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Kerri L. Bell

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# Preoperative Opioid Use Increases the Cost of Care in Total Joint Arthroplasty

Kerri L. Bell, MD

Maxwell Detweiler, BS 

Michael Yayac, MD 

Sreeram Penna, MD 

Antonia F. Chen, MD 

From the Department of Orthopaedic Surgery, Henry Ford Hospital, Detroit, MI (Dr. Bell), Sidney Kimmel Medical College, Thomas Jefferson University (Mr. Detweiler), Rothman Orthopaedic Institute (Dr. Yayac and Dr. Penna), Philadelphia, PA, and the Department of Orthopaedic Surgery, Brigham and Women's Hospital, Boston, MA (Dr. Chen).

Correspondence to Dr. Yayac: [michaelyayac@gmail.com](mailto:michaelyayac@gmail.com)

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## Abstract

**Introduction:** Predictors of financial costs related to total joint arthroplasty (TJA) have become increasingly important because payment methods have shifted from fee for service to bundled payments. The purpose of this study was to assess the relationship between preoperative opioid use and cost of care in primary TJA.

**Methods:** A retrospective study was conducted in Medicare patients who underwent elective unilateral primary total knee or hip arthroplasty between 2015 and 2018. Preoperative opioid usage, comorbidities, length of stay, and demographic information were obtained from chart review. The total episode-of-care (EOC) cost data was obtained from the Centers of Medicare and Medicaid Services based on Bundled Payments for Care Improvement Initiative Model 2, including index hospital and 90-day postacute care costs. Patients were grouped based on preoperative opioid usage. Costs were compared between groups, and multivariate linear regression analyses were performed to analyze whether preoperative opioid usage influenced the cost of TJA care. Analyses were risk-adjusted for patient risk factors, including comorbidities and demographics.

**Results:** A total of 3,211 patients were included in the study. Of the 3,211 TJAs, 569 of 3,211 patients (17.7%) used preoperative opioids, of which 242 (42.5%) only used tramadol. EOC costs were significantly higher for opioid and tramadol users than nonopioid users (\$19,229 versus \$19,403 versus \$17,572,  $P < 0.001$ ). Multivariate regression predicted that the use of preoperative opioids in TJA was associated with increased EOC costs by \$789 for opioid users (95% confidence interval [CI] \$559 to \$1,019,  $P < 0.001$ ) and \$430 for tramadol users (95% CI \$167 to \$694,  $P = 0.001$ ). Total postacute care costs were also increased by 70% for opioid users (95% CI 44% to 102%,  $P < 0.001$ ) and 48% for tramadol users (95% CI 22% to 80%,  $P < 0.001$ ).

**Discussion:** This study demonstrated that preoperative opioid usage was associated with higher cost of care in TJA. Limiting preoperative opioid use for pain management before TJA could contribute to cost savings within a bundled model.

Most clinical practice guidelines recommend treating hip and knee osteoarthritis pain with an analgesic pathway, starting with acetaminophen or NSAIDs, followed by intra-articular corticosteroid injections, and finally, total joint arthroplasty (TJA). Despite efforts to address the opioid epidemic, the literature demonstrates that physicians are still

prescribing opioids to treat chronic osteoarthritis pain, with recent studies reporting that 17 to 39.4% of patients undergoing TJA were prescribed opioids before surgery.<sup>1-6</sup>

Within the orthopaedic surgery literature, preoperative opioid use led to higher complications, longer hospital length of stay (LOS), higher rates of discharge to extended care facilities, higher rates of 30-day readmissions, increased number of revision TJA, and increased morbidity and mortality, all of which can affect the cost and reimbursement within the bundled care payment system.<sup>1,7-11</sup> Although previous studies within spinal and abdominal surgery patients reported higher total costs associated with preoperative opioid usage,<sup>12-14</sup> to our knowledge, no similar studies exist within the TJA literature.

