Social Determinants of Health and Disparities in Spine Surgery: A Ten-Year Analysis of 7,481 Cases using Ensemble Machine Learning and Multilayer Perceptron

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INTRODUCTION: Despite increased appreciation for the importance of social determinants of health (SDOH), the influence of SDOH on patients undergoing spine surgery is poorly understood. Historically, researchers commonly focused on the isolated influences of race, insurance status, or income on healthcare outcomes. However, analysis of SDOH is becoming increasingly more nuanced as viewing social factors in aggregate rather than individually may offer more precise estimates of the impact of SDOH on healthcare delivery. The aim of this study was to evaluate the effects of patient social history on length of stay (LOS) and readmission within 90 days following spine surgery using ensemble machine learning and multilayer perceptron.

METHODS: We analyzed 7,481 elective and emergency spine surgery cases performed from 2013-2023 using our institution's database of longitudinally collected electronic medical record information. Ensemble machine learning and multilayer perception were employed to predict LOS and readmission within 90 days following spine surgery. The following patient information was included in our analysis: patient race and ethnicity, age, sex, body mass index, smoking status, preferred language, religion, marital status, insurance coverage plan type, medical history, and discharge disposition. The following perioperative details were included in our analysis: case type (elective or emergency), add-on status, case scheduling, lab values, delay in surgery, and time relation to the COVID-19 pandemic.

RESULTS SECTION: African-American patients demonstrated lower odds of home discharge, with 49% of African American patients discharged home compared to 68% of non African-American patients (OR = 0.599, 95% CI = 0.497-0.723, p < .001). Caucasian patients had higher odds of home discharge compared to non-Caucasian patients, with 61.8% of Caucasian patients who underwent spinal surgery discharged to home (OR = 1.258, 95% CI = 1.103-1.436, p < .001). Asian patients, when compared to non-Asian patients, showcased lower odds of home discharge, with 53% of Asian patients discharged home compared to 61% of non-Asian patients (OR = 0.727, 95% CI = 0.539-0.981, p = .036). Additionally, patients who preferred another language, compared to those who preferred English, had lower odds of home discharge (OR = 0.765, 95% CI = 0.625-0.938, p < .010). Regarding insurance status, patients who held private insurance had increased odds of home discharge, compared to those with government/public insurance (OR=2.558, 95% CI = 2.261-2.895, p < .001). No significant difference was found regarding sex, but in terms of age, the oldest age group of 65+ was associated with the lowest odds of home discharge, with 49.4% discharged home (OR = 0.499, 95% CI = 0.445-0.559, p <.001), compared to other age groups. The effect of marital status was also determined, finding that single, divorced, and widowed patients had decreased odds of home discharge. Our analysis revealed that 56% of single patients, 52% of divorced patients, and 54% of widowed patients were discharged home, compared to about 62% for non-single, non-divorced, and non-widowed patients (Single OR = 0.775, 95% CI = 0.684-0.879; Divorced OR = 0.669, 95% CI = 0.556-0.791; Widowed OR = 0.515, 95% CI = 0.424-0.625). On the other hand, married patients had increased odds of home discharge, with 67% discharged home, compared to approximately 53% of non-married patients (OR = 1.784, 95% CI = 1.596-1.994). Predicting LOS, the ML model achieved a balanced accuracy of 0.763, an AUC of 0.848, accuracy of 0.782, precision of 0.793, recall of 0.648, and F1 score of 0.713. Predicting readmission, the model achieved a balanced accuracy of 0.638, an AUC of 0.803, accuracy of 0.867, precision of 0.569, recall of 0.294, and F1 score of 0.388 (see Figures 1 and 2).

DISCUSSION: Insurance status, discharge disposition, marital status, BMI, and religion were shown to be associated with increased LOS and 90-day readmission rates after spine surgery. Race and ethnicity were shown to significantly increase LOS, but our study showed an insignificant effect on 90-day readmission rates. Discharge disposition was also separately affected by social factors, with race and ethnicity, preferred language, insurance status, age, and marital status all contributing to higher rates of discharge to home. Machine learning was utilized, accurately predicting LOS and readmission with medical lab information and social factors, as well as just social factors. Additionally, insurance status and religion were ranked as more important than any aspect of medical history, lab values, and other social factors in predicting LOS and readmission, except for religion dropping to 6th most important in predicting LOS with only social factors. Such findings showcase the effect of social determinants of health in spine surgery outcomes, and highlight the need for targeted interventions to ensure equitable post-operative care for all patients. Further research should focus on viewing social factors in aggregate rather than individually to offer more precise estimates of the impact of SDOH on outcomes, as well as investigating the possibility of pre-operative consideration of social factors in conjunction with the consideration of medical and lab values.

SIGNIFICANCE/CLINICAL RELEVANCE: This study highlights that SDOH is influential in determining patient length of stay and likelihood of readmission following spine surgery.

IMAGES AND TABLES:

Figure 1. Prediction of Readmission within 90 Days

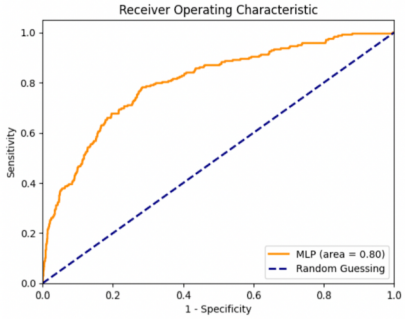

Figure 2. Prediction of LOS