scores as well as clinical and surgery-specific variables of surgical approach [posterior decompression vs. anterior decompression and fusion (reference)], evidence of listhesis on imaging, the number of levels operated on, and presence of motor deficit were included in the models.

We assumed a linear relationship for surgical level, and a smooth relationship for other continuous variables using restricted cubic regression splines with four knots for age and body mass index and three knots for the baseline outcome scores. Missing values of the patient covariates were handled by multiple imputation. The effects of predictors on the odds of patients having better 12-month outcomes were reported as odds ratio. Wald statistics were used to construct the corresponding 95% confidence intervals of odds ratio for the models and assess the importance of the individual variables in predicting each outcome.

We internally validated the calibration and discrimination of the model using bootstrap resampling to estimate the likely performance of the model on a new sample of patients.³² Bootstrap samples were drawn with replacement from the original sample, reflecting the drawing of samples

from an underlying population. Bootstrap samples were of the same size as the original sample. The model performance was measured by c-index, with 0.50 considered a random prediction and a value of 1 suggesting that the model is perfectly discriminating.³³ For ordinal endpoints, the c-index is smaller than the readers are accustomed to for binary outcomes due to the presence of multiple levels. Model discrimination indices (c-index) were generated for each model in three waves: a. patient demographics, b. patient demographics + baseline patient-reported outcome scores, and c. patient demographics + baseline patient-reported outcome scores + clinical/surgical

variables. Standardized mean difference was calculated for baseline variables of patients with and without complete follow-up data. The analysis was performed using the R 3.1.2³⁴ and regression modeling package.³⁵ Statistical significance was set at $P < 0.05$.

RESULTS

Out of 12,507 patients undergoing cervical spine surgery, 7629 (61%) completed 12-month follow-up and were included in analyses (4988 in the radiculopathy and 2641 in the myelopathy cohort). Standardized differences

TABLE 1. Baseline Demographic and Clinical Characteristics

	Total (7629)	Radiculopathy (4988)	Myelopathy (2641)
Age in years, mean ± SD	56.6 ± 11.4	54.6 ± 11.0	60.4 ± 11.4
Race, N (%)			
White	87% (6607)	88% (4410)	83% (2197)
Non-White	13% (1022)	12% (578)	17% (444)
Body mass index, mean ± SD	30.23 ± 6.43	30.14 ± 6.30	30.39 ± 6.68
Sex, N (%)			
Male	51% (3883)	50% (2491)	53% (1392)
Female	49% (3746)	50% (2497)	47% (1249)
Education, N (%)			
High school or less	49% (3717)	48% (2390)	50% (1327)
More than high school	51% (3912)	52% (2598)	50% (1314)
Employed, N (%)	54% (4137)	60% (2974)	44% (1163)
Insurance, N (%)			
Public	32% (2425)	26% (1277)	44% (1148)
Private	68% (5204)	74% (3711)	56% (1493)
Workers' compensation, N (%)	3% (252)	4% (200)	2% (52)
Current smoker, N (%)	20% (1528)	20% (986)	21% (542)
Depression, N (%)	24% (1840)	24% (1184)	25% (656)
Anxiety, N (%)	21% (1574)	21% (1050)	20% (524)
Diabetes, N (%)	18% (1334)	16% (782)	21% (552)
Ambulation, N (%)			
Independent	92% (7039)	97% (4847)	83% (2192)
With assistance	8% (590)	3% (141)	17% (449)
Symptom duration, N (%)			
Less than 3 mo	13% (1028)	14% (712)	12% (316)
3–12 mo	39% (2941)	39% (1941)	38% (1000)
More than 12-mo	48% (3660)	47% (2335)	50% (1325)
Numbness, N (%)	63% (4844)	68% (3372)	56% (1472)
Surgical approach, N (%)			
Anterior decompression with fusion	82% (6301)	86% (4265)	77% (2036)
Posterior decompression	9% (659)	11% (574)	3% (85)
Posterior decompression with fusion	9% (669)	3% (149)	20% (520)
Listhesis, N (%)	17% (1326)	16% (806)	20% (520)
Number of levels, mean ± SD	2.03 ± 1.11	1.83 ± 0.90	2.42 ± 1.34
Motor deficit, N (%)	42% (3197)	36% (1791)	53% (1406)
Baseline NDI score, mean ± SD	41.0 ± 18.3	42.4 ± 17.3	38.3 ± 19.7
Baseline neck pain, mean ± SD	5.97 ± 2.90	6.32 ± 2.68	5.33 ± 3.18
Baseline arm pain, mean ± SD	5.58 ± 3.15	5.95 ± 2.93	4.88 ± 3.41
Baseline mJOA score, mean ± SD	–	–	12.4 ± 2.8

SD indicates standard deviation; NDI, neck disability index; NRS, numeric rating scale; mJOA, modified Japanese Orthopaedic Association.

for the comparisons of baseline characteristics by follow-up status found no meaningful differences (*i.e.*, Cohen's *d* below 0.13).³⁶

Demographic and clinical/surgical characteristics are summarized in Table 1. The myelopathy cohort was older [mean: 60.4 ± 11.4 *vs.* mean: 54.6 ± 11.0, *P* < 0.001], had a higher proportion of patients with motor deficits (53% *vs.* 36%, *P* < 0.001), and had a higher average number of levels operated on (2.42 ± 1.34 *vs.* 1.83 ± 0.90, *P* < 0.001) compared with the radiculopathy cohort.

