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Preoperative Factors Predict Postoperative Trajectories of Pain and Disability Following Surgery for Degenerative Lumbar Spinal Stenosis

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Study Design. Longitudinal analysis of prospectively collected data.

Objective. Investigate potential predictors of poor outcome following surgery for degenerative lumbar spinal stenosis (LSS).

Summary of Background Data. LSS is the most common reason for an older person to undergo spinal surgery, yet little information is available to inform patient selection.

Methods. We recruited LSS surgical candidates from 13 orthopedic and neurological surgery centers. Potential outcome predictors included demographic, health, clinical, and surgery-related variables. Outcome measures were leg and back numeric pain rating scales and Oswestry disability index scores obtained before surgery and after 3, 12, and 24 postoperative months. We classified surgical outcomes based on trajectories of leg pain and a composite measure of overall outcome (leg pain, back pain, and disability).

Results. Data from 529 patients (mean [SD] age = 66.5 [9.1] yrs; 46% female) were included. In total, 36.1% and 27.6% of patients were classified as experiencing a poor leg pain outcome and overall outcome, respectively. For both outcomes, patients receiving compensation or with depression/depression risk were more likely, and patients participating in regular exercise were less likely to have poor outcomes. Lower health-related quality of life, previous spine surgery, and preoperative anticonvulsant medication use were associated with poor leg pain outcome. Patients with ASA scores more than two, greater preoperative disability, and longer pain duration or surgical waits were more likely to have a poor overall outcome. Patients who received preoperative chiropractic or physiotherapy treatment were less likely to report a poor overall outcome. Multivariable models demonstrated poor-to acceptable (leg pain) and excellent (overall outcome) discrimination.

Conclusion. Approximately one in three patients with LSS experience a poor clinical outcome consistent with surgical nonresponse. Demographic, health, and clinical factors were more predictive of clinical outcome than surgery-related factors. These

predictors may assist surgeons with patient selection and inform shared decision-making for patients with symptomatic LSS.

Key words: disability, disease course, pain, patient selection, prediction, prognostic factors, spinal stenosis, spinal surgery, trajectories, treatment outcome.

Level of Evidence: 2

Degenerative lumbar spinal stenosis (LSS) is a common source of pain and disability that negatively impacts the health-related quality of life of older people.[1] Approximately one in five adults 65 years or older experience symptomatic LSS,[1,2] which is the most frequent indication for spinal surgery in this age group.[3]

Symptoms of LSS typically include neurogenic claudication: pain and/or paresthesia in the gluteal region and legs, and functional limitations such as decreased walking capacity.[4,5] Evidence for the efficacy[6,7] and cost-effectiveness[8] of LSS surgery is promising, with the average patient experiencing a favorable postoperative course of pain and disability.[9] However, recent evidence suggests that many patients do not follow the average course of symptoms, with approximately one in three patients following an unfavorable postoperative pain or disability trajectory.[10]

The identification of patients with LSS who are unlikely to benefit from surgery could assist with preoperative shared clinical decision-making. Moreover, linking multiple outcomes may better represent the multidimensional effects of LSS on patients.[11] This study aimed to investigate the potential predictors of clinical outcome following surgery for symptomatic LSS. Specifically, we evaluated demographic, health, clinical, and surgery-related factors for their relationships with poor surgical outcomes defined by unfavorable trajectories of (1) leg pain intensity and (2) an overall outcome measure combining leg pain, back pain, and disability.

METHODS

Study Design and Participants

This study was a longitudinal analysis of prospectively collected data from patients enrolled in the Canadian Spine Outcomes and Research Network (CSORN) database. The CSORN is a multicenter initiative of orthopedic and neurological spine surgeons that includes a clinical outcome registry of patients undergoing spine surgery. Clinical outcomes were measured at the preoperative baseline and 3, 12, and 24 months after surgery.

We included data from patients 50 years and older, with a primary pathology of symptomatic LSS without spondylolisthesis and scoliosis, who underwent decompressive surgery with or without fusion. The principal pathology was determined by the treating spine surgeon prior to surgery. The CSORN project was initially approved by Research Ethics Boards local to each data collection site. The [Horizon Health Network] (2017–2568) and [University of New Brunswick] (2018–025) Research Ethics Boards approved the study protocol. All patients provided written informed consent to participate before study enrollment.

Potential Predictors of Outcome

All patients completed preoperative assessments, including standardized forms and questionnaires to collect demographic, health-related, and clinical information. Medical staff tracked additional clinical (*e.g.*, adverse events) and surgical details. All data were contemporaneously entered into the CSORN surgical registry.

Demographic and Health-Related Factors

Age, sex, and self-reported height and weight were collected at baseline. Body mass index was calculated as weight (kg)/height^2 (m^2). Compensation status was defined as participation in legal consultation, workers compensation, or other insurance claim related to the patient's back problem. Patients reported their frequency of exercise participation defined as 20 minutes or more of nonstop activities such as swimming, jogging, rapid walking, or resistance training. We defined regular exercise participation as exercising twice or more per week. Current smoking or use of nicotine products was self-reported.

