



## Original research

## Payer type does not impact patient-reported outcomes after primary total knee arthroplasty

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## ABSTRACT

**Background:** There is a paucity of literature assessing whether payer type has an impact on postoperative patient-reported outcomes (PROs) after total knee arthroplasty (TKA). The aim of this study was to comparatively evaluate TKA PROs among patients with commercial and Medicare insurance.

**Methods:** We conducted a single-center, retrospective review of patients operated between January 2017 and March 2018. Knee Disability and Osteoarthritis Outcome Score Junior (KOOS-Jr) and Veterans RAND 12 Health Survey (VR-12) Physical Component (VR-12 PCS) and Mental Component (VR-12 MCS) PRO scores were collected prospectively at baseline and 12 weeks postoperatively via an electronic patient rehabilitation application. Univariable and multivariable linear regressions were utilized to assess the effects of patient insurance type on PRO.

**Results:** In total, 193 TKA candidates had commercial ( $n = 91$ ) or Medicare ( $n = 102$ ) as their primary payer type. Demographic variables including age, gender, body mass index, and race varied significantly between the cohorts ( $P < .05$ ). Length of stay and discharge disposition also varied significantly ( $P < .05$ ). When compared with commercial payers, Medicare beneficiaries demonstrated a  $4.13 \pm 2.06$  increase in Knee Disability and Osteoarthritis Outcome Score JR. scores at baseline ( $P < .05$ ). However, after adjusting for patient-specific demographic and perioperative variables, all PROs recorded in this study were similar between the 2 payer groups at baseline and 12 weeks postoperatively ( $P > .05$ ). Furthermore,  $\Delta$ PRO scores from baseline to 12 weeks were also similar ( $P > .05$ ).

**Conclusions:** After adjusting for patient-specific variables, PROs are similar at baseline and 12 weeks postoperatively between commercial and Medicare cohorts. For TKA candidates with similar baseline demographics, surgeons can expect similar perioperative PROs regardless of insurance type.

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## Introduction

Total knee arthroplasty (TKA) is the most popular and successful treatment modalities available to patients with end-stage degenerative joint disease of the knee, and its use is projected to rise exponentially with the aging US population [1,2]. TKA is generally considered to be a safe procedure, bringing patients significant improvements in pain, functional ability, and overall quality of life. However, despite advances in surgical techniques and implant design, approximately 10–20% of patients are unsatisfied with their postoperative outcomes [3–5]. This small but significant percentage of patients underscores the need for valid, reliable measures to

evaluate outcomes, resulting in the development of various patient-reported outcome (PRO) measures for joint arthroplasty. Generic PROs assess overall health status, including physical function and mental health, and joint-specific PROs assess symptoms surrounding hip or knee pathology, such as pain, stiffness, and limitations in physical activity [6]. Because dissatisfaction can be secondary to inadequate improvement and unmet expectations with regard to these factors, PROs have become increasingly utilized by orthopaedic surgeons after total joint arthroplasty (TJA) [5,7].

Various patient factors, including age, sex, race, body mass index (BMI), medical comorbidities, and psychological factors, have been demonstrated to affect patient outcomes after TKA [8–11]. Payer type has also been suggested to be a contributing factor across various surgical fields [12–14]; however, studies evaluating the effect of payer type on PROs after TKA have been limited. Because Medicare is the primary payer for more than 60% of lower extremity arthroplasty procedures, this relationship is important to elucidate [15]. In addition, with the shift toward bundled payment models for joint arthroplasty, providers may be incentivized to engage in “cherry-picking” and “lemon-dropping” behaviors, worsening the access to care for older patients with more medical comorbidities [16–18]. Rosenthal et al. [19] reported no significant difference in the preoperative and postoperative outcomes of commercially insured and Medicare patients; however, a limitation of this study was that they used Blue Cross/Blue Shield, which acts as administrators of Medicare in many states including that of the authors' institution, as a proxy for commercial insurance. In addition, they used abstracted medical record data to calculate a composite clinical function score rather than evaluating outcomes using prospectively collected PROs. A nationwide database study by Veltre et al. [20] on in-hospital complication rates after TKA found Medicare patients to have the highest overall rates of complications. However, given the nature of the study, PROs could not be assessed.

The aim of this study was to comparatively evaluate TKA PROs among patients with different payer types. We retrospectively analyzed PRO scores in patients with Medicare vs commercial insurance undergoing unilateral TKA. We hypothesize that PROs at 12 weeks postoperatively are not affected by insurance payer type.