Mild disability and pain were reported at 12-months following surgery with NDI scores of 18.6 (SD: 19.2) and 20.1 (SD: 18.7), neck pain of 2.53 (SD: 2.5) and 2.59 (SD: 2.76), and arm pain of 1.93 (SD: 2.71) and 2.19 (SD: 2.86) for patients with radiculopathy and myelopathy,

respectively. The myelopathy group had a mJOA score of 14.20 (SD: 2.68) at 12-month follow-up.

Predictive Models for the Radiculopathy and Myelopathy Cohorts

The odds of having worse NDI scores were seen in patients in the radiculopathy cohort with longer symptom duration, workers' compensation claim, ambulation assistance prior to surgery, higher baseline NDI, and undergoing surgery via posterior decompression with or without fusion (*P* < 0.001) as well as patients with presence of depression and females (*P* < 0.05, Figure 1). The odds of having better NDI scores at 12-months were seen in radiculopathy patients with greater age, preoperative employment, private insurance, and greater arm pain (*P* < 0.001) as well as patients having education

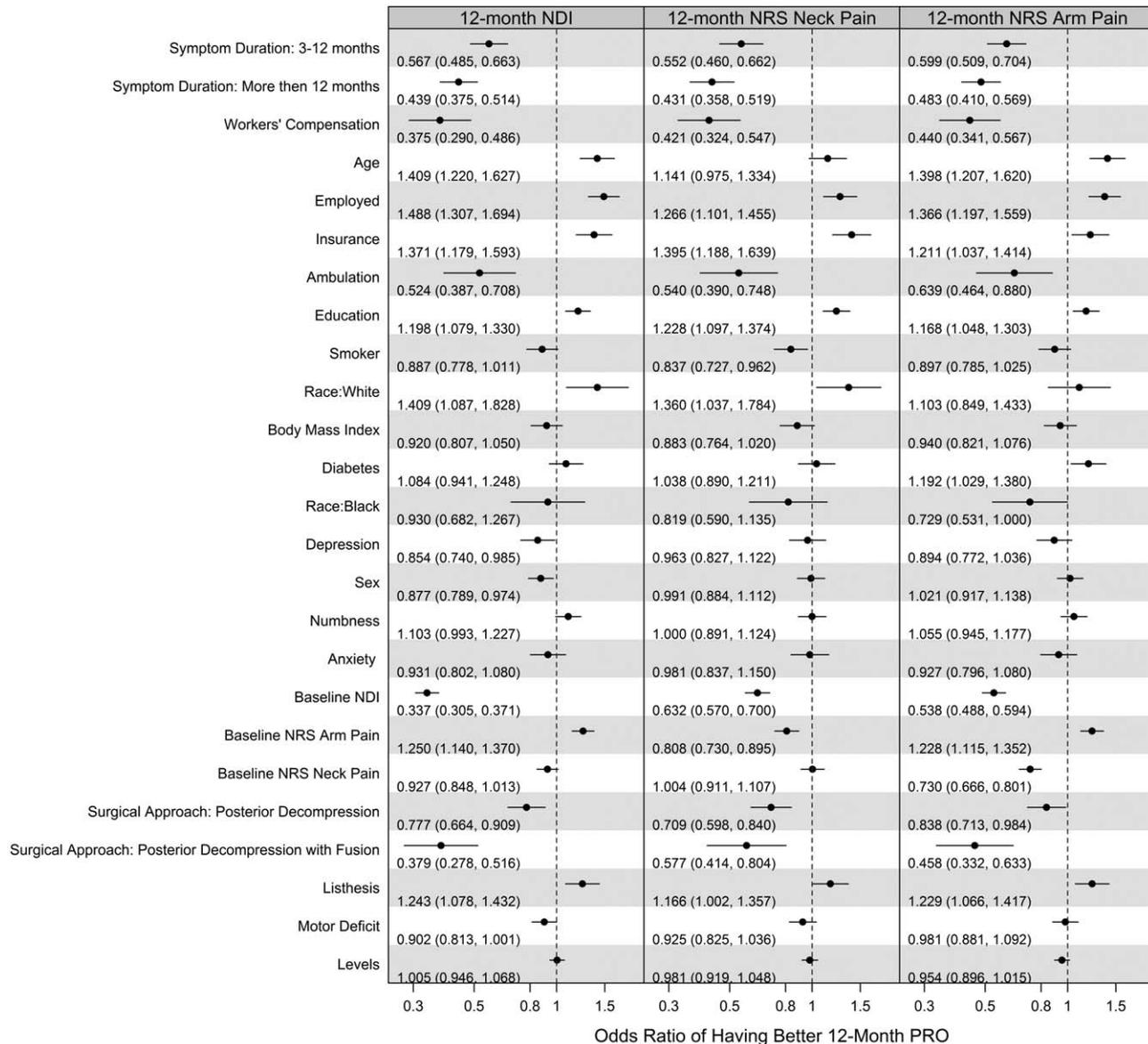


Figure 1. The adjusted effects of predictors for the odds of having better disability, neck pain, and arm pain outcomes in the radiculopathy cohort. Continuous variables that have nonlinear effects on the outcome are shown for the 75th percentile compared to 25th percentile: age (62 *vs.* 47), body mass index (34 *vs.* 26), and baseline NDI (54 *vs.* 30), NRS arm pain (8 *vs.* 4), and NRS neck pain (8 *vs.* 5) scores. Continuous variable that is linearly related to the outcome is shown for the effect of one unit increase: Levels (2 *vs.* 1).