We measured health-related quality of life with the Medical Outcomes Study Short Form 12-Item Health Status Survey version 2 (SF-12v2). The SF-12v2 includes 12 items used to calculate a physical component summary score and a mental component summary score. Each component ranges from 0 to 100, with higher scores indicating greater health-related quality of life. The physical and mental components are reliable and valid for use in the general population,[12] and people living with non-cancer pain.[13]

Clinical Factors

Patients reported their history of preoperative treatment, including previous spine surgery, therapeutic spinal injections, narcotic and anticonvulsant (*e.g.*, pregabalin, gabapentin) medications, as well as treatment with a physiotherapist or chiropractor for their spine problem. Clinical staff collected additional details of the patient's clinical status, including a history of depression, duration of their presenting complaint, and occurrence of sensory or motor deficit related to the presenting complaint.

Preoperative health was categorized using The American Society of Anaesthesiologists physical status (ASA) classification system.[14] ASA scores range from 1 ("A normal healthy patient") to 6 ("A declared brain-dead patient whose organs are being removed for donor purposes") and are used to predict preoperative risk.[15,16] We categorized patients as having normal to mild systemic disease (ASA I–II) or severe systemic disease or worse health status (ASA III or greater).

We screened for risk of depression using the Patient Health Questionnaire-8 (PHQ-8). The PHQ-8 is a valid measure of depression[17] and has been used for patients

undergoing spine surgery.[18,19] Scores more than or equal to 10 indicate moderate-to-severe risk of depression, a cut-point with 88% sensitivity and 88% specificity for major depression.[20]

Surgery-Related Factors

We calculated surgical wait time as the period from initial referral for surgical consultation to the date of surgery. The attending spine surgeon and surgical staff recorded surgical details including the use of fusion or minimally invasive techniques, the total time to complete the surgery, estimated blood loss, and the occurrence of intraoperative or postoperative adverse events. Surgical technique categories included decompression or decompression with fusion. Additionally, the use of minimally invasive procedures (decompression with or without fusion) was noted.

Clinical Outcomes

Pain and disability patient-reported outcomes were collected at preoperative baseline and 3, 12, and 24 months after surgery. Leg pain intensity and low back pain intensity were measured with separate 0 ("no pain") to 10 ("worst pain imaginable") point numeric pain rating scales.[21] Patients rated their typical pain experienced over the preceding 24 hours. The numeric pain rating scale has a minimum level of important change estimated to be 30%.[22]

We quantified disability related to leg and back pain with the modified Oswestry disability questionnaire.[23] Possible scores range from 0 to 100, with higher values indicating greater disability. The minimum level of important change is estimated to be 30%,[22] while clinical success is indicated by achieving a 50% reduction or a score less than 22.[24,25]

Data Analysis

Identification of Surgical Outcome Trajectories

To account for the multidimensional nature of the patient experience, patient-reported outcome scores were used to construct two surgical outcomes measures: leg pain and overall outcome (leg pain, back pain, and disability). We previously reported the results of our group-based trajectory model that identified three distinct leg pain trajectory groups.[10]

Overall outcome was estimated with a group-based multi-trajectory model that identified latent clusters (subgroups) of individuals who follow similar trajectories across multiple outcomes.[26] We constructed this model as an empirical means to identify clusters of individuals who followed a similar course of leg and back pain together with disability. Trajectory models are a person-centered approach in that each patient is fit to a trajectory subgroup. This contrasts with variable-based approaches (*e.g.*, regression) that do not typically account for individual variation and assume a "one size fits all" model for understanding symptom onset and progression. In this way, trajectory models share a perspective similar to the way that clinicians conceptualize clinical outcomes.[27]

The multi-trajectory model applied censored normal distributions of each outcome measure. Patients with less than two follow-up measures and those with minimal preoperative leg or back pain (numeric pain rating scale < 3) or disability (Oswestry ≤ 20) were excluded from the analysis. Missing outcome data were handled with maximum likelihood estimation, resulting in asymptotically unbiased parameter estimates when data are missing at random.[27]

We followed a standardized model selection procedure to identify the optimal number of outcome subgroups. As model selection cannot be reduced to a singular approach,[27] our decision-making was informed by (1) the univariate outcome trajectories, (2) Bayesian information criterion statistics, (3) models diagnostics, and (4) clinical judgment.[26] We first constructed a single group model, and increased the number of subgroups and the complexity of polynomial distributions until optimal models were identified. Model diagnostic criteria comprised: a minimum average posterior probability of individual group membership of 0.7, close correspondence between the estimated and assigned probabilities of group membership, precise confidence intervals around estimated group membership probabilities, and odds of correct classification greater than 5.[27,28] We have reported additional information regarding out trajectory modeling approach for the univariate models elsewhere.[10]

Leg pain and overall outcome trajectory classes were labeled according to the magnitude of change in the numeric pain rating scale and Oswestry index. For example, minimal postoperative pain or disability was considered to represent an excellent outcome, while minimal improvement was considered a poor outcome.