## Material and methods

This study is a retrospective study of prospectively collected data from a single urban, academic, tertiary orthopaedic hospital. Inclusion criteria for this study included any patient undergoing TKA between January 2017 and March 2018. As part of our institution's standard of care, patients were preoperatively registered for an electronic patient rehabilitation application (EPRA; Force Therapeutics, New York, NY) by clinical care coordinators at the time of surgical scheduling. Briefly, the Force Therapeutics EPRA utilizes mobile (eg, smartphones) and web (eg, e-mail) technology to wirelessly push digital PROs surveys at predefined time intervals. PRO surveys were administered within a 1-month period before surgery and 3 months postoperatively. Standard clinical care PROs collected through the EPRA included the Knee Disability and Osteoarthritis Outcome Score JR. (KOOS JR.) and Veterans Rand 12-Item Health Survey (VR-12) Physical Component Score (PCS) and Mental Component Score (MCS). Patients missing any of the 3 PRO surveys preoperatively or postoperatively were excluded from the study. Demographics characteristics (patient age, gender, BMI, race, marital status, smoking status, insurance type, and American Society of Anesthesiologists (ASA) score) and perioperative variables (anesthesia type, length of stay, surgical time, and discharge disposition) were obtained from our electronic data warehouse,

Epic Caboodle (version 15, Verona, WI), using Microsoft SQL Server Management Studio 2017 (Redmond, WA). Unicondylar, bilateral, or revision TKAs were excluded from this study.

In total, 842 candidates undergoing TKA at our institution were registered for the EPRA. Of these patients, 82 bilateral, 30 revision, and 20 unicondylar TKAs were excluded from the study. Of the remaining 628 patients, 201 completed at least one preoperative and one 12-week postoperative PRO survey. Patients completing only one or none of the preoperative or 12-week postoperative PRO surveys were excluded from the study. Patients were stratified into Medicare (Medicare or Medicare Managed Care) and commercial (Preferred Provider Organization, Exclusive Provider Organization, Point of Service Plan, Government Exchange Place Managed Care) cohorts.

## Statistics and analytics

PROs derived from the EPRA were joined based on medical record number and surgical date using MatLab 2018a (MathWorks, Natick, MA). Descriptive statistics were run on all patient entries. Independent *t* tests were used for evaluating continuous baseline variables,  $\chi^2$  tests for nominal variables, and Wilcoxon rank-sum test for ordinal baseline values. Univariable and multivariable linear regressions were performed to assess the unadjusted and adjusted primary outcome of interest, respectively. Owing to the limited sample size of patients receiving Worker's Comp (3 patients) and Medicaid (5 patients), these patients were not included in our statistical analyses.

A power analysis was conducted to demonstrate the minimum number of subjects for adequate study power. Assuming a minimal detectable change (ie, the minimal amount of change required to distinguish a true change in health from normal measurement variability) of 11 points on the KOOS JR. 100-point scale, the minimum number of total subjects needed to detect a difference between the commercial and Medicare cohorts is 61 [21].

## Results

Of the 201 TKA recipients, there were 102 Medicare, 91 commercial, 5 Medicaid, and 3 Worker's Compensation beneficiaries (Table 1). When compared against commercial payers, Medicare beneficiaries were significantly older (70.50 vs 60.12 years;  $P < .00001$ ) and more likely to be female (66.67% vs 52.68% female;  $P < .05$ ), have a worse ASA comorbidity distribution (49.02% vs 33.33% ASA score  $\geq 3$ ;  $P < .05$ ), and have higher percentage of Caucasians (82.35% vs 68.82%;  $P < .05$ ). Marital status, surgical time, in-hospital length of stay, and discharge disposition did not differ significantly among the groups.

Preoperatively, KOOS JR. scores were significantly higher for Medicare patients when compared to their commercial payer counterparts (51.91 vs 47.78;  $P < .05$ ; Table 2). All other pre- and post-operative KOOS Jr., VR-12 PCS and VR-12 MCS PRO scores were otherwise non-significantly different between the two cohorts. When evaluating the change in PRO scores ( $\Delta$ ) between pre- and post-operative PRO scores, all patients demonstrated an increase in KOOS JR. (commercial:  $\Delta 19.69$ ; Medicare:  $\Delta 18.35$ ), VR-12 PCS (commercial:  $\Delta 6.68$ ; Medicare:  $\Delta 7.85$ ) and VR-12 MCS (commercial:  $\Delta 5.24$ ; Medicare:  $\Delta 3.74$ ). When comparing  $\Delta$ PRO scores between Medicare and Commercial payors, each cohort demonstrated statistically similar magnitudes of improvement in PRO scores ( $P > .05$ ; Figs. 1–3).

