

A Supervised Machin Learning Approach to the Identification of Risk Factors for Spinal Cord and Sacral Nerve Stimulator Explantation

Peyton Murin, MD (1), Patrick Murin (2), Yuri Chaves Martins, MD, PhD (3)

1. Department of Neurology, SSM Health/Saint Louis University, Saint Louis, Missouri
2. Department of Psychology, Rhodes College, Memphis, Tennessee
3. Department of Anesthesiology and Critical Care, SSM Health/Saint Louis University, Saint Louis, Missouri

Introduction

- Spinal Cord Stimulators (SCS) are used for the treatment of chronic pain resistant to conservative therapies. Sacral nerve stimulators (SNS) are used for the treatment of overactive bladder and urinary retention.
- However, due to the high costs associated with trial and implant of these devices, it is increasingly important to accurately identify patients at high risk of early explantation.
- Previously certain psychiatric and social comorbidities have been identified as risks factors for explantation. However, given the paucity of robust evidence, attempts to establish guidelines have been unsuccessful.

Materials and Methods

- Data was collected and compiled from the MOVER database.
- Basic chi-square analysis was performed for each risk factor in the overall, SCS, and SNS cohorts.
- Data was imported into Anaconda (Anaconda Software Distribution. Austin, TX) with the following add-ons used for analysis: pandas, numpy, sklearn, sklearn extra, matlab, and seaborn.
- The data was scaled, and the classes were balanced. The data was split into training and testing, with performance assessed using precision, recall, f-score, and area under the curve.
- Once performance was deemed satisfactory, the model was used to calculate odds ratios and 95% confidence intervals for each assessed variable.

Conclusions/Discussion

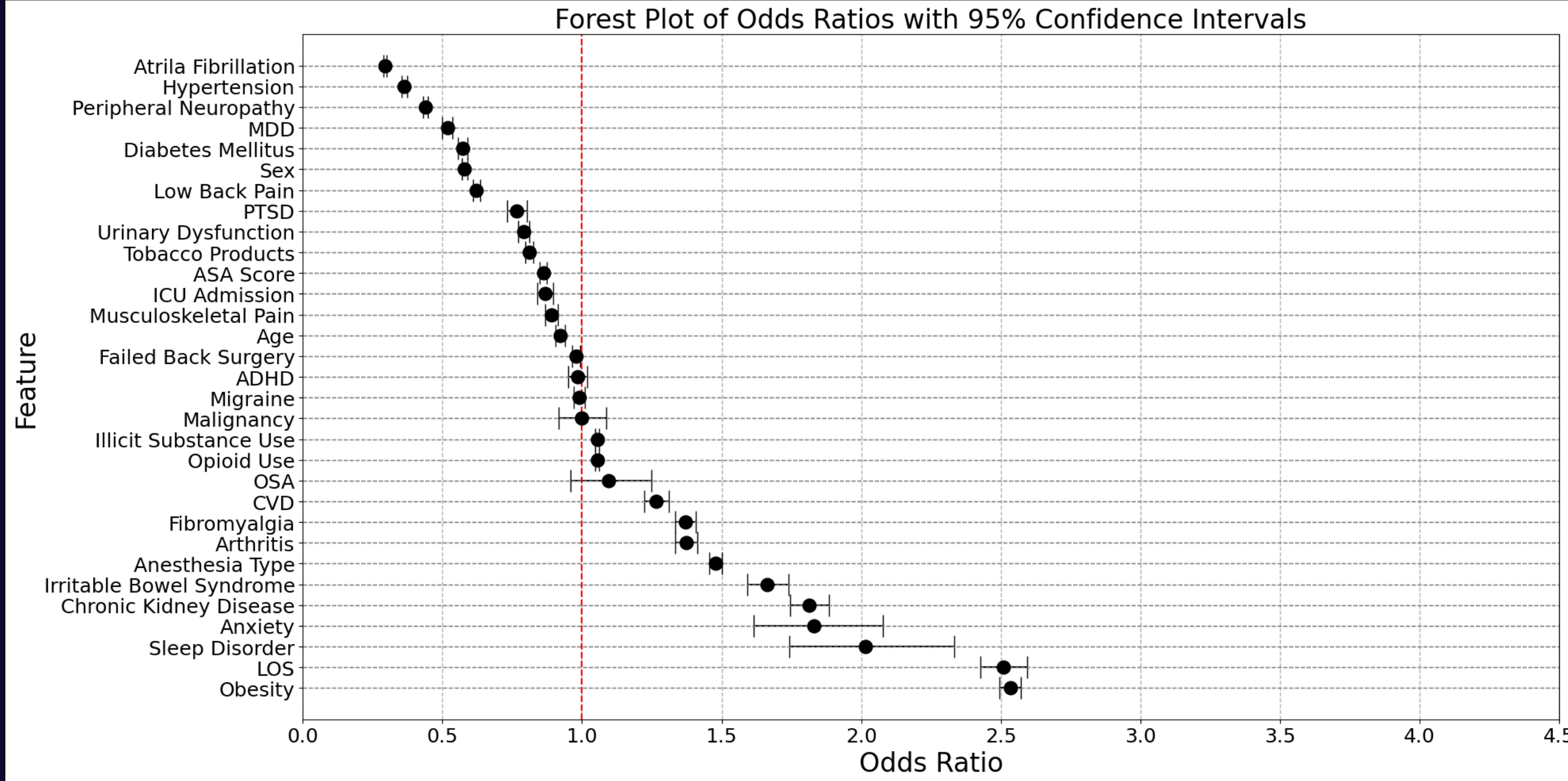
- We applied supervised machine learning in the form of a multivariate logistic regression to a well characterized, publicly available cohort (MOVER), identifying many important, novel risk factors for SCS and SNS explantation.
- The logistic regression model displayed excellent performance for the overall cohort (AUC: 0.87) and SCS subgroup (AUC: 0.82) cohort. However, performance was less robust within the SNS subgroup (AUC: 0.63).
- History of sleep disorders, malignancy, and chronic kidney disease were highly predictive of early explantation within the overall cohort.
- History of malignancy and arthritis were the most predictive factors for early SNS explantation.
- Sleep disorders, obesity, and CKD appear to be the most predictive risk factors for early SCS explantation.
- Previous literature has primarily focused on psychiatric and social comorbidities. However, our analysis would suggest that these factors offer only limited predictive value compared to other medical comorbidities.