We calculated the proportion of patients within each trajectory who met five clinical benchmarks at the 12-month follow-up. Benchmarks were the minimum important change (30%) in leg pain, back pain, and disability,[22] as well as relative (50% improvement)[24] and absolute (≤22)[25] estimates of clinical success based on Oswestry scores. Twelve-month outcomes were used as patient-reported outcomes typically stabilize 1 year after LSS surgery.[29]

Identification of Outcome Predictors

We investigated potential predictors of poor outcome using mixed-effects logistic regression models with robust standard errors. To account for within-surgeon clustering, we entered surgeon identifiers as random effects. We adjusted all models for age, sex, and preoperative leg pain intensity (leg pain outcome) or preoperative disability (overall outcome). Model results were reported with odds ratios (OR) and 95% confidence intervals (95% CI). When significant categorical predictors were identified, we also converted odds ratios to number needed to be exposed to harm (NNEH) or benefit (NNEB) statistics.[30]

Multivariable Prediction Models

Multivariable prognostic models for each outcome were developed using the same mixed-effects logistic regression

modeling procedure used to identify individual predictors. All predictors associated with surgical response at the $P \leq 0.10$ significance level were entered. We then applied a sequential backward variable manual selection procedure.[31] The predictor with the highest P-value was removed one-by-one until all variables had a P-value ≤ 0.05. We tested for collinearity with variance inflation factor (VIF) and tolerance statistics and considered VIF less than or equal to 0.2 or greater than or equal to 5.0 or tolerance less than 0.1 as indicative of collinearity.[32]

To quantify model discrimination, we constructed receiver operating characteristic curves and calculated the total area under the curve (AUC).[33] AUC values between 0.5 and less than 0.7 indicate poor discrimination, while scores between 0.7 and less than 0.8, 0.8 to less than 0.9, and 0.9 to less than 1.0 represent acceptable, excellent, and outstanding discrimination.[34] All analyses were performed with Stata 15.1 software (StataCorp, College Station, TX).

RESULTS

In total, 529 patients from 13 spine centers contributed data to the trajectory models (Figure 1). Sample sizes for predictors ranged from 235 to 529, owing to between-site differences in the early implementation of CSORN procedures. Table 1 includes preoperative demographic, health, and clinical information, as well as surgical details for the sample population.

Clinical Outcome Trajectories

The group-based multi-trajectory model of overall surgical outcome achieved satisfactory performance according to our predefined criteria (Table 2). We previously reported the results of a univariate group-based trajectory model that demonstrated three distinct leg pain groups, with 36.1% of patients categorized as experiencing a poor outcome (Figure 2).[10] Similarly, the multi-trajectory model of overall clinical outcome (leg pain, back pain, and disability) estimated that 30.5% of patients experienced an excellent clinical outcome and 41.9% of patients experienced a good clinical outcome. In total, 27.6% of patients were classified as following pain and disability trajectories indicative of poor overall outcome (Table 3, Figure 3). Table 4 reports the proportion of patients who met the clinical benchmarks of clinical success and minimum important change. Approximately 90% of patients assigned to the excellent overall outcome group achieved a successful outcome at 12 months, while less than 2% of patients assigned to the poor overall outcome group met these criteria. More than 9 in 10 patients in the excellent overall outcome group and 17.2% to 43.0% of patients in the poor overall outcome group met the benchmarks for minimum important change in pain or disability. Similar results for the leg pain model have been reported previously.[10]

Perioperative Predictors Associated with Surgical Non-response

After controlling for age, sex, and baseline leg pain or disability, we identified 14 factors that were associated with trajectories of leg pain or overall outcome (Figure 4).

Demographic and Health-related Predictors

Patients involved in legal consultation, workers compensation, or other insurance claim related to their back problem were more likely to experience poor leg pain (OR[95% CI] = 2.96[1.34–6.57]; NNEH = 3.8 patients) and overall (OR[95% CI] = 3.40[1.56–7.44]; NNEH = 3.6) outcomes.