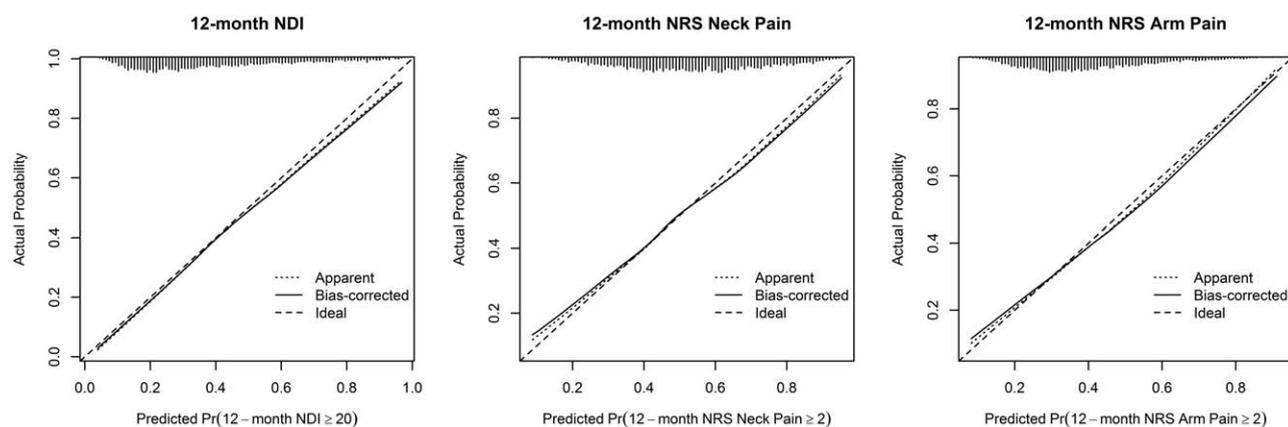


Figure 2. The radiculopathy models' discriminative performance (measured by overfitting-corrected c-index).

greater than high school ($P=0.001$), evidence of listhesis ($P=0.003$), and being of white race ($P=0.010$). Similar patterns of significant predictors were found for the pain models, except for presence of depression, sex, and arm pain. Greater arm pain was significantly associated with odds of having worse neck pain scores ($P < 0.001$) which was opposite of the findings for the NDI and arm pain models. Figure 2 demonstrates the radiculopathy models' discriminative performance: [(NDI = wave a. 0.644, b. 0.686, c. 0.690), (NRS-NP = wave a. 0.631, b. 0.668, c. 0.672), (NRS-AP = wave a. 0.625, b. 0.650, c. 0.654)].

The patients in the myelopathy cohort with longer symptom duration, workers' compensation claim, and higher baseline NDI ($P < 0.001$) as well as those with current smoking status, presence of anxiety or depression and undergoing surgery via posterior decompression with fusion had lower odds of having better 12-month NDI score ($P < 0.05$, Figure 3). The odds of having better NDI at 12-months in the myelopathy cohort was higher for patients with preoperative employment and higher baseline mJOA score ($P < 0.001$), evidence of listhesis ($P=0.003$), white race ($P=0.015$), and higher age ($P=0.023$). The patterns of statistically significant predictors were similar for the pain models, except smoking status, presence of anxiety/depression, surgical approach, and listhesis were no longer significant for the myelopathy cohort.

For myelopathic symptoms, the odds of having worse 12-month mJOA was seen in those with longer symptom duration, ambulation assistance prior to surgery, current smoking status, higher baseline NDI score, and patients undergoing surgery via posterior decompression with or without fusion ($P < 0.001$). The odds of having better mJOA at 12-months was seen in those with preoperative employment and higher baseline mJOA ($P < 0.001$), white race ($P=0.025$), and female sex ($P=0.005$). Figure 4 demonstrates the myelopathy models' discriminative performance: [(NDI = wave a. 0.639, b. 0.700, c. 0.702), (NRS-NP = wave a. 0.622, b. 0.688, c. 0.690), (NRS-AP = wave a. 0.623, b. 0.680, c. 0.681), (mJOA = wave a. 0.657, b. 0.723, c. 0.725)].

A patient's baseline NDI score proved to be the most important predictor for the radiculopathy cohort

(Figure 5), while the baseline mJOA and then the NDI score were the most important predictors for the myelopathy cohort (Figure 6). The demographic variables and baseline arm and neck pain added relatively smaller effects and the least impact was noted for the clinical/surgery-specific variables (surgical approach, listhesis, motor deficit, and surgical levels). Among the demographic characteristics, symptom duration, workers' compensation, age, employment status, preoperative ambulation, and smoking status contributed the most to the predictive models for both cohorts. Surgical approach was the only clinical/surgical factor showing consistent predictive importance for all 12-month outcomes.