Univariate Analysis with Chi-Square Offers Limited Predictive Value

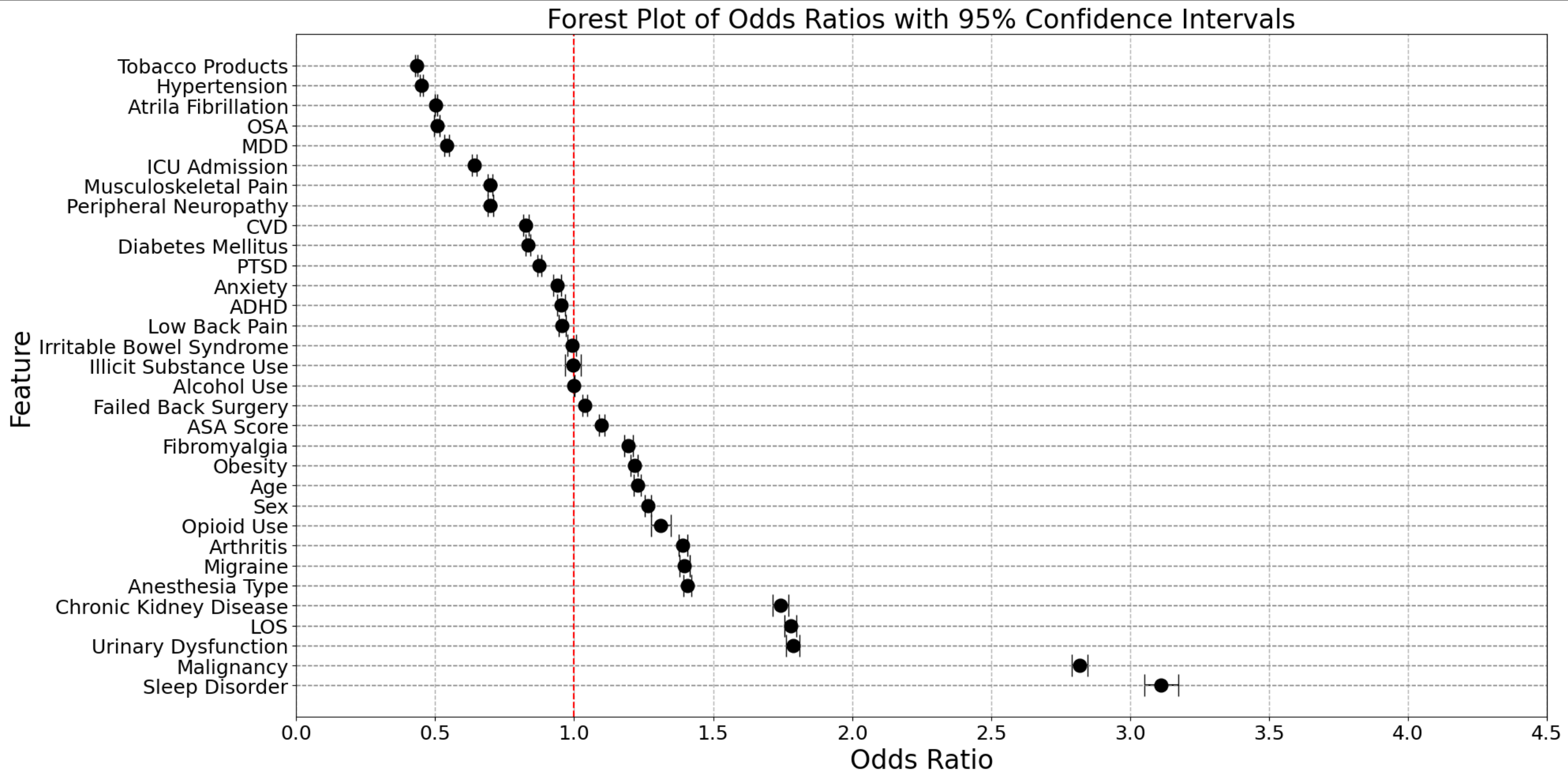
Risk Factor	Odds Ratio – Overall	p-value	Odds Ratio – Lumbar/Thoracic	p-value	Odds Ratio – Sacral	p-value
Female Sex	3.000*	0.0211	0.9890	1.000	5.142	0.1460
Monitored Anesthesia Care	2.573*	0.0203	1.370	0.9176	0.9441	1.000
ICU Admission	0.3836	0.7358	0.9556	1.000	ID	ID
Indication for SCS***						
• Failed Back Surgery n (%)	0.7733	0.9596	2.222	0.4682	ID	ID
• Peripheral Neuropathy n (%)	0.7639	0.8398	0.3167	0.4979	2.576	0.6918
• Low Back Pain n (%)	0.2722*	0.0017	0.5882	0.5805	0.9412	1.000
• Cervical Pain n (%)	0.5600	0.5444	0.9524	1.000	0.4444	0.8118
• Urinary Dysfunction	4.762*	0.0002	1.5385	0.8838	<0.0001	1.000
Past Medical History						
• Cerebrovascular Disease	0.7821	1.000	3.143	0.5805	<0.0001	0.6996
• Obstructive Sleep Apnea	0.7176	0.7048	1.583	0.8838	0.3059	0.2105
• Sleep Disorder	1.1209	0.9786	1.583	0.7671	0.6933	0.8276
