Developing Machine Learning Models to Predict Patient-Reported Outcomes Following Anterior Cervical Discectomy and Fusion

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INTRODUCTION: Anterior cervical discectomy and fusion (ACDF) is commonly utilized for radiculopathy/myelopathy. Patient-reported outcome measures (PROMs) are important metrics of response to surgery. Machine learning (ML) has been used to predict ACDF surgical outcomes, but few ML studies have investigated ACDF PROM prediction. This study aimed to develop ML algorithms predictive of favorable PROMs 1-year following ACDF.

METHODS: Patients who underwent elective, primary ACDF at an academic institution (2014-2020) were included. Patients without complete Neck Disability Index (NDI) scores preoperatively and at 1-year were excluded. Demographics/surgical variables, and preoperative PROMs were collected. The primary outcome was achievement of NDI ≤17 1-year postoperatively; prior literature has used this NDI cutoff to represent a "good" outcome. Descriptive statistics were performed to identify demographic differences between patients who did versus did not achieve NDI ≤17. Using an 80-20 training-testing dataset, the performances of several models were evaluated regarding their predictive ability for NDI ≤17 1-year postoperatively. An independent validation cohort was then used to identify the best performing model.

RESULTS: A total of 1237 patients were included, 654 with a 1-year NDI > 17 and 583 ≤17. Of all patients, 607 (49.1%) were male and 630 (50.1%) were female. The NDI > 17 cohort had a greater proportion of females (56.6% vs 44.6%, p<0.001), diabetics (15.4% vs 9.95%, p=0.005), black patients (8.71% vs 3.16%, p<0.001), current smokers (14.4% vs 7.03%, p<.001), former smokers (28.6% vs 23.7%, p<.001), Charles Comorbidity Index (CCI) (0.67 vs 0.49, p=0.001), Elixhauser Comorbidity Index (ECI) (1.32 vs 0.91, p<0.001), distress score (31.4 vs 27.7, p = 0.004), and symptom duration (324 vs. 226 days, p<0.001). Among the machine learning models, the Ridge model demonstrated the best performance. The Ridge model identified several demographic/socioeconomic factors such as Black race, divorced marital status, at-risk distress quintile, and Medicare Insurance to be most predictive of achieving an NDI ≤17 1-year postoperatively.

CONCLUSION: The most impactful preoperative variables for achieving an acceptable NDI score at 1-year were race, marital status, distress score, and insurance coverage. These findings highlight the importance of socioeconomic factors on ACDF outcomes and may also be used to inform future advanced predictive models.

CLINICAL RELEVANCE: Machine learning models can be used to prognosticate outcomes and identify factors that influence outcomes after commonly performed surgeries, which were largely found to be socioeconomic factors in the present work.