A Comparison of the ASA, Charlson Comorbidity Index, and Elixhauser Comorbidity Index: Assessing Hospital Readmissions Following Primary Knee or Hip Arthroplasty

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Disclosures: None of the authors have any relevant disclosures.

INTRODUCTION: Knee and hip arthroplasties (KHAs) are amongst the most common elective surgeries in the United States each year, with the American Joint Replacement Registry (AJRR) 2022 Annual Report reporting over 2.5 million KHAs from 2012 and 2021 alone. As part of the Affordable Care Act, the Hospital Readmissions Reduction Program's scope was expanded in 2015 to include KHAs, with penalties of up to a 3% reduction in system-wide Medicare reimbursement to hospitals with high 30-day readmission rates. To aid in the preoperative classification of patients who are at increased risk of post-KHA readmissions, currently used comorbidity indices include the American Society of Anesthesiologists Physical Status Classification System (ASA), the Charlson Comorbidity Index (CCI), and the Elixhauser Comorbidity Index (ECI). However, none of these indices were created to specifically assess the preoperative readmission risk following KHA. The purpose of this study was to evaluate the independent predictive value of the ASA, CCI, and ECI to assess preoperative risk of 30- and 90-day readmissions following primary knee or hip arthroplasty.

METHODS: Following institutional review board approval, a retrospective analysis of the University of Minnesota Health System (12 Minnesota hospitals and 60 primary care clinics) between January 2011 and June 2023 was performed. Inclusion criteria consisted of the presence of a billing and/or clinical diagnosis code (ICD-10) of osteoarthritis or polyosteoarthritis alongside CPT codes for the KHAs for adults ≥18 years of age. Primary knee arthroplasties included were patellofemoral with and without prosthesis, partial (femoral condyles or tibial), unicompartmental, and totals. Primary hip arthroplasties included were totals and hemiarthroplasties. Independent variables collected included: age, sex, BMI, laterality, year of surgery, ASA score, CCI score, and ECI score. Outcomes of interest included 30- and 90-day all-cause readmissions. Multivariable regression was performed for each independent variable while controlling for all other factors. Direct comparative analysis was performed through a test of discrimination using area under the curve (AUC) regression from a receiver operating characteristics (ROC) analysis.

RESULTS: 40,496 primary KHAs (25,410 knees, 15,086 hips) were identified from 3,490,236 total EHR encounters, with 977 and 1,934 30- and 90-day readmissions identified, respectively (Table 1). Increasing ECI, CCI, and ASA scores are associated with higher odds of a 30- or 90-day readmission following primary KHA (Table 2). Direct comparison of the ECI, CCI, and ASA through AUC from ROC analysis suggests that the ECI and CCI are better at assessing preoperative risk of a 30- or 90-day readmission than the ASA, though not statistically significant for 30-day readmissions (Table 2).

DISCUSSION: Although the ASA, CCI, and ECI are widely validated comorbidity indices, there is no published literature comparing their utility in preoperatively assessing readmission risk following KHAs. A strong association was found between increasing severity of scores and 30- and 90-day readmissions. The strongest association was the ASA, but the ASA also has the fewest score possibilities. Comparative analysis using AUC from ROC analysis suggested that the ECI and CCI had more utility in preoperatively assessing 30- and 90-day readmission risk. These results are in accordance with a similar study in spine surgery. Due to its ease of access, the ASA may be the most optimal index score for orthopedic surgeons to implement into practice as a score is assigned by the anesthesia team for each operative case. However, the CCI or ECI can be employed at any time preoperatively whereas ASA scores usually are not assigned until the same day of the anesthesia procedures. For this reason, alongside the presented comparative data, the authors strongly encourage the use of the ECI or CCI preoperatively.

This study is not without limitations. The study was retrospective in its design. Data collection was limited to one health system, so 30- and 90-day readmissions at an outside system were missed. Data collection was based on CPT and ICD-10 codes. There can be variability in coding, but the CPT and ICD-10 codes were kept broad to mitigate coding differences among providers. Despite these limitations, the authors believe the results are robust and deserve attention.

SIGNIFICANCE/CLINICAL RELEVANCE: The CCI and ECI can be used at any time during the preoperative period and provide surgeons the ability to classify, categorize, and stratify patients for their risk of 30- and 90-day readmissions better than the ASA.

Table 1. 30- and 90-Day Readmissions with Demographics.

N = 40,496	**30-Day Readmission?**		**90-Day Readmission?**	
	No	**Yes**	**No**	**Yes**
Patients	**39,519**	**977**	**38,562**	**1,934**
Sex (Female)	15,989 (40.5%)	391 (40.0%)	15,559 (40.3%)	821 (42.5%)
Mean Age (Years)	68.9	70.2	68.9	68.2
Mean BMI	30.8	31.9	30.8	31.9
Laterality (Right)	20,415 (51.7%)	501 (51.3%)	19,941 (51.7%)	975 (50.4%)
Knee Arthroplasty	24,828 (62.8%)	582 (59.6%)	24,230 (62.8%)	1,180 (61.3%)
Hip Arthroplasty	14,691 (37.2%)	395 (40.4%)	14,332 (37.2%)	754 (39.0%)

Table 2. Logistic Regression and Direct Comparative Analyses.

	30-Day Readmissions			**90-Day Readmissions**		
	Logistic Regression Analysis					
	Odds Ratio	**95% Confidence Interval**	***P* value**	**Odds Ratio**	**95% Confidence Interval**	***P* value**
ECI	1.038	1.029-1.048	<0.001	1.037	1.030-1.044	<0.001
CCI	1.139	1.104-1.176	<0.001	1.127	1.100-1.115	<0.001
ASA	1.612	1.419-1.832	<0.001	1.366	1.248-1.495	<0.001
	Direct Comparative Analysis					
	AUC for ROC	**95% Confidence Interval**		**AUC for ROC***	**95% Confidence Interval**	
ECI	0.739	0.723-0.755		0.712	0.701-0.724	
CCI	0.737	0.721-0.753		0.714	0.703-0.725	
ASA	0.731	0.715-0.747		0.698	0.687-0.710	

* Indicates statistical significance ($P<0.05$) from χ^2 testing with H_O: $AUC_{ECI}=AUC_{CCI}=AUC_{ASA}$.