Further analysis using a multivariable linear regression demonstrated no significant differences in preoperative, post-operative or  $\Delta$  PRO scores when comparing the Medicare and commercial payer cohorts ( $P > .05$ ; Table 3). Among Medicare

**Table 1**  
Demographics.

| Demographic and surgical variables | Commercial (n = 91) | Medicare (n = 102) | P                    | Medicaid (n = 5) | Worker's compensation (n = 3) |
|------------------------------------|---------------------|--------------------|----------------------|------------------|-------------------------------|
| Age                                | 60.12 ± 7.29        | 70.50 ± 5.86       | <.00001 <sup>a</sup> | 57.00 ± 4.18     | 59.00 ± 8.19                  |
| Gender                             |                     |                    | <.05 <sup>a</sup>    |                  |                               |
| Female                             | 49 (52.68%)         | 68 (66.67%)        |                      | 3 (60.00%)       | 0                             |
| Male                               | 44 (47.31%)         | 34 (33.33%)        |                      | 2 (40.00%)       | 3 (100.00%)                   |
| BMI                                | 32.97 ± 6.69        | 30.38 ± 6.01       | <.01 <sup>a</sup>    | 33.74 ± 5.59     | 32.77 ± 4.94                  |
| ASA                                |                     |                    | <.05 <sup>a</sup>    |                  |                               |
| 1                                  | 5 (5.38%)           | 0                  |                      | 0                | 0                             |
| 2                                  | 55 (59.14%)         | 50 (49.02%)        |                      | 2 (40.00%)       | 2 (66.67%)                    |
| 3                                  | 31 (33.33%)         | 50 (49.02%)        |                      | 3 (60.00%)       | 1 (33.33%)                    |
| 4                                  | 2 (2.15%)           | 2 (1.96%)          |                      | 0                | 0                             |
| Median                             | 2                   | 3                  |                      |                  |                               |
| Race                               |                     |                    | <.05 <sup>a</sup>    |                  |                               |
| African-American (black)           | 19 (20.43%)         | 8 (7.84%)          |                      | 1 (20.00%)       | 0                             |
| Asian                              | 0                   | 3 (2.94%)          |                      | 0                | 0                             |
| White                              | 64 (68.82%)         | 84 (82.35%)        |                      | 2 (40.00%)       | 3 (100.00%)                   |
| Other                              | 10 (10.75%)         | 7 (6.86%)          |                      | 2 (40.00%)       | 0                             |
| Marital status                     |                     |                    | .10                  |                  |                               |
| Married/partner                    | 60 (64.52%)         | 51 (50.00%)        |                      | 3 (60.00%)       | 2 (66.67%)                    |
| Divorced/separated                 | 5 (5.38%)           | 12 (11.76%)        |                      | 1 (20.00%)       | 1 (33.33%)                    |
| Single/widowed                     | 28 (30.11%)         | 39 (38.24%)        |                      | 1 (20.00%)       | 0                             |
| Surgical time                      | 111.67 ± 34.83      | 106.76 ± 37.53     | .27                  | 119.40 ± 45.85   | 100.33 ± 47.72                |
| Length of stay                     | 2.10 ± 1.38         | 2.23 ± 1.26        | .50                  | 2.20 ± 1.64      | 2.67 ± 2.08                   |
| Discharge disposition              |                     |                    | .15                  |                  |                               |
| Home with self-care                | 9 (9.68%)           | 8 (7.84%)          |                      | 0                | 0                             |
| Home health services               | 80 (86.02%)         | 86 (84.31%)        |                      | 5 (100.00%)      | 3 (100.00%)                   |
| Skilled nursing                    | 1 (1.08%)           | 7 (6.83%)          |                      | 0                | 0                             |
| Acute rehab                        | 3 (3.23%)           | 1 (0.98%)          |                      | 0                | 0                             |

<sup>a</sup> Denotes a statistically significant difference between commercial and medicare cohorts ( $P < .05$ ).

beneficiaries, adjusted preoperative Medicare PRO scores differed by  $-0.63 \pm 2.40$  points for KOOS JR. ( $P = .79$ ),  $0.29 \pm 2.49$  points for VR-12 PCS and  $0.91 \pm 3.07$  points for VR-12 MCS ( $P = .77$ ) when compared to commercial payer types. When assessing  $\Delta$ PRO scores, Medicare beneficiaries demonstrated non-significant differences of  $0.56 \pm 2.40$  points for KOOS JR. ( $P = .82$ ),  $-1.06 \pm 1.96$  points for VR-12 PCS ( $P = .59$ ),  $-1.62 \pm 2.25$  points for VR-12 MCS ( $P = .47$ ) when compared to their commercial counterparts. Final PRO scores at 12 weeks differed on average by  $1.99 \pm 1.65$  points for KOOS JR. ( $P = .23$ ),  $0.22 \pm 1.60$  points for VR-12 PCS ( $P = .89$ ), and  $2.21 \pm 1.90$  points for VR-12 MCS ( $P = .25$ ).