Predictors of financial cost have become increasingly important in the wake of the Centers for Medicare and Medicaid Services (CMS) using alternative payment models such as the Bundled Payment for Care Improvement Initiative. Because TJAs are among the most common surgical procedures performed in the United States,<sup>15</sup> costs have important economic implications for providers, institutions, and insurers. Thus, determining the role of preoperative opioid use on the total financial expenses of TJA could shed light on potential costs and identify cost-saving measures. Therefore, the primary purpose of this study was to assess the relationship between preoperative opioid use and 90-day episode-of-care (EOC) cost for primary TJA. Second, we determined if preoperative opioid use had an impact on short-term outcomes measures that influenced cost, such as discharge disposition or 90-day readmissions. Finally, we sought to determine the independent effect of preoperative opioid use on costs when controlling for confounding factors.

## METHODS

### Study Design and Patient Cohort

A retrospective, observational study within a single institution was conducted on Medicare patients who underwent elective unilateral primary total knee arthroplasty and total hip arthroplasty (THA) between January 1, 2015, and September 30, 2018. A total of 3,211 patients were eligible for inclusion in the study, and none of these patients were from subacute nursing facilities. Institutional Review Board approval was obtained before conducting this study. Patient medications were manually documented from preadmission testing notes. Preoperative opioid users were defined as patients who had one or more opioid medications reported as current medication in the last outpatient note before surgery or in preadmission testing notes. The duration of opioid use could not be determined from these notes. Opioid medications included tramadol, oxycodone, hydrocodone, codeine, hydromorphone, and other opioid medications (Table 1). Patients were divided into one of three groups according to preoperative opioid use; 1—No Opioids, 2—Tramadol Only, and 3—All Opioids, which did not include tramadol only users. Demographic information including age, sex, race, body mass index, Charlson Comorbidity index, and joint type (knee or hip) along with the hospital LOS were recorded from electronic medical records.

Cost of care data were based on financial information obtained from CMS Bundled Payments for Care Improvement Model 2 claims data. Model 2 is a retrospective bundled payment model where fee-for-service payments for TJA are reconciled against target prices. This model incentivizes providers who are able to effectively reduce the cost of care without compromising the quality.

Cost data from this model include reimbursements from time of admission to 90-days postdischarge. *Total EOC costs* included all inpatient and outpatient costs. *Total index costs* included any inpatient charges, whereas *total postacute care (PAC) costs* included any payments postdischarge, which included, but were not limited to, discharge facilities, home health aides, and physical therapy.

### Statistical Analysis

Demographics, costs, and outcomes were compared between groups. Continuous variables were reported as mean and standard deviation and compared using Kruskal-Wallis tests because they were all nonparametric in distribution. Categorical variables were reported as counts and percentages and compared using chi-square analysis. Multivariate regression models were conducted to evaluate the relative impact of preoperative opioids usage on EOC cost, total index cost, and total PAC costs. Because financial data are not normally distributed, data transformations were required to obtain normality for each group. For EOC cost, costs in the upper and lower 15th percentiles were winsorized, respective to the mean raw cost. Total index costs in the upper and lower 10th percentiles were also winsorized. Total PAC cost and LOS were normalized with log transformations. *P*-values less than 0.05 were considered statistically significant. Statistical analysis was performed using R version 3.6.3 (R Foundation for Statistical Computing).

## RESULTS

Of the 3,211 patients included in the study, there were 1,663 total knee arthroplasties and 1,548 THAs, and 1,282 (39.9%) were men. The overall prevalence of preoperative opioid usage was 17.7% (569 of 3,211), of which 242 patients (42.5%) only

used tramadol. Of the opioids consumed, tramadol (48.3%, 275 of 569) and oxycodone (30.4%, 173 of 569) were the most commonly used (Table 1). Some patients had more than one opioid prescribed. Significant differences between the groups were observed for age, sex, Charlson Comorbidity index, and ethnicity (Table 2).

Total EOC costs were significantly higher for the All Opioids and Tramadol Only groups compared with the No Opioids group (\$19,229 versus \$19,403 versus \$17,572,  $P < 0.001$ , Table 3). This difference was because of both a difference in total index costs (\$13,868 versus \$13,778 versus \$13,679,  $P < 0.001$ ) and PAC costs (\$5,361 versus \$5,625 versus \$3,893,  $P < 0.001$ ).