Patients who engaged in regular preoperative exercise were less likely to be classified as members of the poor leg pain (OR[95% CI] = 0.69[0.50–0.94]; NNEB = 12.2 patients) or overall (OR[95% CI] = 0.54[0.39–0.75]; NNEB = 8.5) outcome subgroups. Worse health-related quality of life (1 SD change) on the SF-12v2 physical (OR[95% CI] = 1.16[1.02–1.33]) and mental (OR[95% CI] = 1.32[1.09–1.59]) component scores were associated with increased odds of poor leg pain outcome only.
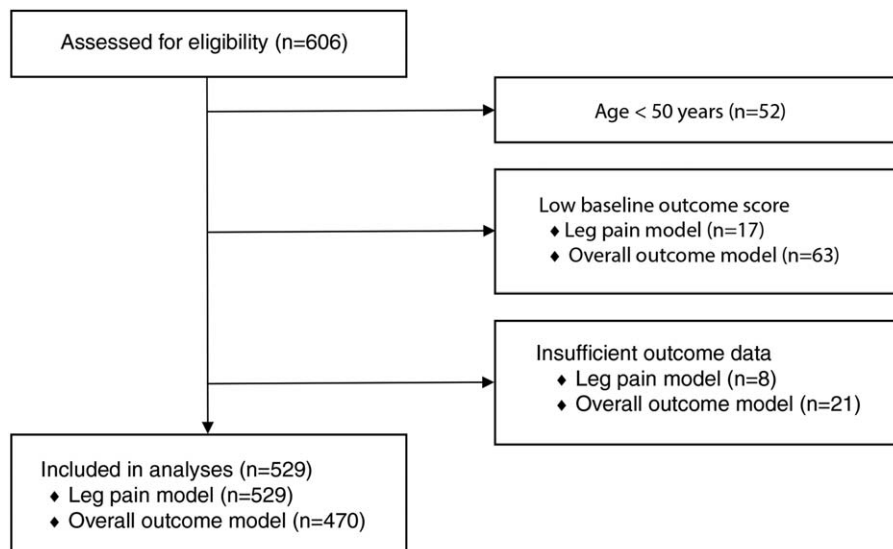

Figure 1. Study flow diagram.

TABLE 1. Preoperative Characteristics and Surgical Details (N = 529)

Variable	Sample Size	Value
Age	529	66.5 ± 9.1
Female sex	529	242 (45.8%)
Body mass index	510	29.6 ± 5.8
Compensation	258	46 (17.8%)
Regular exercise	516	182 (35.3%)
Current smoking/nicotine	520	80 (15.4%)
PCS	499	32.1 ± 8.1
MCS	499	48.7 ± 8.3
ASA score >2	289	90 (31.1%)
Comorbid depression	529	59 (11.2%)
PHQ-8 moderate to severe	294	94 (32.0%)
Complaint duration	529	
<1 year		311 (58.8%)
1–2 year		79 (14.9%)
>2 year		139 (26.3%)
Neurological deficit	421	235 (55.8%)
Previous spine surgery	519	135 (26.0%)
Medication, opioids	240	134 (55.8%)
Medication, anticonvulsants	235	108 (46.0%)
Spinal injection	269	98 (36.4%)
Physiotherapy	272	94 (34.6%)
Chiropractic	271	51 (18.8%)
Surgery wait time, d*	269	263 (119 to 601)
Fusion surgery	524	308 (58.8%)
Minimally invasive surgery†	529	173 (32.7%)
Number of operated spinal levels	525	
1		248 (47.2%)
2		145 (27.6%)
3		67 (12.8%)
>3		65 (12.4%)
Procedure time, min	277	156.1 ± 90.6
Surgical blood loss, mL	515	407.9 ± 458.9
Perioperative adverse event	529	110 (20.8%)

Values are number (percentage) or mean ± SD unless otherwise specified.
*Median (interquartile range).
†Decompression with or without fusion.

Clinical Predictors

Patients with comorbid depression were more likely to experience a poor leg pain outcome (OR[95% CI] = 2.10[1.33–3.31]; NNEH = 5.6) and poor overall outcome (OR[95% CI] = 2.03[1.12–3.69]; NNEH = 6.4). Similarly, patients with PHQ-8 scores indicating moderate-to-severe risk for depression demonstrated increased odds of poor leg pain (OR[95% CI] = 2.15[1.44–3.21]; NNEH = 5.6) and overall (OR[95% CI] = 2.02[1.17–3.50]; NNEH = 7.7) outcome.

Patients who reported a previous spine surgery (OR[95% CI] = 1.76[1.28–2.43]; NNEH = 7.4), or use of anticonvulsant medications (OR[95% CI] = 2.25[1.24–4.09]; NNEH = 5.2)

TABLE 2. Diagnostic Results for the Group-Based Multi-trajectory Model of Overall Outcome

	Average Posterior Probability*	Estimated Membership (95% CI)	Assigned Membership	Odds of Correct Classification†
Multi-trajectory groups (N = 491)				
''Excellent outcome''	0.94	30.5 (25.1–36.0) %	30.4%	34.80
''Good outcome''	0.91	41.9 (36.3–47.4) %	41.7%	13.45
''Poor outcome''	0.92	27.6 (21.9 to 33.3) %	27.9%	30.66