DISCUSSION

As part of a value-based approach to care, there is an increased emphasis on patient-centered management and the assessment of patient-reported outcomes.³⁷ Predictive models that provide individualized estimates of outcomes that are meaningful to patients allow for risk stratification and shared decision-making for surgical and nonsurgical treatment. In the current analysis, we used prospectively collected data from a national multicenter registry to develop and validate predictive models for 12-month patient-reported outcomes in patients undergoing elective surgery for radiculopathy and myelopathy due to degenerative cervical disease.

Results demonstrated that patients with higher baseline NDI scores for radiculopathy and lower mJOA scores for myelopathy were more likely to have poorer outcomes at 12-months after surgery. The literature has consistently reported on the importance of baseline functional status on postoperative outcomes.³⁸⁻⁴⁰ We also demonstrated that patients in the radiculopathy cohort with higher baseline arm pain had higher likelihood of having better disability and arm pain outcomes. Passias *et al*⁴¹ reported an arm *versus* neck pain ratio parameter and concluded that higher preoperative arm pain compared with neck pain was associated with higher odds of having improved outcomes. Radicular symptoms are associated with higher extremity pain and clinically appear more responsive to surgical decompression than axial pain.

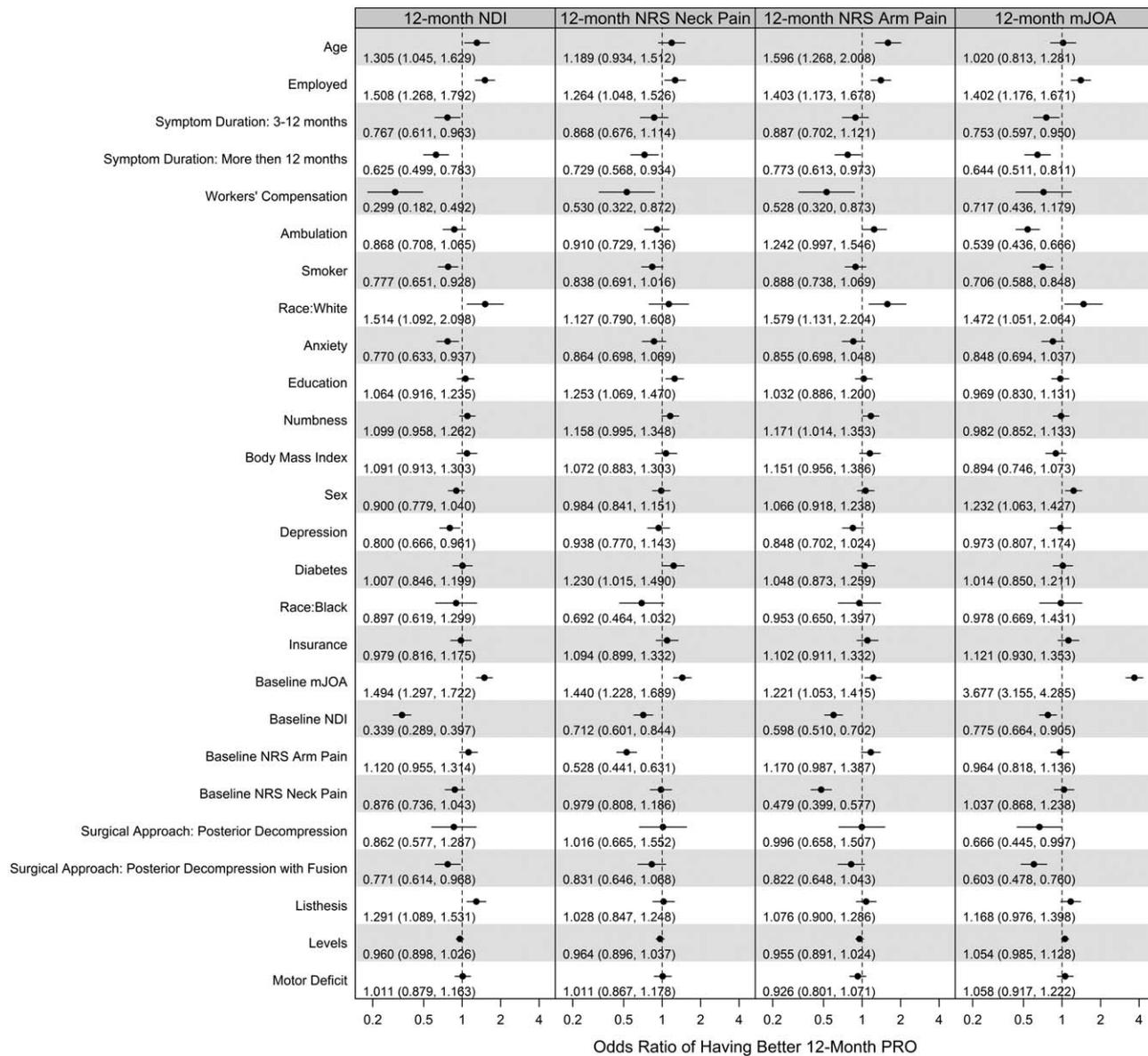


Figure 3. The adjusted effects of predictors for the odds of having better disability, neck pain, arm pain, and myelopathic symptom outcomes in the myelopathy cohort. Continuous variables that have nonlinear effects on the outcome are shown for the 75th percentile compared to 25th percentile: age (68 vs. 52), body mass index (34 vs. 26), and baseline NDI (52 vs. 24), NRS arm pain (8 vs. 2), NRS neck pain (8 vs. 3), and mJOA (15 vs. 11) scores. Continuous variable that is linearly related to the outcome is shown for the effect of one unit increase: Levels (2 vs. 1).