Further review of the multivariable analysis was performed to evaluate patient factors that may affect preoperative, postoperative, and  $\Delta$ KOOS JR. scores. Preoperatively, increasing age was positively correlated with improved KOOS JR. scores ( $\beta = 0.45$ ;  $P < .01$ ), while “other race” was negatively correlated with KOOS JR. scores ( $\beta = -7.78$ ;  $P < .05$ ). Postoperatively, KOOS JR. scores were negatively correlated with BMI ( $\beta = -0.33$ ;  $P < .05$ ) and single/widowed marital status ( $\beta = -4.44$ ;  $P < .05$ ). Finally,  $\Delta$ KOOS JR. scores were found to be positively correlated with increasing ASA score ( $\beta =$

$4.53$ ;  $P < .05$ ) and “other race” ( $\beta = 9.26$ ;  $P < .05$ ), while being single/widowed was still negatively correlated ( $\beta = 5.82$ ;  $P < .05$ ).

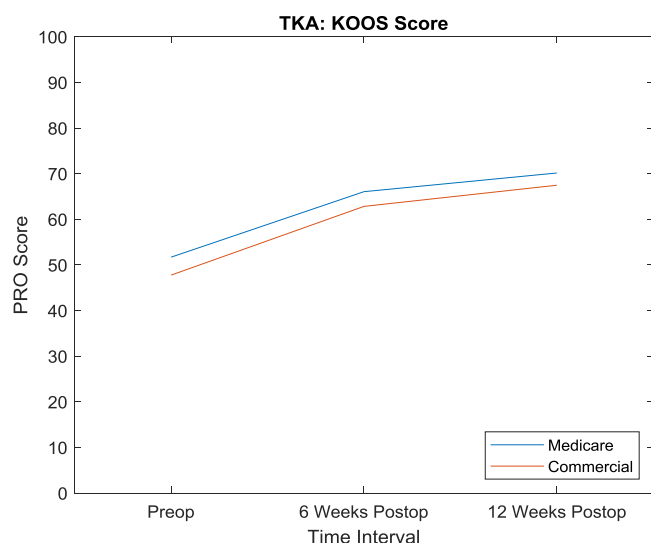
## Discussion

The effects of various patient factors on TKA postoperative outcomes have been well studied [8–11], but the impact of payer type on outcomes still has yet to be established. Owing to an increased demand for knee arthroplasty procedures and an unsustainable Medicare fee-for-service payment model, novel bundled payment models for arthroplasty have been explored and been shown to be successful in reducing costs with concomitant increases in quality [22–24]. The Centers for Medicare and Medicaid Services is requiring the utilization of PROs in recent models of bundle payments, such as the Comprehensive Care for Joint Replacement program, in which they will be used as a core component of a hospital's quality score [25]. We, therefore, investigated whether patients receiving government-based health insurance demonstrate better or worse outcomes compared to their commercially insured counterparts.

**Table 2**  
TKA PRO scores relative to commercial insurance.

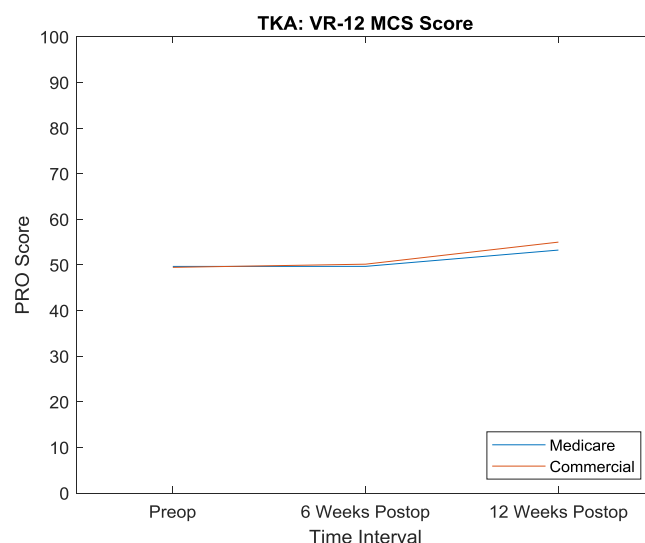
| Patient reported outcomes | Commercial    | Medicare      | P                 | Medicaid      | Worker's compensation |
|---------------------------|---------------|---------------|-------------------|---------------|-----------------------|
| Preoperative PROs         |               |               |                   |               |                       |
| KOOS JR.                  | 47.78 ± 11.82 | 51.91 ± 13.88 | <.05 <sup>a</sup> | 50.76 ± 22.57 | 46.34 ± 10.81         |
| VR-12 PCS                 | 32.92 ± 8.55  | 32.19 ± 8.62  | .53               | 33.28 ± 11.32 | 23.15 ± 2.78          |
| VR-12 MCS                 | 49.47 ± 12.35 | 49.65 ± 11.68 | .96               | 41.77 ± 11.87 | 45.55 ± 10.59         |
| 12 weeks postop PROs      |               |               |                   |               |                       |
| KOOS JR.                  | 67.47 ± 13.62 | 70.26 ± 12.61 | .15               | 62.42 ± 6.10  | 66.49 ± 9.60          |
| VR-12 PCS                 | 40.11 ± 8.48  | 40.03 ± 7.89  | .76               | 43.72 ± 3.00  | 33.22 ± 9.01          |
| VR-12 MCS                 | 55.00 ± 8.97  | 53.40 ± 9.91  | .26               | 44.17 ± 4.49  | 50.72 ± 19.52         |
| $\Delta$ PROs             |               |               |                   |               |                       |
| KOOS JR.                  | 19.69 ± 15.44 | 18.35 ± 15.92 | .58               | 12.34 ± 18.77 | 20.15 ± 19.17         |
| VR-12 PCS                 | 6.68 ± 10.21  | 7.85 ± 9.04   | .41               | 10.44 ± 8.78  | 10.07 ± 6.95          |
| VR-12 MCS                 | 5.24 ± 11.66  | 3.74 ± 10.59  | .36               | 2.40 ± 11.60  | 9.17 ± 9.45           |