*Minimum acceptable threshold = 0.70.
†Minimum acceptable threshold = 5.0.
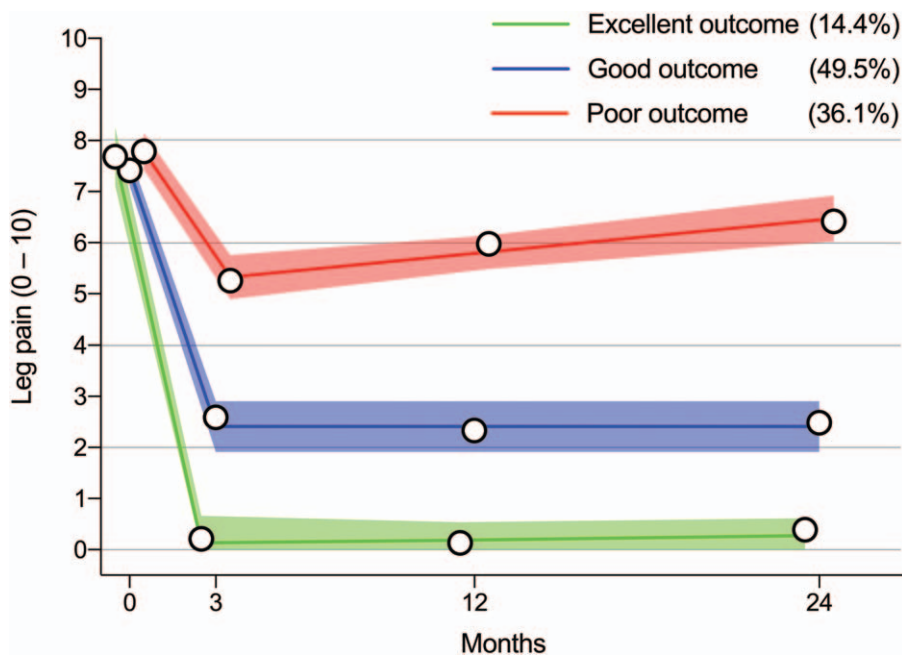
Figure 2. Clinical outcome trajectory groups for leg pain with prevalence estimates (N = 529). Point estimates are average outcome scores (0–10 numeric pain rating scale). Shaded areas represent 95% confidence intervals.

before surgery were more likely to be classified as experiencing a poor outcome. Patients with an ASA score more than two were more likely to have a poor overall outcome (OR[95% CI] = 2.09[1.13–3.87]; NNEH = 6.4 patients), as were those with preoperative pain duration more than 2 years (OR[95% CI] = 2.65[1.12–6.25]; NNEH = 4.6), and those with higher baseline Oswestry disability scores (OR[95% CI] per 10 points = 1.70[1.37–2.12]). Patients receiving preoperative treatment with a chiropractor (OR[95% CI] = 0.32[0.15–0.66]; NNEB = 5.5) or physiotherapist (OR[95% CI] = 0.40[0.18–0.87]; NNEB = 6.1) were less likely to have a poor overall outcome.

Surgery-related Predictors
Patients with longer wait times for surgery were more likely to experience a poor overall outcome (OR[95% CI] per 180 days = 1.07[1.02–1.12]). No other surgical factors were associated with leg pain or overall outcome classification.

Multivariable Prediction Models
Table 5 shows the final predictive model results. The leg pain outcome model included four predictors, and the overall outcome model included six predictors. Mean VIF was 1.02 to 1.04 and tolerance statistics ranged from 0.94 to 1.00, indicating low risk for collinearity in both models. The leg pain outcome model demonstrated poor-to-acceptable (AUC[95% CI] = 0.69[0.62–0.76]) discrimination, and the overall outcome model demonstrated excellent (AUC[95% CI] = 0.83[0.77–0.89]) discrimination.

DISCUSSION
This study aimed to investigate potential predictors of poor clinical outcome following LSS surgery. The primary study

TABLE 3. Descriptive Clinical Outcomes Stratified by Overall Clinical Outcome Trajectory Group