Symptom duration, workers' compensation, age, employment, ambulatory status, and smoking status were consistently the more important demographic predictors of overall outcomes in both the radiculopathy and myelopathy cohorts. These findings are consistent with those previously reported in the literature.⁴²⁻⁴⁶ Studies have found that early diagnosis and intervention lead to improved clinical outcomes,⁴⁶⁻⁴⁸ while patient postsurgical recovery depends on job satisfaction, the type of physical labor, and financial support in the form of workers' compensation.⁴⁹⁻⁵¹ Results also demonstrated that patients with higher age improve more in terms of disability and arm pain when compared with younger patients; however, age had no impact on neck pain or mJOA scores. The literature identifies inconsistent impact of increasing age on long-term outcomes in patients

undergoing cervical spine surgery.^{52,53} Patients who preoperatively needed assistance for ambulation had higher odds of worse disability, neck and arm pain in the radiculopathy cohort, and worse mJOA in the myelopathy cohort. While Zakaria *et al*⁵⁴ identified preoperative ambulation status as a risk factor for readmissions, no other study to date has examined the independent relationship between preoperative ambulation and postoperative patient-reported outcomes. Many studies have reported on the association between smoking and biochemical and clinical outcomes in spine surgery.⁵⁵⁻⁵⁷ Smoking increases the risk of perioperative complications, particularly pseudarthrosis in spinal fusion surgery.⁵⁷⁻⁵⁹ Berman *et al*⁶⁰ recommended smoking cessation for at least the first 4 weeks after spine surgery.