<sup>a</sup> Denotes a statistically significant difference between commercial and medicare cohorts ( $P < .05$ ).



**Figure 1.** KOOS JR. scores at preoperative, 6-week postoperative, and 12-week postoperative time points.

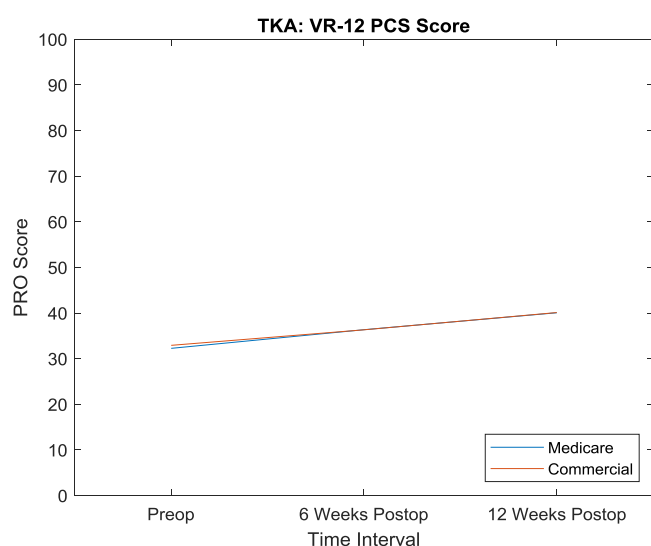
PROs have emerged as a useful way for surgeons to quantify the degree of postoperative pain relief and functional gain in their patients. More than 40 PROs have been identified in leading orthopaedic journals to quantify outcomes after hip and knee arthroplasty; a “good” PRO measure must be validated, reliable, and responsive to change in patient health status [7,26]. The Centers for Medicare and Medicare Services, with its newly placed emphasis on performance and quality, solely adopted the KOOS to assess whether TKA outcomes meet their pay-for-performance measures [27]. Despite being widely used, however, the full KOOS is a 42-item survey with redundancies and questions irrelevant to those with end-stage osteoarthritis (eg, assessing pain during running and jumping) [7,27]. Long surveys with content perceived by patients to be confusing or not relevant are commonly cited barriers to PRO measure completion [6]. This prompted the development of the KOOS JR., a more efficient 7-item survey that retained questions from the long form KOOS most relevant to patients with end-stage osteoarthritis undergoing TKA [27]. The KOOS JR., used in this



**Figure 3.** VR-12 MCS at preoperative, 6-week postoperative, and 12-week postoperative time points.

study, was administered to patients via an EPRA, the use of which is associated with better patient completion rates, improved data accuracy, and cost-effectiveness relative to traditional in-office methods [28].

Among the 193 patients who underwent primary TKA and were included in the final analysis, it was found that demographic variables including age, gender, BMI, and race varied significantly. Despite being significantly older with a higher ASA comorbidity index, Medicare patients reported a higher KOOS JR. score preoperatively, indicating slightly better levels of pain and function at baseline. This may be due to the significantly higher BMI of the commercially insured cohort as obesity has been associated with poorer patient-reported pain and function [29–31]. The racial distribution in the commercial payer cohort also reveals a greater frequency of African-American patients, who have been shown to have worse range of motion and Knee Society Scores (KSS) at 2-year follow-up after TKA when compared with Caucasians [11]. In addition, one study exploring predictors of postoperative pain after TKA found an inverse relationship between age and pain scores [32]. Proposed explanations for this suggest that older patients may de-emphasize pain due to having experienced other significant life stressors and other medical comorbidities and may be less likely to engage in activities that typically exacerbate pain [32,33]. After adjusting for all patient-specific demographic and perioperative variables, all PROs recorded in this study were similar between the 2 payer groups at baseline and 12 weeks postoperatively. Our study