	Preoperative	3 Months	12 Months	24 Months
Leg numeric pain rating scale score				
"Excellent outcome"	7.7 ± 1.7	1.3 ± 2.0	1.0 ± 1.6	1.3 ± 1.8
"Good outcome"	7.3 ± 1.6	3.7 ± 2.7	3.5 ± 2.6	3.9 ± 2.6
"Poor outcome"	8.0 ± 1.6	5.0 ± 2.8	6.0 ± 2.5	6.2 ± 2.4
Back numeric pain rating scale score				
"Excellent outcome"	7.4 ± 1.7	1.4 ± 1.4	1.4 ± 1.5	1.5 ± 1.6
"Good outcome"	7.1 ± 1.7	3.5 ± 2.0	3.3 ± 1.9	3.7 ± 2.3
"Poor outcome"	8.0 ± 1.4	5.5 ± 2.0	6.2 ± 1.8	6.7 ± 1.6
Modified Oswestry disability index score				
"Excellent outcome"	43.9 ± 12.0	17.7 ± 13.4	9.7 ± 9.2	12.8 ± 11.5
"Good outcome"	47.7 ± 12.4	35.0 ± 16.1	28.0 ± 14.2	30.9 ± 13.1
"Poor outcome"	54.4 ± 12.4	49.9 ± 13.9	48.6 ± 11.5	51.0 ± 10.7
Values are mean ± SD.				
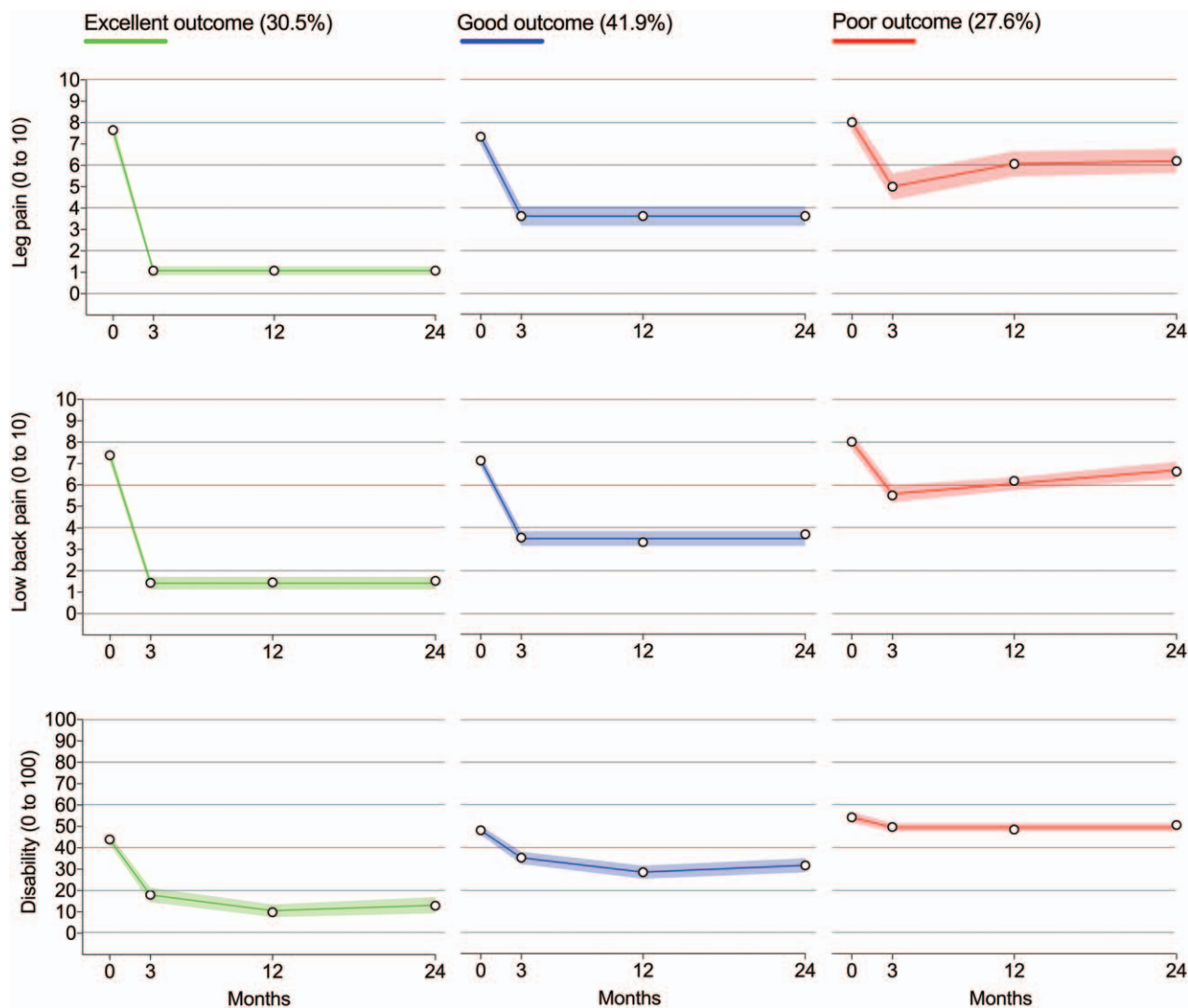
Figure 3. Clinical outcome multi-trajectory groups comprising leg pain, low back pain, and Oswestry disability scores with prevalence estimates (N = 470). Point estimates are average outcome scores. Shaded areas represent 95% confidence intervals.

findings were (1) the identification of individual and multi-variable outcome predictors, and (2) the reporting of a new composite multi-trajectory model comprising leg pain, back pain, and pain-related disability outcomes. The trajectory models indicated that 28.1% (overall outcome) to 36.1% (leg pain outcome) of patients experienced a poor outcome, suggesting that approximately one in three patients were surgical non-responders. Demographic, health, and clinical factors appeared to be more relevant to clinical outcomes than surgery-related factors and a multivariable model of overall outcome demonstrated greater discrimination than the leg pain model. This information may assist surgeons with patient selection and inform shared decision-making prior to surgery.

Based on these results, NNEH estimates ranged from four to eight, and NNEB estimates ranged from six to 13. This means that exposing four to eight patients to a potentially "harmful" predictor was associated with one additional patient having a poor surgical outcome. Conversely, exposing six to 13 patients to a "beneficial" predictor was associated with one fewer poor outcome. The final multivariable leg pain and overall outcome models demonstrated poor-to acceptable and excellent discrimination, respectively.