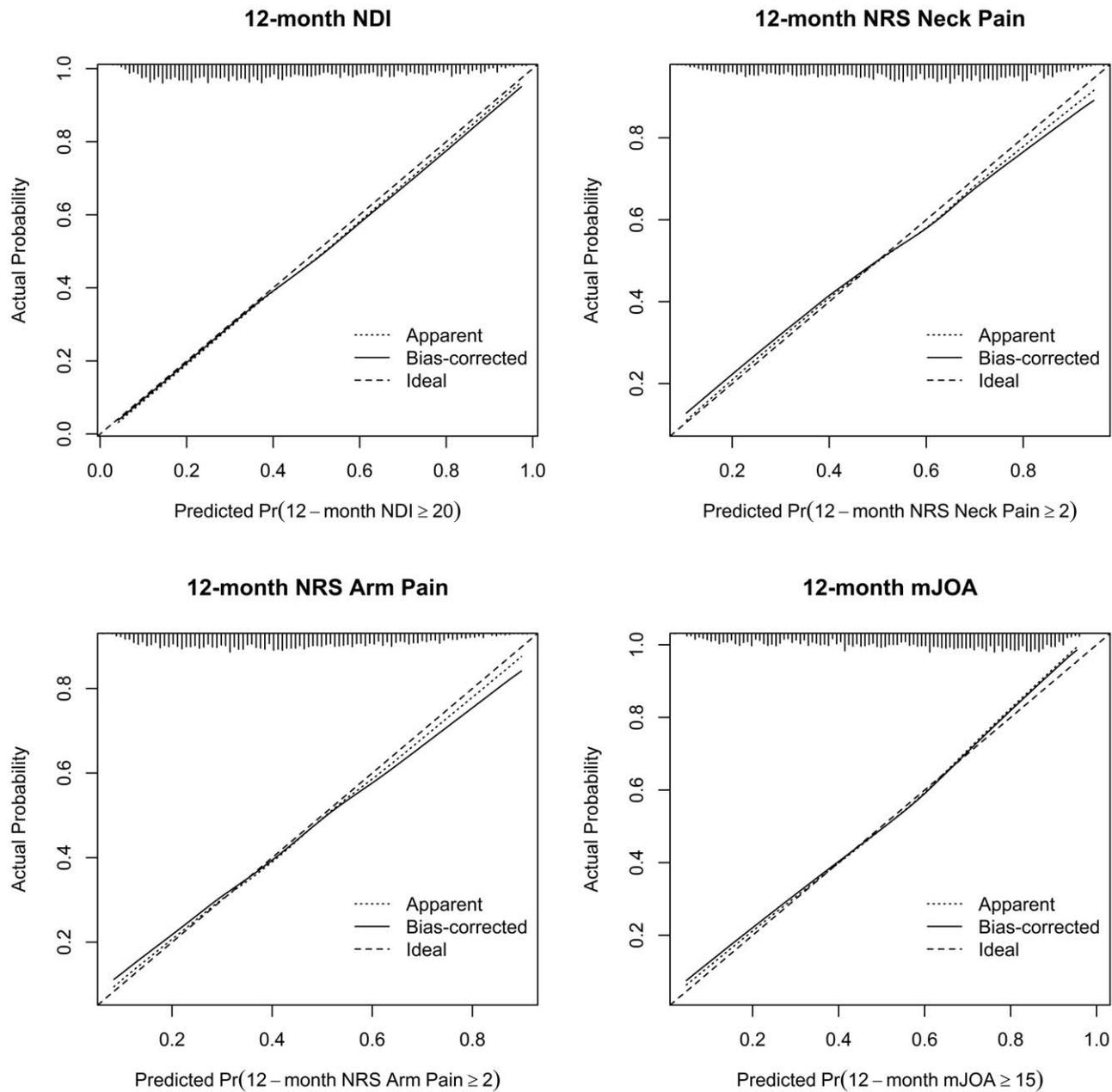


Figure 4. The myelopathy models’ discriminative performance (measured by overfitting-corrected c-index).

The clinical and surgical variables had a lower predictive importance when compared with baseline patient-reported outcome scores and demographic characteristics. Posterior decompression with or without fusion was associated with higher odds of having worse 12-month outcome scores in the radiculopathy cohort and posterior decompression and fusion was associated with higher odds of having worse NDI and mJOA scores in the myelopathy cohort. These findings are consistent with the literature and reinforce previous observations that patient-specific variables are the primary drivers of outcomes following elective spine surgery.^{61–66}

Real-World—Clinical Application

Patient-reported outcomes are one component in the decision-making process and the estimates of the presented Spine

models will certainly not deter providers from operating on patients with identified risk factors, such as higher baseline disability. Information from our predictive models can be used to identify modifiable risk factors and facilitate shared decision-making during preoperative clinic visits to help achieve improved outcomes.

As an example of the value of these predictive models, two hypothetical patients are presented to support the clinical application of predicting the probability of mean disability, neck and arm pain, and mJOA scores at 12 months after elective cervical spine surgery (Table 2). Patient A, a 35-year-old White, nonsmoking male with radiculopathy and an anterior surgical approach has a predicted probability for mean NDI and neck and arm pain scores of 8.2, 1.6, and 0.73, respectively, at 12 months. For