**Figure 2.** VR-12 PCS at preoperative, 6-week postoperative, and 12-week postoperative time points.

**Table 3**  
Adjusted TKA PRO scores relative to commercial insurance.

| Patient reported outcomes   | Commercial | Medicare         | P   | Model P-value |
|-----------------------------|------------|------------------|-----|---------------|
| <b>Preoperative PROs</b>    |            |                  |     |               |
| KOOS JR.                    | Reference  | $-0.63 \pm 2.40$ | .79 | <.01          |
| VR-12 PCS                   | Reference  | $0.29 \pm 2.49$  | .91 | <.05          |
| VR-12 MCS                   | Reference  | $0.91 \pm 3.06$  | .77 | .17           |
| <b>12 weeks postop PROs</b> |            |                  |     |               |
| KOOS JR.                    | Reference  | $-1.99 \pm 1.65$ | .23 | <.01          |
| VR-12 PCS                   | Reference  | $0.22 \pm 1.60$  | .89 | .08           |
| VR-12 MCS                   | Reference  | $2.21 \pm 1.90$  | .25 | .17           |
| <b>ΔPROs</b>                |            |                  |     |               |
| KOOS JR.                    | Reference  | $0.56 \pm 2.40$  | .82 | .48           |
| VR-12 PCS                   | Reference  | $-1.06 \pm 1.96$ | .59 | .89           |
| VR-12 MCS                   | Reference  | $-1.62 \pm 2.25$ | .47 | .67           |

suggests TKA candidates, regardless of the payer type, may enjoy similar PROs at each perioperative time point. These findings have important implications for the future of joint arthroplasty under new APMs, as they suggest that patients with similar baseline characteristics but different payer types will be roughly equal cost burdens to the health-care system.

Although there is no difference in TJA access between Medicare- and PPO-insured patients, despite lower reimbursement rates for Medicare [34,35], few prior studies have investigated the differences in TKA outcomes after stratifying by insurance type. To date, the present study is the largest of its kind and the first to use PROs as a primary outcome. Our findings concur with those of a similar study by Rosenthal et al., in which beneficiaries of Medicaid, Medicare, and Blue Cross/Blue Shield (BCBS) were assessed with KSS preoperatively and postoperatively. They found no significant difference in outcome scores between Medicare and BCBS patients at all time points. This was also found in a prior analysis by Hinman and Bozic [36] assessing the effect of payer type on Harris Hip Scores before and after total hip arthroplasty. However, BCBS administers Medicare in many states, including that of the authors' institution, act as a potential confounder for any differences in outcomes between Medicare and commercial beneficiaries. The commercial beneficiaries in the present study were covered by a variety of health plans, allowing our analysis to be more generalizable to a greater number of patients.

Other patient factors which may have affected preoperative, postoperative, and delta KOOS JR. scores were also ascertained from the multivariable analysis. Preoperatively, increasing age was positively correlated with improved KOOS JR. scores; postoperatively, increasing BMI was negatively correlated with outcome scores. Interestingly, single and widowed patients were found to be significantly associated with lower postoperative and  $\Delta$ KOOS JR. scores. These findings are similar to previous studies which have shown unmarried patients have lower outcome scores than married patients postoperatively after TKA even after controlling for preoperative scores, possibly the result of poorer social support [37]. Finally, "other race" was negatively correlated with preoperative and  $\Delta$ KOOS JR. scores; however, this may be the result of a type I error as there were very few patients in this category.

Although it would have been interesting to include Medicaid and Worker's compensation beneficiaries in our analysis, the sample size of patients was too low. Rosenthal et al. included Medicaid patients in their study and found them to have significantly worse preoperative KSS scores than Medicare and BCBS patients and poorer postoperative scores than BCBS patients. The commonly cited reasons for the worse clinical outcomes experienced by these patients are increased travel distance and limited access to care [36,38]. Expanded Medicaid eligibility and increased coverage under the Patient Protection and Affordable Care Act does not necessarily translate to increased health-care access. Kim et al. found that Medicaid patients have the lowest rate of appointment success for evaluation for TKA when compared against Medicare and privately insured patients, citing reasons such as decreasing reimbursement rates, increased paperwork required to process reimbursements, lack of primary care provider referral, and physician perception that Medicaid patients will be less compliant with medical instruction [35].

This study is not without limitations. Six-hundred twenty-eight patients undergoing TKA were registered for the EPRA, but only 201 patients had completed both the preoperative and 12-week postoperative surveys necessary to be included in the analysis. This response rate is on par with reported rates after total joint replacement and other orthopaedic procedures [39,40]. The capture rate also fails to account for reasons that patients may have been unable to otherwise complete the surveys. For instance, not all

patients own or regularly use a smartphone or tablet, or they may have simply not enabled push notifications on their smart device.

