

# Predicting PROMs, Satisfaction, Healthcare Utilization, and Return to Work After TKA Using Machine Learning: A 14,900-Patient Study

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## INTRODUCTION:

Total knee arthroplasty (TKA) is a widely performed and effective procedure for end-stage osteoarthritis; however, up to 20% of patients remain dissatisfied postoperatively. As healthcare shifts toward value-based care, there is growing emphasis on patient-reported outcome measures (PROMs) and healthcare utilization (HCU) as key metrics of surgical success. Accurate, individualized prediction of outcomes such as pain relief, functional recovery, satisfaction, and readmission risk could improve preoperative counseling, guide patient selection, and optimize resource planning. Machine learning techniques, such as Random Forest (RF) and XGBoost (XGB), offer advantages over traditional modeling by capturing nonlinear interactions across a large number of clinical, demographic, and socioeconomic variables. This study aimed to develop and validate predictive models for PROMs, HCU, satisfaction, mortality, and return to work using advanced machine learning techniques in a large cohort of TKA patients.

## METHODS:

A prospective cohort of 14,900 patients undergoing primary unilateral TKA between 2016 and 2022 at a single academic center was analyzed. Patients undergoing bilateral procedures or missing baseline PROMs were excluded. Predictor variables included demographics, comorbidities, socioeconomic status (Area Deprivation Index), PROM phenotype, baseline KOOS scores, surgical timing, and anesthesia type. Random Forest and XGBoost models were trained and evaluated for key outcomes: KOOS Pain, Physical Function (PS), Joint Replacement (JR), and Quality of Life (QoL); Patient Acceptable Symptom State (PASS); length of stay (LOS  $\geq 3$  days); discharge disposition; 90-day readmission; 90-day reoperation; 1-year mortality; and return to work. Model performance was assessed using root mean square error (RMSE) and out-of-bag (OOB) accuracy.

## RESULTS:

Model performance was moderate to strong across outcomes. PROM models achieved RMSEs of 15.1–23.5. For categorical outcomes, OOB accuracy ranged from 55% (reoperation) to 78% (return to work). Top predictors of PROMs included baseline KOOS JR, PROM phenotype, age, race, and KOOS QoL. PASS prediction was influenced by BMI, ADI, age, and surgery start time. Key HCU predictors included KOOS JR, age, BMI, ADI, and surgery timing. Mortality and return-to-work models achieved 73% and 78% accuracy, respectively.

## DISCUSSION AND CONCLUSION:

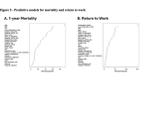
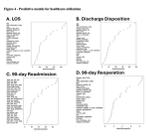
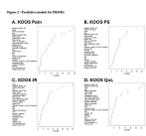
Machine learning models using readily available preoperative variables can accurately predict PROMs, satisfaction, and healthcare utilization after TKA. These models have the potential to enhance shared decision-making, personalize perioperative planning, and support risk stratification efforts. Future work should focus on external validation and clinical integration.

**Table 1. Cohort Characteristics**

Characteristic	n (%)
Age (mean, SD)	67.2 (10.5)
Female	78.5%
White	72.1%
Black	18.3%
Hispanic	5.2%
Other	2.1%
Area Deprivation Index (mean, SD)	0.12 (0.15)
Baseline KOOS Pain (mean, SD)	42.5 (15.2)
Baseline KOOS PS (mean, SD)	38.1 (14.8)
Baseline KOOS JR (mean, SD)	35.2 (13.5)
Baseline KOOS QoL (mean, SD)	40.3 (14.1)
Baseline PROM Phenotype (mean, SD)	1.2 (0.8)
Surgery Start Time (mean, SD)	10:15 (1:30)
LOS $\geq 3$ days	12.5%
Discharge Disposition	
Home	85.2%
Subacute	10.1%
Skilled Nursing Facility	4.7%
90-day Readmission	8.3%
90-day Reoperation	5.1%
1-year Mortality	1.2%
Return to Work	78.5%

**Table 2. Performance Comparison of Random Forest and XGBoost Models for PROMs**

Outcome	Model	RMSE	OOB Accuracy
KOOS Pain	Random Forest	15.1	62%
	XGBoost	15.5	61%
KOOS PS	Random Forest	18.2	58%
	XGBoost	17.8	59%
KOOS JR	Random Forest	21.3	73%
	XGBoost	20.9	72%
KOOS QoL	Random Forest	23.5	68%
	XGBoost	23.1	67%



**Table 3. Model Performance Summary**

Outcome	Model	RMSE	OOB Accuracy
KOOS Pain	Random Forest	15.1	62%
	XGBoost	15.5	61%
KOOS PS	Random Forest	18.2	58%
	XGBoost	17.8	59%
KOOS JR	Random Forest	21.3	73%
	XGBoost	20.9	72%
KOOS QoL	Random Forest	23.5	68%
	XGBoost	23.1	67%
PASS	Random Forest	12.5	65%
	XGBoost	12.8	64%
LOS $\geq 3$ days	Random Forest	0.15	55%
	XGBoost	0.16	54%
Discharge Disposition	Random Forest	0.12	60%
	XGBoost	0.13	59%
90-day Readmission	Random Forest	0.08	58%
	XGBoost	0.09	57%
90-day Reoperation	Random Forest	0.05	55%
	XGBoost	0.06	54%
1-year Mortality	Random Forest	0.02	73%
	XGBoost	0.03	72%
Return to Work	Random Forest	0.01	78%
	XGBoost	0.02	77%