We found preoperative therapies and engagement in regular preoperative exercise to be potentially important predictors of clinical outcome. After controlling for preoperative leg pain intensity, age, and sex, patients who used anticonvulsant medications before surgery were more likely to be classified as members of the poor outcome group for leg pain. A recent systematic review found moderate-to-high-quality evidence that anticonvulsant medications such as pregabalin and gabapentin are ineffective for low back pain or lumbar radicular pain.[35] Among patients with neurogenic claudication, pregabalin results in greater pain-related disability and more adverse events compared with placebo.[36] We found that treating six patients with anticonvulsant medications was associated with one

TABLE 4. Proportion of Patients Meeting 12-month Clinical Outcome Benchmarks, Stratified by Trajectory Group

|	Leg pain MIC[1]	Back pain MIC[2]	ODI MIC[3]	Relative ODI success[4]	Absolute ODI success[5]
Overall outcome trajectory groups					
1, 'excellent'	97.2%	98.0%	93.7%	90.2%	89.5%
2, 'good'	70.6%	76.4%	63.3%	40.8%	38.8%
3, 'poor'	43.0%	35.4%	17.2%	1.6%	1.6%

1: ≥30% reduction in NRS for leg pain
2: ≥30% reduction in NRS for back pain
3: ≥30% reduction in ODI
4: ≥50% reduction in ODI
5: ODI score ≤22

Green ≥75%; yellow 50 to 74%; red <50%

MIC = minimum important change; ODI = modified Oswestry disability index; NRS = numeric rating scale

additional patient experiencing a poor outcome, suggesting that anticonvulsant medications also negatively impact leg pain outcomes following surgery. Our findings, together with the previous evidence, question the use of anticonvulsant medications in patients with symptomatic LSS.

To our knowledge, previous studies have not evaluated the role of regular exercise, or chiropractic or physiotherapy treatment in LSS surgery outcomes. Preoperative physiotherapy is associated with increased leg pain intensity but not disability following lumbar discectomy for disc
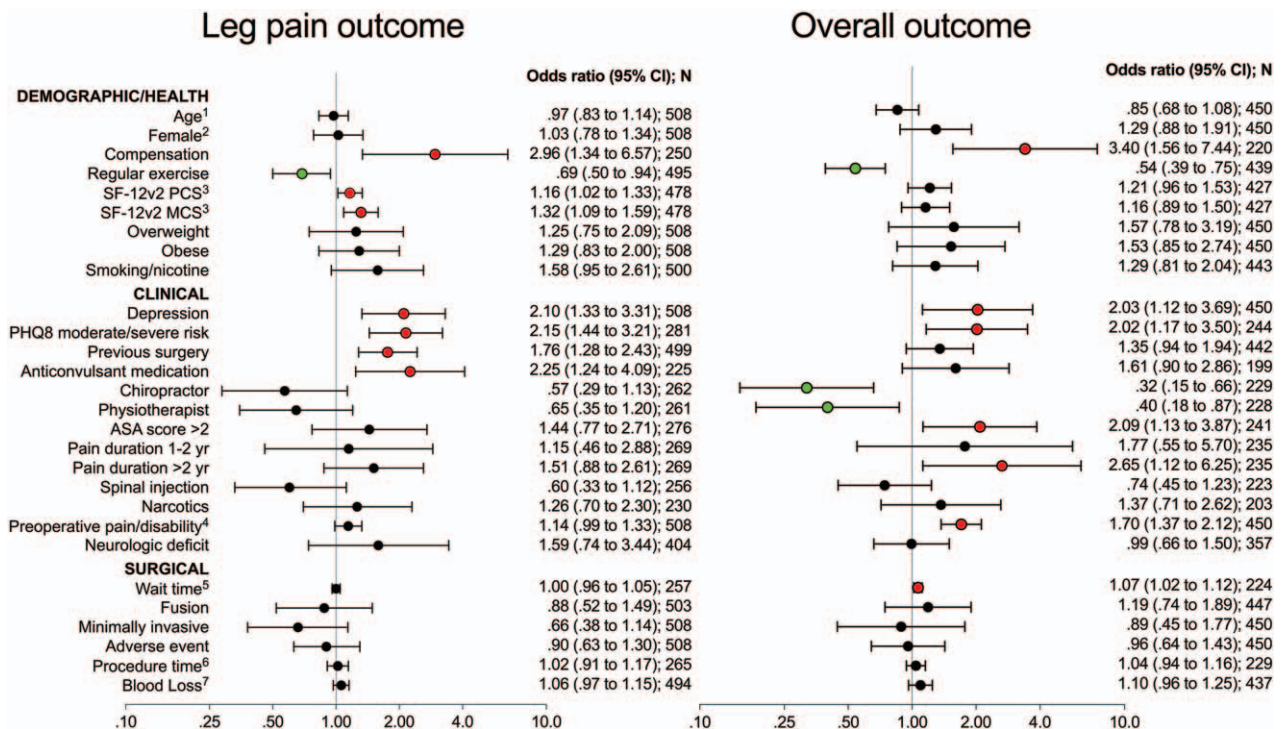
Figure 4. Potential predictors of leg pain and overall surgical non-response. All variables adjusted for age, sex, and preoperative leg pain (leg pain outcome) or disability (overall outcome) unless otherwise indicated. 1 = adjusted for sex and preoperative leg pain (leg pain outcome) or preoperative disability (overall outcome) and expressed as odds per 10 years. 2 = adjusted for age and preoperative leg pain (leg pain outcome) or preoperative disability (overall outcome). 3 = reverse scored (100-score) and expressed as odds per standard deviation. 4 = adjusted for age and sex, disability expressed as odds per 10 points. 5 = odds per 180 days. 6 = odds per 30 minutes. 7 = odds per 200 mL. ASA indicates American Society of Anaesthesiologists physical status; MCS, mental component score; PCS, physical component score; PHQ8, Patient Health Questionnaire-8 score; SF-12v2, Medical Outcomes Study Short Form 12-Item Health Status Survey version.