Another limitation of this study was that postoperative complication rates of the different payer types were not compared. Preoperative comorbidities are known to increase the risk of postoperative complications and to result in increased costs to the medical system after TJA [18]. A study performed by Veltre et al. [20] on a nationwide database evaluated the effect of patient insurance status on in-hospital complication rate. They found that the Medicare population had the highest complication rates, followed by the Medicaid/uninsured, other insurance, and privately insured cohorts. Increasing age and comorbidity index were also significantly associated with more medical complications, emphasizing the importance of optimizing patient health prior to surgery.

## Conclusions

In conclusion, although patient demographic variables vary substantially by payer type (eg, age, gender, and race), PROs are similar at baseline and 12 weeks postoperatively after adjusting for patient-specific variables. This may be of increasing importance with the shift toward bundled payments for discrete episodes of care as it bolsters the notion that if Medicare patients can expect similar outcomes, they may be an equal cost burden to the health-care system, as their younger, healthier counterparts. In addition, this study further demonstrates the success of an EPRA for collecting patient outcome information via a short, focused survey such as the KOOS JR. that assesses pain, function, and symptoms. Further efforts should be made to encourage patient participation and integrate PROs into routine clinical practice.

## References

- [1] Gray CF, Bozic KJ. Epidemiology, cost, and health policy related to total knee arthroplasty. *Curr Orthop Pract* 2015;26:212.
- [2] Kurtz S, Ong K, Lau E, Mowat F, Halpern M. Projections of primary and revision hip and knee arthroplasty in the United States from 2005 to 2030. *J Bone Joint Surg* 2007;89:780.
- [3] Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: who is satisfied and who is not? *Clin Orthop Relat Res* 2010;468:57.
- [4] Noble PC, Condit MA, Cook KF, Mathis KB. The John Insall Award: patient expectations affect satisfaction with total knee arthroplasty. *Clin Orthop Relat Res* 2006;452:35.
- [5] Dunbar MJ, Richardson G, Robertsson O. I can't get no satisfaction after my total knee replacement. *Bone Joint J* 2013;95-B:148.
- [6] Franklin PD, Lewallen D, Bozic K, Hallstrom B, Jiranek W, Ayers DC. Implementation of patient-reported outcome measures in U.S. total joint replacement registries: rationale, status, and plans. *J Bone Joint Surg* 2014;96:104.
- [7] Siljander MP, McQuivey K, Fahs A, Galasso L, Serdahely K, Karadsheh MS. Current trends in patient reported outcome measures in total joint arthroplasty: a study of four major orthopedic journals. *J Arthroplasty* 2018;33:3416.
- [8] Bourne RB, McCalden RW, MacDonald SJ, Mokete L, Guerin J. Influence of patient factors on TKA outcomes at 5 to 11 years followup. *Clin Orthop Relat Res* 2007;2001:27.
- [9] Khatib Y, Madan A, Naylor JM, Harris IA. Do psychological factors predict poor outcome in patients undergoing TKA? A systematic review. *Clin Orthop Relat Res* 2015;473:2630.
- [10] Singh JA, Kwok CK, Richardson D, Chen W, Ibrahim SA. Sex and surgical outcomes and mortality after primary total knee arthroplasty: a risk-adjusted analysis. *Arthritis Care Res (Hoboken)* 2013;65:1095.
- [11] Kamath AF, Horneff JG, Gaffney V, Israelite CL, Nelson CL. Ethnic and gender differences in the functional disparities after primary total knee arthroplasty. *Clin Orthop Relat Res* 2010;468:3355.
- [12] Lapar DJ, Bhamidipati CM, Mery CM, et al. Primary payer status affects mortality for major surgical operations. *Ann Surg* 2010;252:544.
- [13] Stone ML, Lapar DJ, Mulloy DP, et al. Primary payer status is significantly associated with postoperative mortality, morbidity, and hospital resource utilization in pediatric surgical patients within the United States. *J Pediatr Surg* 2013;48:81.
- [14] Daniel VT, Ayturk D, Ward DV, McCormick B, Santry HP. The influence of payer status on outcomes associated with surgical repair of perforated peptic ulcer disease in the United States. *Gastroenterology* 2018;154:121.

