# Predictive Modeling of Medical and Orthopaedic-Related 30-Day-Readmissions following Primary Total Hip Arthroplasty

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INTRODUCTION:

Efforts to reform the US healthcare system have focused on improving care quality, provider accountability, and cost reduction. A significant challenge in this reform agenda is the issue of hospital readmissions within 30 days of discharge, which burdens the healthcare system and negatively impacts patient well-being. Recent policy changes aim to reduce readmission rates for various medical and surgical conditions, including total hip arthroplasties (THA). Specifically, attention is given to identifying at-risk patients, optimizing their health before THA, and preventing postoperative complications that may lead to readmission. Despite a general understanding of risk factors leading to early readmission, the relationship between specific factors and different types of complications (i.e., medical or orthopaedic-related) resulting in readmissions remains uncertain. Therefore, this study aimed to: 1) Develop a predictive model for 30-day readmissions following THA and 2) Determine specific risk factors for medical and orthopaedic-related 30-day readmissions.

METHODS:

A prospective cohort of primary unilateral THAs performed at a large tertiary academic center in the United States from 2016-2020 was included (n=8,893 patients). Unplanned readmissions were identified using a validated institutional data collection system and reviewed individually to determine the primary cause of readmission (e.g., medical or orthopaedic-related). Orthopaedic-related readmissions were specific complications affecting the prosthesis or the surgical wound. Medical readmissions were due to medical diagnoses requiring medical treatment or management and were grouped by the principal organ system involved. Multivariable logistic regression models were used to investigate associations between pre-specified risk factors and 30-day readmissions, as well as, medical/orthopaedic-related readmissions independently. Patients not readmitted were the reference group. Bias-corrected Area under the ROC Curve (AUC) were obtained for different specifications of the models by using 100 bootstrap resampling replicates repeated for 1,000 times. A ranking of the predictors was made by ranking the AUC increase through the calculation of AUC difference between the model without the predictor of interest and the full model The model results were shown using odds ratios (OR) and their respective 95% confidence intervals (CI). Cohort characteristics are displayed in **Table 1**.

RESULTS:

The rate of 30-day readmissions was 3.5%. Medical readmissions were more frequent than orthopaedic reasons (2.7% vs. 0.82%, respectively). Age, years of education, Charlson Comorbidity Index (CCI), Patient-Reported Outcomes Measure (PROM) Phenotype (Pain+ PS+ MCS- and Pain+ PS- MCS-), Surgical Approach, NARX Score, and Discharge Disposition were associated with 30-day readmissions (**Figure 1**). The AUC for the 30-day Readmission Model was 0.70 (95% CI: 0.67-0.72). While only higher BMI, PROMs phenotypes ( Pain+ PS+ MCS- and Pain- PS- MCS+), and higher NARX scores were associated with orthopaedic-related 30-day readmissions, age, years of education, black race, CCI, Approach, PROMs phenotypes ( Pain+ PS+ MCS- and Pain+ PS- MCS-), NARX, and discharge disposition, were associated with medical-related 30-day readmissions (**Table 2**). The effect plots for the variables having a statistically significant relationship with 30-day medical or orthopaedic-related readmissions are shown in **Figure 2**.

DISCUSSION AND CONCLUSION:

By leveraging a large prospective cohort, a successful predictive model for 30-day readmissions post-THA was developed with the top 5 ranking variables being comorbidity burden, NARX, LOS, age, and PROM phenotype. Moreover, this study has illuminated the potential differential impact of various risk factors on medical versus orthopaedic-related readmissions. Such an understanding may inform future risk-stratification efforts and facilitate the tailoring of preventive strategies based on the individual patient's risk profile.