• Hypertension	0.6283	0.4143	0.8461	1.000	0.6563	0.8310
• Hyperlipidemia	0.6000	0.3802	1.909	0.4690	0.2229	0.1148
• Atrial Fibrillation	0.1536	0.1122	<0.0001	0.4000	0.2162	0.4960
• Diabetes Mellitus	0.3176	0.1483	<0.0001	0.2309	0.4286	0.5970
• Chronic Kidney Disease	1.8235	0.8459	10.385	0.0829	<0.0001	0.6996
• Anxiety	1.0628	1.000	0.3714	0.6250	1.806	0.7596
• Depression	0.6750	0.6573	0.2400	0.3091	2.727 e^10	0.2666
• ADHD	<0.0001	1.000	<0.0001	1.000	ID	ID
• OCD	ID	ID	ID	ID	ID	ID
• PTSD	<0.0001	1.000	<0.0001	1.000	ID	ID
• Fibromyalgia	3.706	0.4942	10.384	0.0829	ID	ID
• Irritable Bowel Syndrome	2.423	0.8814	6.429	0.3262	ID	ID
• Obesity	1.213	0.9575	3.030	0.2069	0.9444	1.000
• Migraine	3.163	0.3105	1.467	1.000	2.118 e^10	0.3827
• Musculoskeletal Pain	1.036	1.000	1.583	0.7671	0.4877	0.3900
• Arthritis	2.450	0.1034	4.920*	0.0432	1.333	0.9795
• Malignancy	4.621*	0.0361	2.048	0.8231	4.800 e^10	0.0903

