# Machine Learning Models Outperform the ACS Risk Calculator in Predicting Non-Home Discharge and Early Readmission Following Primary Total Knee Arthroplasty: A National Cohort Analysis

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INTRODUCTION: The increased demand for primary total knee arthroplasty (TKA) yields great focus on reducing rates of non-home discharge (NHD) and early readmission rates NHD and early readmissions are associated with suboptimal patient outcomes and exacerbation of already high cost burden. Being able to accurately predict NHD following TKA has the potential to improve patient outcomes and cost efficiency. Previous studies showed that the American College of Surgeons (ACS) risk calculator had a fair capacity to distinguish patients likely to have NHD and/or early readmission. The machine learning algorithm is increasingly recognized as a tool for predicting many adverse events after surgery. Therefore, this study aimed to evaluate and compare the performance of the ACS risk calculator and machine learning model in predicting NHD and early readmission after TKA using a national patient database.

METHODS: The ACS-NSQIP database was queried to acquire 365,394 patients who underwent primary TKA between 2013 and 2020, stratified by CPT code 27447. Patient variables are selected based on the predictors included in the ACS risk calculator. The patient data were stratified and randomly split into training and testing datasets. Artificial neural network (ANN) was selected as the representative machine learning model in the study and derived from the training dataset through hyper-parameter tuning and fivefold cross-validation. The performance of ANN and the ACS risk calculator was assessed using the testing dataset and compared based on discrimination, calibration, and decision curve analysis.

RESULTS: In the study cohort, 18.41% and 3.12% were NHD or readmitted within 30 days of the primary TKA. Age (>68 years), BMI (>35.45 kg/m$^2$), ASA classification ($\geq$2), gender (male), and functional status (non-independent) were found to be the strongest predictors of NHD following TKA. Similarly, BMI (>33.51kg/m$^2$), age (>69 years), and gender (male) were the strongest predictors for early readmission. ANN demonstrated a significantly superior capacity (DeLong test: p = 0.002) to identify patients at risk of NHD and early readmission compared to the ACS risk calculator. The ANN model demonstrated good predictive ability for NHD compared to the ACS risk calculator with an AUC of 0.69 (vs. 0.5), calibration slope of 0.85 (vs. 4.46), and intercept of 0.04 (vs. 0.06). ANN also demonstrated good performance in predicting readmission risk compared to the ACS risk calculator, with an AUC of 0.72 (vs. 0.55), a calibration slope of 1.32 (vs. -0.21), and an intercept of -0.09 (vs. 0.04). ANN also produced a higher net benefit than the default treatment strategies in the decision curve analysis for both outcomes

DISCUSSION: This study provides evidence of machine learning models' superiority over the traditionally used ACS risk calculator in predicting NHD and early readmission following TKA. The results of this studyunderscore the potential benefits of integrating machine learning models into clinical practice to improve preoperative patient-specific risk identification and optimization. The study also highlights the importance of incorporating other pertinent patient factors, such as the in-lab tests and surgical details, into the model to further improve its prediction accuracy.

SIGNIFICANCE/CLINICAL RELEVANCE: The findings of this study support the utilization of machine learning models over the traditionally used ACS risk calculator for the patient-specific risk stratification following primary TKA.

**Table 1.** The predictive performance of the ANN and ACS risk calculator in the testing dataset for primary TKA

|  | AUC | Calibration Slope | Calibration Intercept |
| --- | --- | --- | --- |
| **Non-home Discharge** |  |  |  |
| **ANN** | 0.69 | 0.85 | 0.04 |
| **ACS Risk Calculator** | 0.50 | 4.46 | 0.06 |
| **Readmission** |  |  |  |
| **ANN** | 0.72 | 1.32 | -0.09 |
| **ACS Risk Calculator** | 0.55 | -0.21 | 0.04 |
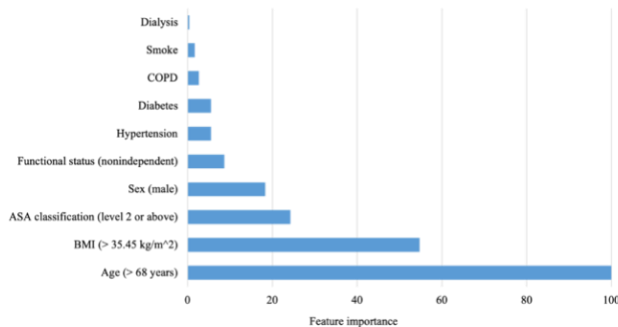


**Fig 1.** Feature importance plot for the prediction of NHD following primary TKA as indicated by the ANN
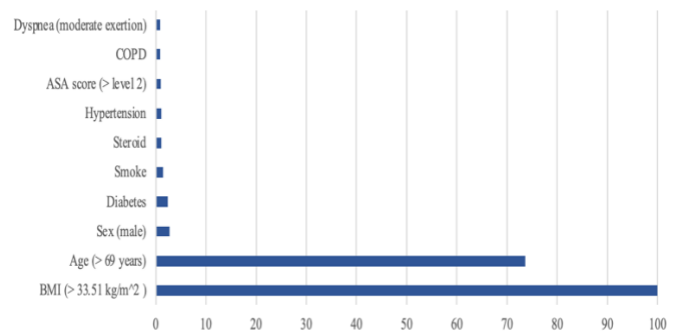


**Fig 2.** Feature importance plot for the prediction of readmission following primary TKA as indicated by the ANN