TABLE 5. Final Multivariable Prognostic Models of Factors Associated with Poor Leg Pain Outcome and Poor Overall Clinical Outcome

Predictor	Odds Ratio (95% CI)	P Value	AUC (95% CI)
Leg pain outcome (n = 239)			
Preoperative leg pain intensity	1.35 (1.15–1.59)	<0.001	
Compensation	2.04 (1.11–3.72)	0.021	
SF-12v2 mental component score*	1.34 (1.02–1.77)	0.037	
Regular preoperative exercise	0.52 (0.27–1.00)	0.048	
			0.69 (0.62–0.76)
Overall outcome (n = 153)			
Preoperative disability†	1.97 (1.48–2.84)	<0.001	
Surgery wait time‡	1.06 (1.04–1.10)	<0.001	
Pain duration >2 years	3.16 (1.53–6.54)	0.002	
Regular preoperative exercise	0.34 (0.15–0.78)	0.010	
Chiropractic treatment	0.35 (0.15–0.83)	0.018	
Compensation	2.83 (1.12–7.17)	0.028	
			0.83 (0.77–0.89)

*Reverse scored (100-score), and expressed as odds per standard deviation (8.3 points).
†Odds per 10 points.
‡Odds per 180 days.
AUC indicates area under the curve; SF-12v2, Medical Outcomes Study Short Form 12-Item Health Status Survey version 2.

herniation.[37] We found that patients who engaged with preoperative exercise (NNEB = 9–13) and treatment with a chiropractor/physiotherapist (NNEB = 6–7) were less likely to experience a poor outcome. The potential for exercise, chiropractic, and physiotherapy to improve postoperative outcomes following LSS surgery will be important topics for future research.

Systematic reviews report preoperative depression to be associated with increased pain[38] and disability[39] after LSS surgery. We found that patients reporting depression or elevated risk of depression were twice as likely (OR = 1.82–2.15) to have a poor outcome. Previous spine surgery and a preoperative ASA score greater than two have been associated with greater 12-month disability after LSS surgery.[40] While we found similar associations between these factors and clinical outcome, the relationships were not consistent between the different outcome models, indicating that the relevance of prior surgery and ASA score may be outcome specific.

One prospective study reported modest differences in pain and disability (8–9/100 points) between normal-weight and obese patients 2 years after surgery for LSS,[41] while another study reported no association between body mass index and clinical outcome.[40] Our results did not indicate preoperative overweight or obesity status to be predictors of postoperative leg pain or overall outcome trajectories. Similarly, a recent study reported small differences in disability (4.2/100 points) among smokers and non-smokers 1 year after micro-decompression for LSS,[42] while we found no association between smoking/use of nicotine products and outcome. Differences in study populations or measurement protocols may explain the conflicting results.

This study had several strengths and weaknesses. We included patient data from a national spine surgery registry that utilizes standardized patient-centered outcomes.

Outcome trajectories were modeled with novel person-centered statistical techniques, including a composite outcome model that may better reflect the complex postoperative pain and disability experiences of patients. Although we were able to estimate missing outcome data, between-center procedural differences in the collection of prognostic information resulted in missing data for some predictors. Because of the systematic mechanism of missing data, we were unable to impute missing information, and this may have increased the risk of overfitting in some models. Although observational designs are appropriate for the identification of outcome predictors, future randomized trials are needed to evaluate the ability of the factors to modify the effects of surgery. Finally, we were unable to assess the outcomes associated with some specific surgical techniques (e.g., osteotomy, lumbopelvic fusion). However, evidence to date shows no differences between different types of surgery.[43]

➤ Key Points

❑ In this longitudinal study of 529 patients with symptomatic degenerative lumbar spinal stenosis, approximately one in three patients were classified as experiencing a poor outcome following surgery.

❑ Demographic, health, and clinical factors were more predictive of clinical outcome than surgery-related factors.

❑ The identification of preoperative factors that predict clinical outcome may assist surgeons with patient selection and inform shared decision-making for patients with symptomatic degenerative lumbar spinal stenosis.

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