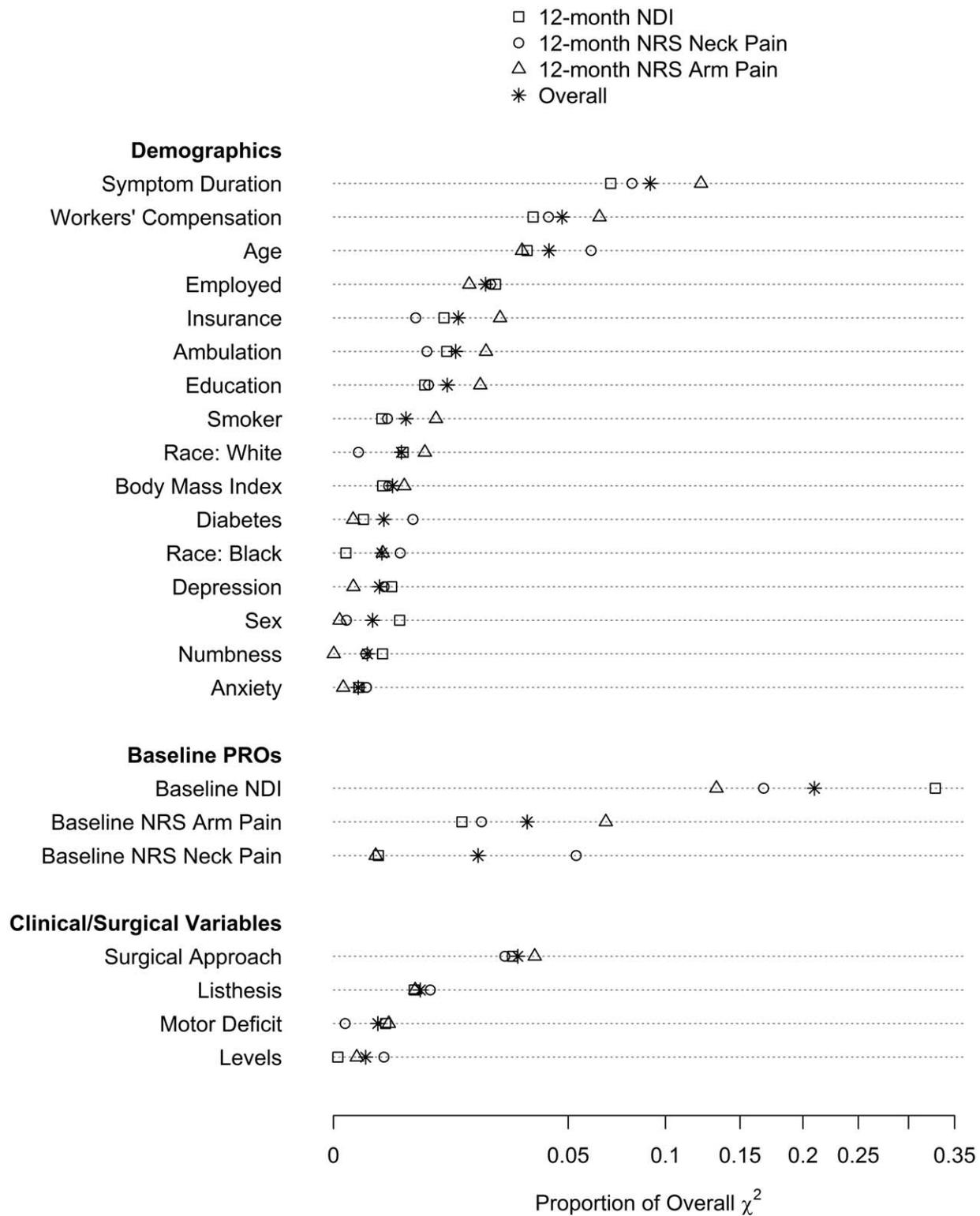


Figure 5. Importance of predictors, measured by Wald chi-square value minus the degree of freedom of the predictor, based on multivariable models. The overall rank is based on the average of the normalized values of the three multivariable models of patients with radiculopathy.

this patient, a provider could focus on providing reassurance about the surgical intervention. Patient B, a 66-year-old White, female who currently smokes and has myelopathy and a posterior decompression with fusion has higher mean predicted probabilities for NDI (45.9), neck pain (4.6), and arm pain (3.9) at 12-month follow-up, with a mean mJOA

predicted probability of 10.3. A discussion with Patient B could focus on nonsurgical treatment options and referral to address modifiable factors (*i.e.*, smoking and psychological distress). If Patient B chooses to undergo surgery, preoperative counseling could help set realistic expectations, which may ultimately increase patient satisfaction.^{67,68}

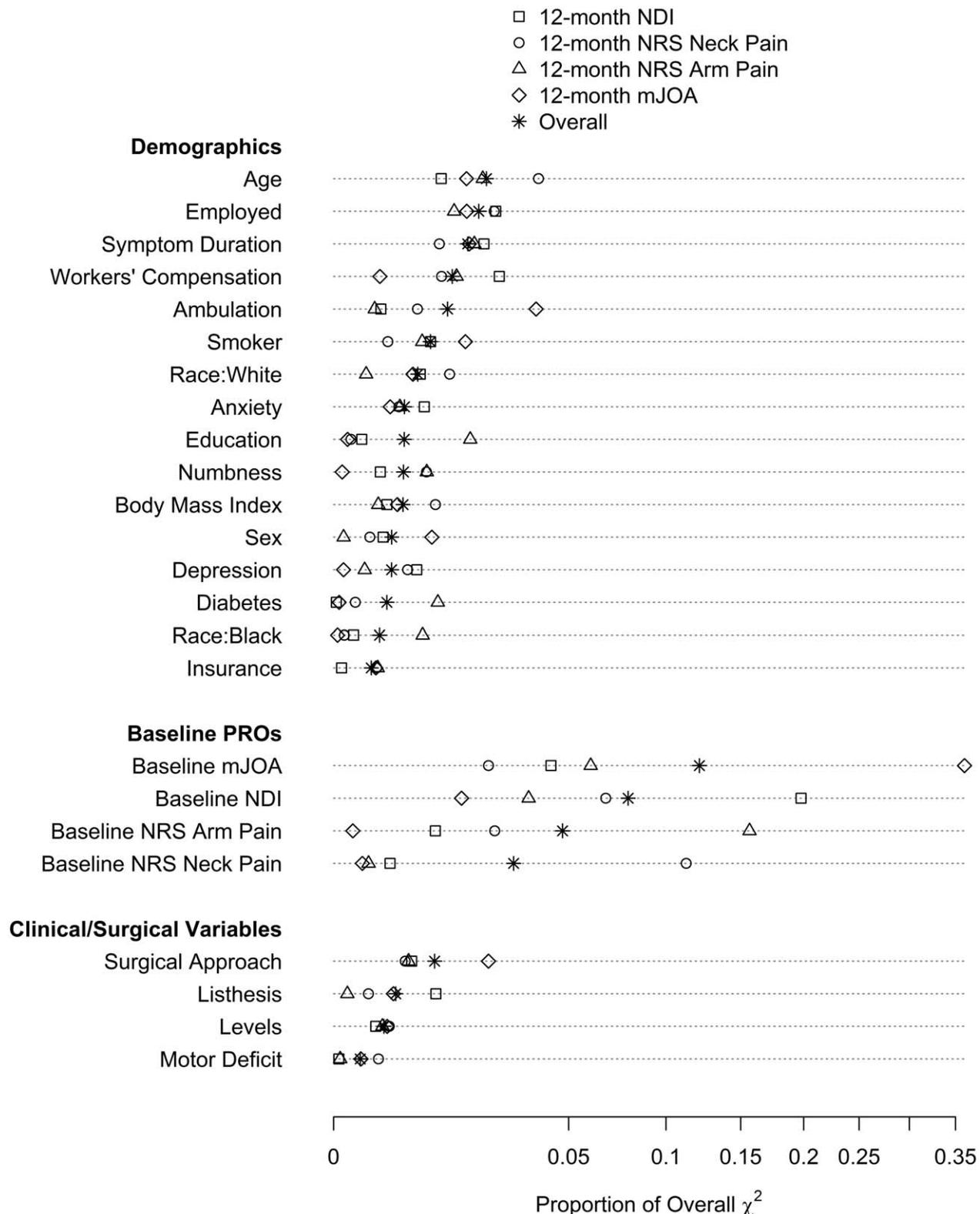


Figure 6. Importance of predictors, measured by Wald chi-square value minus the degree of freedom of the predictor, based on multivariable models. The overall rank is based on the average of the normalized values of the four multivariable models for patients with myelopathy.

