Predicting 90-Day Risk of Hip-Related Readmission or ER Visit among Patients with Open Reduction, Internal Fixation or Hemiarthroplasty for Hip Fracture

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Background

Hip fractures in older adults represent a major public health burden in the US, with an average annual incidence rate in the Medicare population from 1992 to 2005 of around 957 per 100,000 in women and 414 per 100,000 in men. Following these hip fractures, patients are at high risk for a number of complications, including:

- Delirium
- Infection
- Dislocation
- Loss of Mobility

The Johnson and Johnson Medical Devices Hip Fracture Care Program (HFCP) aims to limit these negative outcomes by promoting a protocol driven approach aimed at optimizing the treatment of elderly fragility fracture patients through multidisciplinary care coordination, clinical standardization, and patient-centered care. This project attempted to augment the HFCP by providing a predictive model and calculator for a hip fracture repair patient’s risk.

Dataset and Methods

This project utilized Medicare claims data from 2013-2017, examining patients with a hip fracture repair (index procedure) between Q1 of 2016 and Q3 of 2017 with no history of hip fracture in the baseline. A hip-related readmission or ER visit within 90 days was the target variable, as these events were considered economically and clinically significant. Data were analyzed and modeled using R, with the predictive calculator created as a Shiny app. There were 164,163 observations, with 31.7% of patients having a readmission/ER visit.

Data Exploration and Visualization

Data exploration included creating counts of binary/categorical variables, finding means, medians, and standard deviations for continuous variables, and producing visualizations of distributions.

Demographic variables such as age, race, and gender were expected to have an effect on readmission risk from a literature review. While race proved to have low predictive value, age and gender showed interesting trends for the risk of readmission/ER visit (Figure 2). Between the ages of 65 and 70, the proportion of patients with readmission/ER visit steadily increased, with a higher percentage of male patients having this outcome. Patients under 65 (4.5%) were excluded from final models to increase the likelihood of a homogeneous population, particularly with respect to fracture etiology.

In addition to patient-level variables, provider level variables for the facility performing the index procedure were expected to be impactful in model development. The proportion of patients with a readmission/ER visit varied geographically, with the state indicator providing the most useful level of detail (Figure 3). The proportion varied from 0.23 to 0.37 between states, with the lowest proportion in the north western area and the highest in the north eastern and southern regions.

Conclusions and Recommendations for Future Work

XGBoost was found to have the best performance on key metrics, and work on the final model is ongoing. Upon completion, the model will be integrated into the Shiny app, which will output whether the patient is predicted to be at risk of hip-related readmission or ER visit within 90 days of their surgical hip fracture repair, as well as the probability and key variables impacting this result.

There is no single, unified profile for Medicare patients with a readmission/ER visit following hip fracture repair, and further study is necessary to accurately model risk. Future directions could include: additional modeling techniques, under- and over-sampling the dataset, and prediction of other negative outcomes (i.e. mortality, readmissions/ER visits in other periods).

Data Modeling

Training was performed with an 80-20 train-test split, and performance metrics calculated and reported for the test set. Accuracy and sensitivity are reported below with a prediction cut off of 0.5 probability in each model. Mixed effects models are not included here due to low predictive performance.

Logistic Regression

- Accuracy: 0.683
- AUC: 0.588
- Sensitivity: 0.025

Preliminary modeling with logistic regression was performed with the knowledge that the data was hierarchical in nature, and thus this technique was used primarily for feature exploration. The best model included comorbidity scores for various conditions (i.e. renal failure, cancer, obesity, alcohol abuse, diabetes); surgical and inpatient history; index procedure length of stay (LOS); age; gender; and index procedure provider. Logistic regression was found to be an ineffective strategy. In general, the models predicted that nearly all patients would not have a readmission/ER visit, as seen from the low sensitivity score and accuracy score close to the proportion of patients without these events (0.683).

XGBoost

- Accuracy: 0.691
- AUC: 0.627
- Sensitivity: 0.082

As expected with a hierarchical dataset, XGBoost performed better than logistic regression, though the dataset still proved problematic for sensitivity performance. The best model included various comorbidity scores; various prior healthcare utilization indicators; index procedure LOS; Medicare-covered LOS; age; gender; index procedure provider; provider volume indices; provider wage and income indices; and provider division. The most important feature was found to be prior inpatient LOS, followed by Medicare-covered index LOS, and number of Home Health Agency (HHA) visits in the baseline period (Figure 4).

References