- [15] Belatti DA, Pugely AJ, Phisitkul P, Amendola A, Callaghan JJ. Total joint arthroplasty: trends in medicare reimbursement and implant prices. *J Arthroplasty* 2014;29:1539.
- [16] Weeks WB, Rauh SS, Wadsworth EB, Weinstein JN. The unintended consequences of bundled payments. *Ann Intern Med* 2013;158:62.
- [17] Siddiqi A, White PB, Mistry JB, et al. Effect of bundled payments and health care reform as alternative payment models in total joint arthroplasty: a clinical review. *J Arthroplasty* 2017;32:2590.
- [18] Karas V, Kildow BJ, Baumgartner BT, et al. Preoperative patient profile in total hip and knee arthroplasty predictive of increased medicare payments in a bundled payment model. *J Arthroplasty* 2018;33:2728.
- [19] Rosenthal BD, Hulst JB, Moric M, Levine BR, Sporer SM. The effect of payer type on clinical outcomes in total knee arthroplasty. *J Arthroplasty* 2014;29:295.
- [20] Veltre DR, Yi PH, Sing DC, et al. Insurance status affects in-hospital complication rates after total knee arthroplasty. *Orthopedics* 2018;41:e340.
- [21] Lyman S, Lee Y-Y, McLawhorn AS, Islam W, MacLean CH. What are the minimal and substantial improvements in the hoos and koos and jr versions after total joint replacement? *Clin Orthop Relat Res* 2018;476:2432.
- [22] Iorio R, Clair AJ, Inneh IA, Slover JD, Bosco JA, Zuckerman JD. Early results of medicare's bundled payment initiative for a 90-day total joint arthroplasty episode of care. *J Arthroplasty* 2016;31:343.
- [23] Dundon JM, Bosco J, Slover J, Yu S, Sayeed Y, Iorio R. Improvement in total joint replacement quality metrics. *J Bone Joint Surg* 2016;98:1949.
- [24] Althausen PL, Mead L. Bundled payments for care improvement. *J Orthop Trauma* 2016;30:S50.
- [25] Centers for Medicare Medicaid Services. Overview of Comprehensive care for joint replacement (CJR) model quality measures, composite quality score, and pay-for-performance methodology. n.d. 1–15. <https://innovation.cms.gov/Files/x/cjr-qualsup.pdf>. [accessed 25.07.2018].
- [26] Collins NJ, Roos EM. Patient-reported outcomes for total hip and knee arthroplasty. *Clin Geriatr Med* 2012;28:367.
- [27] Lyman S, Lee Y-Y, Franklin PD, Li W, Cross MB, Padgett DE. Validation of the KOOS, JR: a short-form knee arthroplasty outcomes survey. *Clin Orthop Relat Res* 2016;474:1461.
- [28] Bell K, Warnick E, Nicholson K, et al. Patient adoption and utilization of a web-based and mobile-based portal for collecting outcomes after elective orthopedic surgery. *Am J Med Qual* 2018;33:649.
- [29] Núñez M, Lozano L, Núñez E, Sastre S, Luis del Val J, Suso S. Good quality of life in severely obese total knee replacement patients: a case-control study. *Obes Surg* 2011;21:1203.
- [30] McElroy M, Pivec R, Issa K, Harwin S, Mont M. The effects of obesity and morbid obesity on outcomes in TKA. *J Knee Surg* 2013;26:083.
- [31] Cooper NA, Rakel BA, Zimmerman B, et al. Predictors of multidimensional functional outcomes after total knee arthroplasty. *J Orthop Res* 2017;35:2790.
- [32] Roth ML, Tripp DA, Harrison MH, Sullivan M, Carson P. Demographic and psychosocial predictors of acute perioperative pain for total knee arthroplasty. *Pain Res Manag* 2007;12:185.
- [33] Lachapelle DL, Hadjistavropoulos T. Age-related differences among adults coping with pain: evaluation of a developmental life-context model. *Can J Behav Sci* 2005;37:123.
- [34] Schwarzkopf R, Phan DL, Hoang M, Ross SDK, Mukamel D. Do patients with income-based insurance have access to total joint arthroplasty? *J Arthroplasty* 2014;29:1083.
- [35] Kim CY, Wiznia DH, Hsiang WR, Pelker RR. The effect of insurance type on patient access to knee arthroplasty and revision under the affordable care act. *J Arthroplasty* 2015;30:1498.
- [36] Hinman A, Bozic KJ. Impact of payer type on resource utilization, outcomes and access to care in total hip arthroplasty. *J Arthroplasty* 2008;23:9.
- [37] Roubion RC, Fox RS, Townsend LA, Pollock GR, Leonardi C, Dasa V. Does marital status impact outcomes after total knee arthroplasty? *J Arthroplasty* 2016;31:2504.
- [38] Martin CT, Callaghan JJ, Liu SS, Gao Y, Warth LC, Johnston RC. Disparity in total joint arthroplasty patient comorbidities, demographics, and postoperative outcomes based on insurance payer type. *J Arthroplasty* 2012;27:1761.
- [39] Ayers DC. Implementation of patient-reported outcome measures in total knee arthroplasty. *J Am Acad Orthop Surg* 2017;25:S48.
- [40] Makhni EC, Higgins JD, Hamamoto JT, Cole BJ, Romeo AA, Verma NN. Patient compliance with electronic patient reported outcomes following shoulder arthroscopy. *Arthrosc J Arthrosc Relat Surg* 2017;33:1940.