The modern healthcare system is undergoing a rapid shift from traditional volume driven fee-for-service toward value-based reimbursement models.⁶⁹ Predictive models can be used to compare performance between providers and sites by comparing the observed and the risk-adjusted estimates

of outcomes.⁷⁰ Thus, the providers taking care of higher-risk patients (*i.e.*, more severe disease and comorbidities) can provide care with less concern for financial penalty. However, the “real-world” clinical application of predictive models faces issues of feasibility. The majority of

TABLE 2. Predicted Probabilities of Mean Outcome Scores at 12 Months After Cervical Spine Surgery Derived From Predictive Models for Hypothetical Patients

Characteristic	Patient A	Patient B
Pathology	Radiculopathy	Myelopathy
Age in years	35	66
Education	Postcollege	Postcollege
Race	White	White
Depression	Yes	Yes
Anxiety	No	Yes
Body mass index	30	35
Sex	Male	Female
Diabetes	No	Yes
Ambulation	Independent	With assistance
Insurance	Private	Medicare
Duration of symptoms	Less than 3 mo	Greater than 12 mo
Employed	Yes	No
Insurance	Private	Public
Numbness	Yes	Yes
Current smoker	No	Yes
Workers' compensation	No	No
Surgical approach	Anterior cervical discectomy and fusion	Posterior decompression with fusion
Listhesis	Yes	No
Number of levels	1	1
Motor deficit	Yes	Yes
Baseline disability (NDI)	40	68
Baseline neck pain (NRS)	9	9
Baseline arm pain (NRS)	7	6
Baseline mJOA	–	10
Predicted probabilities for 12 mo		
Mean disability (NDI)	8.235	45.872
Mean neck pain (NRS)	1.598	4.580
Mean arm pain (NRS)	0.731	3.857
Mean mJOA	–	10.250

NDI indicates neck disability index; NRS, numeric rating scale; mJOA, modified Japanese Orthopaedic Association.

evidence-based models are not used in clinical practice due to limited generalizability, poor discrimination indices, and the cost and time associated with implementation in a busy clinical setting. To address this, user-friendly online interfaces and web-based risk calculators can help with clinical implementation of predictive models (<https://statcomp2.app.vumc.org/cervical/>). Future research is needed to externally validate prediction models and pragmatically assess the clinical implementation of these risk calculators.

Limitations

An inherent limitation of clinical registries is the potential for selection bias. Even though QOD has a standardized enrollment process that requires centers to enroll patients

continuously or on a prespecified rotating cycle, we cannot ensure unbiased enrollment into the registry. This study reported a 61% follow-up rate for outcomes at 12 months. While no meaningful differences were found in baseline characteristics between those with and without complete data, we acknowledge the limitations associated with our follow-up rate. Studies have documented the negative impact of psychosocial characteristics, such as expectations and fear of movement, and opioids on patient-reported outcomes.^{71–76} Thus, there is a possibility that the models' discriminative performance would improve with the inclusion of a broader range of patient characteristic variables. A history of depression and anxiety was ascertained through patient self-report and the EMR. It is possible that using validated questionnaires may result in a stronger association between psychological distress and 12-month patient-reported outcomes.

CONCLUSION

This study developed and validated predictive models for 12-month patient-reported outcomes in patients undergoing elective spine surgery for degenerative cervical spine disease. The discrimination indices of these models ranged from 0.654 to 0.725, which are defined as “good” performance. The most important drivers of poor postoperative outcomes at 12-months were the baseline patient-reported outcome scores, in particular the NDI score for patients with radiculopathy and mJOA score for patients with myelopathy. The most important demographic characteristics included symptom duration, workers' compensation, age, employment, and ambulation and smoking status, while clinical/surgical variables contributed minimally. These predictive models have the potential to be used as a shared decision-making tool for evidence-based preoperative counseling.

➤ Key Points

- ❑ This study is a retrospective analysis of prospectively collected data from a national spine registry, the QOD—4988 patients underwent surgery for radiculopathy and 2641 patients for myelopathy.
- ❑ The most important predictor of poor postoperative outcomes at 12-months was the baseline Neck Disability Index score for patients with radiculopathy and mJOA score for patients with myelopathy.
- ❑ Symptom duration, workers' compensation, age, and baseline employment, ambulatory and smoking status were the most important demographic predictors of all 12-month patient-reported outcomes.
- ❑ A posterior surgical approach was associated with higher odds of having worse 12-month outcome scores; however, this variable was of minimal importance for the prediction models.

- Our predictive models provide individualized risk-adjusted estimates of 12-month disability, pain, and myelopathy outcomes for patients undergoing spine surgery for degenerative cervical disease.

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