When comparing outcomes, mean LOS was greater for the All Opioids and Tramadol Only groups compared with the No Opioids group (2.0 days versus 1.9 days versus 1.6 days,  $P < 0.001$ ) (Table 3). In addition, patients using opioids or tramadol were twice as likely to be discharged to a facility (14% versus 14% versus 7%,  $P < 0.001$ ), specifically skilled nursing facilities (18% versus 14% versus 7%,  $P < 0.001$ ). No significant difference was observed, however, for complication rates (4% versus 3% versus 3%,  $P = 0.555$ ) or readmission rates (7% versus 5% versus 5%,  $P = 0.302$ ) between groups.

In a multivariate analysis, controlling for confounding factors, total EOC costs were \$789 greater for opioid users (95% confidence interval [CI] \$559 to \$1019,  $P < 0.001$ ) and \$430 (95% CI \$167 to \$694,  $P = 0.001$ ) for tramadol users (Table 4) compared with nonopioid users. Opioid use and tramadol use also increased total index costs by \$74 (95% CI \$45 to \$102,  $P < 0.001$ ) and \$39 (95% CI \$6 to \$72,  $P = 0.020$ ), respectively (Table 5). A more profound effect was observed

for PAC costs, where opioid use was associated with a 70% increase (95% CI 44% to 102%,  $P < 0.001$ ) and tramadol use was associated with a 48% increase (95% CI 22% to 80%,  $P < 0.001$ , Table 6) compared with nonopioids users.

## DISCUSSION

Using Medicare reimbursement payments, this study evaluated the impact of preoperative opioid use on the cost of TJA. Preoperative opioids, even tramadol alone, were found to markedly account for increased total episode, index, and postacute costs of primary knee and hip arthroplasty surgeries. In addition to cost, our study also demonstrated that preoperative opioids use was associated increased health utilization, specifically increased LOS and likelihood of discharge to a skilled care facility.

Research has shown an increasing prevalence of preoperative opioid utilization in elective orthopaedic patients, which is associated with increased mortality and morbidity in the postoperative period.<sup>16</sup> In the postsurgical period, opioid users are known to have increased opioid-related adverse events such as ileus, respiratory failure, and requirement of mechanical ventilation.<sup>8,16</sup> Previous opioid users have lower pain thresholds, opioid-induced hyperalgesia, and associated increased in postoperative opioid use.<sup>7,17</sup> In addition, previous opioid use in TJA patients is associated with increased periprosthetic joint and surgical site infection rates.<sup>16,18</sup> Opioid users have also been found to have increased hospital utilization including increased length of inpatient stay, increased use of physiotherapy, and nonroutine discharge.<sup>1,12,13,19</sup> Based on the above, one may infer that TJA patients with preoperative opioid use may increase the overall cost of care; however, cost utility analyses of preoperative opioid use in TJA are scarce in the literature.

**Table 1**

Opioid Usage	
Opioid Used	No. of Patients
Tramadol	275
Oxycodone	173
Hydrocodone	87
Codeine	47
Fentanyl patch	10
Hydromorphone	8
Buprenorphine patch	5
Tapentadol	3
Morphine	2
Methadone	1

Previous studies have investigated the cost in patient cohorts with degenerative lumbar stenosis and those undergoing abdominal surgery.<sup>12-14</sup>

A study by Tye et al<sup>12</sup> based on the Ohio Bureau of Workers' Compensation data found that patients with degenerative lumbar stenosis who were prescribed opioids for greater than 3 months before surgery incurred over \$70,000 more in total medical costs compared with those who received opioids for less than 3 months before surgery. In the same study, long-term opioid user group also had higher opioid use postoperatively and also had more psychiatric diagnoses postsurgery. The cost difference between the groups was substantially higher than in our study, likely because of several key differences in study cohort and design. Our study cohort was exclusively comprised Medicare patients.<sup>20</sup> In addition, we were unable to determine opioid prescription strength or length of opioid use before TJA in this study, which precluded our ability to distinguish short-term from long-term opioid users in our analysis. In addition, Tye et al evaluated the total costs incurred over the 3-year postoperative period, whereas our study only evaluated 90-day costs.