**Figure 1** Top ranking risk factors for 30-day Readmission.

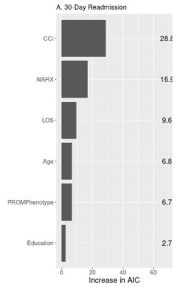


**Figure 2.** Effect plots showing the variables having statistically significant relationship with **30-day medical and orthopedic readmissions.**

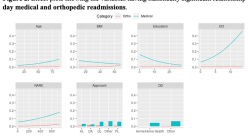


**Table 1.** Study cohort baseline demographic characteristics.

| Variable | Level | Total (N=8893) |
|---|---|---|
| Age, Median [25th;75th] | | 66.0 [58.0;73.0] |
| Sex, N (%) | F | 5063 (56.9%) |
| | M | 3830 (43.1%) |
| BMI, Median [25th;75th] | | 29.3 [25.6;33.9] |
| Race, N (%) | White | 7404 (85.8%) |
| | Black | 1039 (12.0%) |
| | Other | 188 (2.18%) |
| Education, Median [25th;75th] | | 14.0 [12.0;16.0] |
| Smoking, N (%) | Never | 4344 (52.1%) |
| | Quit 6m+ | 2746 (32.9%) |
| | Quit <6m | 381 (4.57%) |
| | Current | 863 (10.4%) |
| ADI, Median [25th;75th] | | 53.0 [31.0;75.0] |
| CCI, Median [25th;75th] | | 0.00 [0.00;1.00] |
| Insurance, N (%) | Commercial/Private/Other | 2824 (37.3%) |
| | Medicaid/Medicare | 4625 (61.1%) |
| | Self-Pay | 119 (1.57%) |
| T0 HOOS Pain, Median [25th;75th] | | 35.0 [25.0;45.0] |
| T0 HOOS PS, Median [25th;75th] | | 49.2 [38.4;62.3] |
| T0 MCS, Median [25th;75th] | | 50.5 [40.1;59.7] |
| PROMPhenotype, N (%) | Pain+ PS+ MCS+ | 1919 (23.1%) |
| | Pain+ PS+ MCS- | 1144 (13.7%) |
| | Pain+ PS- MCS+ | 438 (5.26%) |
| | Pain+ PS- MCS- | 481 (5.78%) |
| | Pain- PS+ MCS+ | 412 (4.95%) |
| | Pain- PS+ MCS- | 521 (6.26%) |
| | Pain- PS- MCS+ | 1120 (13.5%) |
| | Pain- PS- MCS- | 2288 (27.5%) |
| Surgery Duration, Median [25th;75th] | | 90.0 [71.0;113] |
| Surgery Day, N (%) | M | 2089 (23.5%) |
| | T | 2228 (25.1%) |
| | W | 2016 (22.7%) |
| | R | 1588 (17.9%) |
| | F | 972 (10.9%) |
| Indication, N (%) | OA | 7691 (86.5%) |
| | Non-OA | 1202 (13.5%) |
| Approach, N (%) | DA | 2613 (29.4%) |
| | AL | 693 (7.79%) |
| | DL | 1353 (15.2%) |
| | PL | 3849 (43.3%) |
| | Other | 385 (4.33%) |
| Anesthesia, N (%) | General | 3442 (38.7%) |
| | Spinal | 5121 (57.6%) |
| | Other | 320 (3.60%) |
| NARX Score (Risk), Median [25th;75th] | | 110 [0.00;210] |
| LOS, Median [25th;75th] | | 1.00 [1.00;2.00] |
| LOS>=3, N (%) | No | 7272 (81.9%) |
| | Yes | 1610 (18.1%) |
| Discharge Disposition, N (%) | Home/Home Health | 7750 (87.3%) |
| | Other | 1129 (12.7%) |

**Table 3.** Multivariable Multinomial Regression Model showing risk factors for 30-day Medical and Orthopedic Readmissions.