Using A Multivariate Logistic Regression Model, We Identified Several Novel Risk Factors for Spinal Cord and Sacral Nerve Stimulator Explantation

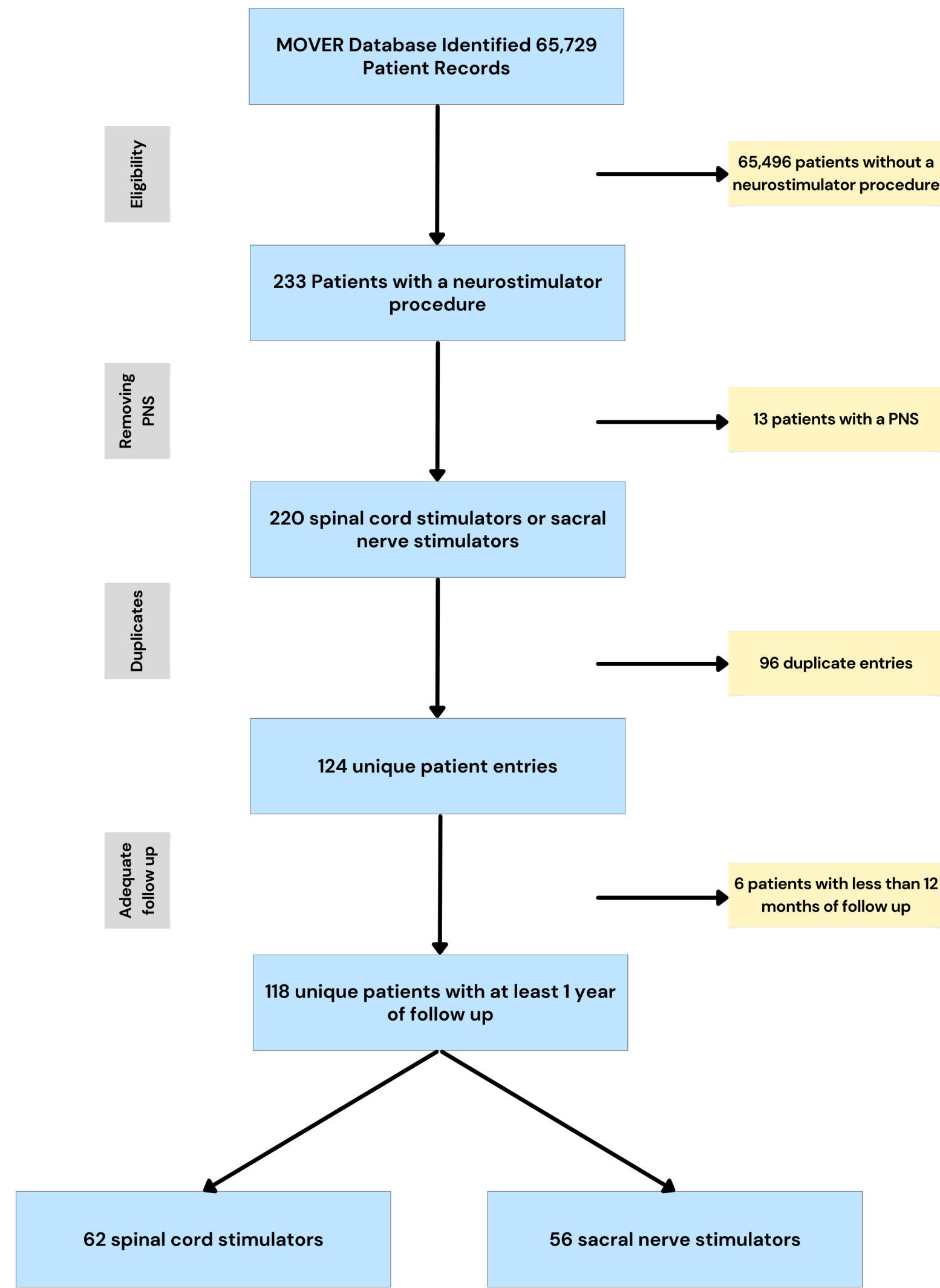
Spinal Cord Stimulator