Table 2

Patient Characteristics				
Demographic Variable	No Opioids N = 2,642	All Opioids N = 327	Tramadol Only N = 242	P Value
Age	71.7 (6.41)	69.8 (8.34)	71.9 (7.86)	<0.001 <sup>a,b</sup>
Sex				<b>0.004<sup>a</sup></b>
Females	1,557 (58.9%)	204 (62.4%)	168 (69.4%)	
Men	1,085 (41.1%)	123 (37.6%)	74 (30.6%)	
Body mass index (kg/m <sup>2</sup> )	29.3 (4.99)	30.0 (5.50)	29.5 (5.26)	0.066
Charlson Comorbidity index	2.22 (1.89)	1.46 (1.69)	1.75 (1.83)	<0.001 <sup>a,c</sup>
Ethnicity				<0.001 <sup>c</sup>
Caucasian	2,132 (85.6%)	247 (78.4%)	187 (81.3%)	
African American	228 (9.15%)	58 (18.4%)	32 (13.9%)	
Other	131 (5.26%)	10 (3.17%)	11 (4.78%)	
Joint				<b>0.038</b>
Hip	1,247 (47.2%)	169 (51.7%)	132 (54.5%)	
Knee	1,395 (52.8%)	158 (48.3%)	110 (45.5%)	

<sup>a</sup> No opioids significantly differed from tramadol only.

<sup>b</sup> All opioids significantly differed from tramadol only.

<sup>c</sup> No opioids significantly differed from all opioids.

Reported as mean (SD) or n (%), bold denotes statistical significance.

Although preoperative opioid use did not have as large an impact on cost in our study, demonstrating differences in the hundreds of dollars for categories such as total index cost or postacute skilled facility costs, TJA has become one of the most common surgical procedures. A 2018 review of the National Inpatient Sample data estimates the rates of TJA to increase by greater than 70%, reaching over 1.5 million cases performed annually by 2030.<sup>21</sup> Considering the incidence of opioid use and cost differences observed in our study, we estimate that preoperative opioid use would incur greater than \$177 million in TJA EOC expenses for CMS by 2030. This would represent a notable source of potential savings for CMS if rates of preoperative opioid use can be decreased, even with the reduction of tramadol alone.

A similar study conducted by O'Donnell et al<sup>13</sup> reported that opioid use defined for more than 90 days before lumbar discectomy was an independent predictor of higher

medical costs because the opioid user group had higher resource utilization for postoperative care. Waljee et al<sup>14</sup> reported that preoperative opioid use was associated with markedly greater cost expenditures at 90, 180, and 365 days after elective abdominal surgery. Although their study found no notable differences in inpatient costs, this differed from our results where inpatient costs were increased in reported opioid user group most likely secondary to increased LOS.

In the current study, preoperative opioid users were more likely to have longer length of inpatient stay and more likely be discharged to nonhome locations compared with nonopioid users. A study by Pivec et al<sup>19</sup> found significantly increased LOS in patients with previous opioid use undergoing THA. In their study, opioid users stayed 4 hospital days compared with 3 days for the nonopioid group. In another study by Zarling et al,<sup>11</sup> the authors reported a trend toward increased nonhome discharge in opioid patients who underwent TJA. In their study,

31% of patients who used chronic preoperative opioids ( $\geq 2$  opiate prescriptions filled for 6 weeks in the 3 months before surgery) were discharged to extended care facilities compared with 21% of the control group. Using the national inpatient sample data, Menendez et al<sup>16</sup> found that opioid users undergoing elective orthopaedic procedures had markedly more nonhome-bound discharge and increase in length of inpatient stay. We hypothesize that these preoperative opioid users have lower pain threshold, increased use of opioids in the postoperative period because of opioid-induced hyperalgesia, decreased mobilization, and increased utilization of postoperative care including physical therapy as possible causes for this finding.