| | Ortho | | Medical | |
|---|---|---|---|---|
| Factor | OR | Pvalue | OR | Pvalue |
| Age | 1.27 (0.83, 1.95) | 0.275 | 1.4 (1.11, 1.78) | 0.005 |
| Sex, M | 0.88 (0.54, 1.45) | 0.622 | 0.91 (0.69, 1.2) | 0.493 |
| BMI | 1.42 (1.06, 1.88) | 0.017 | 0.89 (0.74, 1.06) | 0.194 |
| Race, Black | 0.47 (0.18, 1.22) | 0.12 | 1.74 (1.18, 2.55) | 0.005 |
| Race, Other | 0.74 (0.1, 5.47) | 0.765 | 1.43 (0.57, 3.62) | 0.447 |
| Education | 1.07 (0.76, 1.52) | 0.688 | 0.75 (0.61, 0.92) | 0.005 |
| SmokingQuit 6m+ | 1.12 (0.66, 1.89) | 0.668 | 0.98 (0.72, 1.33) | 0.891 |
| SmokingQuit <6m | 0.96 (0.28, 3.21) | 0.941 | 1.11 (0.6, 2.07) | 0.735 |
| SmokingCurrent | 1.76 (0.55, 5.88) | 0.586 | 1.08 (0.67, 1.61) | 0.99 |
| ADI | 1.11 (0.7, 1.76) | 0.645 | 0.85 (0.65, 1.11) | 0.227 |
| CCI | 1.04 (0.91, 1.18) | 0.598 | 1.2 (1.13, 1.27) | <0.001 |
| InsuranceMedicaid/Medicare | 0.94 (0.48, 1.86) | 0.865 | 0.87 (0.59, 1.29) | 0.485 |
| InsuranceSelf-Pay | 0 (0, 0.26) | 0.053 | 0.64 (0.1, 3.94) | 0.626 |
| PROMPhenotypePain+ PS+ MCS- | 2.91 (1.16, 7.28) | 0.023 | 1.85 (1.14, 3.03) | 0.013 |
| PROMPhenotypePain+ PS- MCS+ | 0 (NaN, NaN) | | 1.08 (0.48, 2.42) | 0.856 |
| PROMPhenotypePain+ PS- MCS- | 2.04 (0.63, 6.57) | 0.235 | 2.05 (1.13, 3.73) | 0.018 |
| PROMPhenotypePain- PS+ MCS+ | 1.73 (0.44, 6.83) | 0.433 | 0.83 (0.34, 2.02) | 0.688 |
| PROMPhenotypePain- PS+ MCS- | 1.4 (0.4, 4.92) | 0.604 | 1.25 (0.63, 2.47) | 0.518 |
| PROMPhenotypePain- PS- MCS+ | 2.65 (1.05, 6.69) | 0.039 | 0.98 (0.56, 1.71) | 0.942 |
| PROMPhenotypePain- PS- MCS- | 1.74 (0.72, 4.22) | 0.223 | 1.35 (0.85, 2.16) | 0.205 |
| Day, T | 0.82 (0.41, 1.64) | 0.583 | 0.89 (0.6, 1.31) | 0.551 |
| Day, W | 1.08 (0.56, 2.09) | 0.809 | 1.08 (0.73, 1.59) | 0.709 |
| Day, R | 0.62 (0.28, 1.41) | 0.255 | 0.68 (0.44, 1.06) | 0.093 |
| Day, F | 0.9 (0.4, 2.05) | 0.807 | 1.07 (0.69, 1.66) | 0.758 |
| Indication, Non-OA | 1.24 (0.62, 2.45) | 0.54 | 1.11 (0.76, 1.62) | 0.577 |
| Approach, AL | 0.43 (0.12, 1.47) | 0.177 | 1.4 (0.7, 2.81) | 0.346 |
| Approach, DL | 0.85 (0.39, 1.88) | 0.692 | 2.58 (1.5, 4.41) | <0.001 |
| Approach, PL | 0.6 (0.31, 1.17) | 0.132 | 2.57 (1.62, 4.06) | <0.001 |
| Approach, Other | 0.27 (0.04, 2.12) | 0.214 | 2.89 (1.37, 6.12) | 0.005 |
| Anesthesia, Spinal | 1.17 (0.66, 2.07) | 0.594 | 0.97 (0.7, 1.34) | 0.849 |
| Anesthesia, Other | 1.16 (0.34, 3.92) | 0.81 | 1.23 (0.62, 2.44) | 0.56 |

| | Ortho | | Medical | |
|---|---|---|---|---|
| Factor | OR | Pvalue | OR | Pvalue |
| NARX | 2.1 (1.34, 3.31) | 0.002 | 1.48 (1.12, 1.95) | 0.008 |
| LOS | 1.02 (0.95, 1.1) | 0.538 | 1.01 (0.97, 1.06) | 0.529 |
| DD, Other | 1.63 (0.86, 3.1) | 0.132 | 1.53 (1.09, 2.17) | 0.015 |