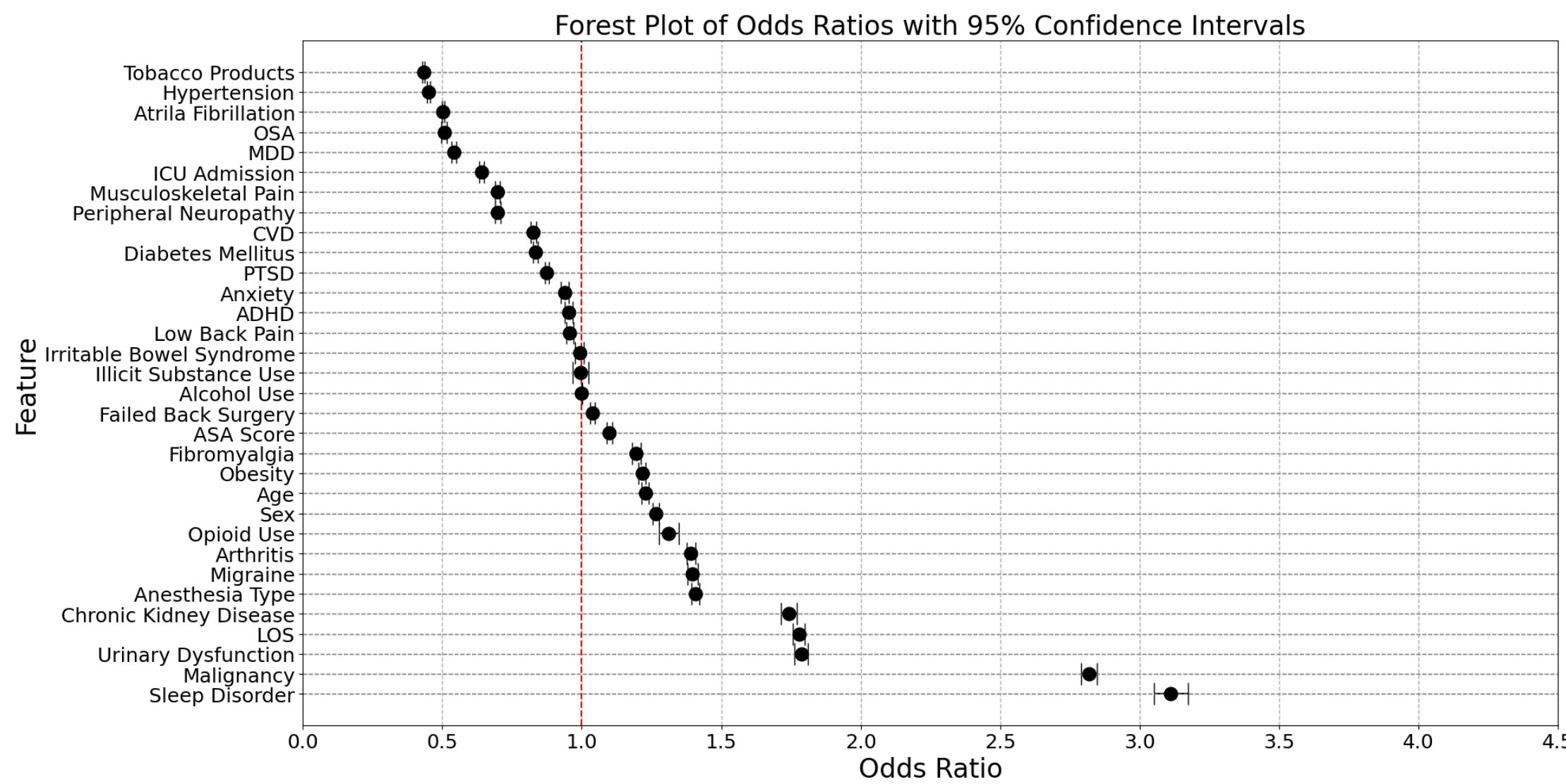
Sacral Nerve Stimulator



MOVER Database



Overall Risk Factors



Peyton J. Murin, M.D.
Saint Louis University, Department of Neurology
Email: peyton.murin@slucare.ssmhealth.com
Phone: (901) 569 - 7998