Our findings were similar to those found by Chen et al,<sup>22</sup> who demonstrated that patients with documented opioid dependence had significantly higher total hospital charges. Our findings were unique from theirs in that we considered any patient using opioid

**Table 3**

**Comparison of Costs and Outcomes**

Variable	No Opioids N = 2,642	All Opioids N = 327	Tramadol Only N = 242	P Value
Short-term outcome measures				
LOS (d)	1.59 (1.05)	2.02 (1.42)	1.86 (1.18)	< <b>0.001</b> <sup>a,b</sup>
Discharge to facility	193 (7.31%)	44 (13.5%)	33 (13.6%)	< <b>0.001</b> <sup>a,b</sup>
Skilled nursing facility	81 (6.67%)	39 (17.8%)	26 (13.9%)	< <b>0.001</b> <sup>a,b</sup>
Inpatient rehab	17 (1.40%)	4 (1.83%)	5 (2.67%)	0.335
Long-term acute care	1 (0.08%)	1 (0.46%)	0 (0.00%)	0.439
90-d complications	78 (3.04%)	13 (4.15%)	8 (3.42%)	0.555
90-d readmission	141 (5.34%)	24 (7.34%)	12 (4.96%)	0.302
EOC costs				
Total episode cost	17,572 (7,731)	19,229 (8,772)	19,403 (11,310)	< <b>0.001</b> <sup>a,b</sup>
Total index cost	13,679 (754)	13,868 (1,077)	13,778 (1,149)	< <b>0.001</b> <sup>a</sup>
Index facility cost	11,615 (665)	11,764 (993)	11,696 (929)	< <b>0.001</b> <sup>a</sup>
Index part B services	1,266 (792)	1602 (762)	1,742 (879)	< <b>0.001</b> <sup>a,b</sup>
Index DME	7.62 (28.3)	11.1 (31.9)	6.26 (20.1)	0.296
Total PAC cost	3,893 (7,656)	5,361 (8,621)	5,625 (11,068)	< <b>0.001</b> <sup>a,b</sup>
IRF cost	197 (2,008)	356 (2,672)	622 (3,483)	<b>0.015</b> <sup>b</sup>
SNF cost	778 (3,422)	1,406 (3,989)	1,674 (5,320)	< <b>0.001</b> <sup>b</sup>
HHA cost	473 (1,253)	817 (1,470)	727 (1,437)	< <b>0.001</b> <sup>a,b</sup>
Outpatient cost	554 (1,160)	610 (991)	449 (723)	<b>0.049</b>
Part B cost	1,609 (1,898)	1,618 (1,876)	1,540 (1,770)	0.722
DME cost	35.7 (139)	57.9 (179)	47.1 (160)	0.318
Readmission cost	557 (3,268)	616 (3,171)	679 (4,290)	0.339

DME = durable medical equipment, EOC = episode of care, HHA = home health aide, IRF = inpatient rehabilitation facility, LOS = length of stay, PAC = postacute care, SNF = skilled nursing facility  
<sup>a</sup> No opioids significantly differed from all opioids.  
<sup>b</sup> No opioids significantly differed from tramadol only.  
 Reported as mean (SD) or n (%), bold denotes statistical significance.

**Table 4**

**Total Episode Cost Predictive Factors**

Variable	Estimate (\$)	95% CI Lower Bound	95% CI Upper Bound	P Value
Age	47.16	36.75	57.56	< <b>0.001</b>
Body mass index	11.86	-2.20	25.93	0.098
Male sex	-301.08	-442.60	-159.57	< <b>0.001</b>
Joint (knee versus hip)	1,001.86	861.41	1,142.32	< <b>0.001</b>
All opioids with no tramadol	789.16	559.13	1,019.19	< <b>0.001</b>
Tramadol only	430.40	166.98	693.82	<b>0.001</b>

CI = confidence interval  
 Bold denotes statistical significance.

medications preoperatively to be an opioid user and were able to demonstrate that preoperative opioid use

had a large effect on PAC costs. Similar to their study, we observed notable differences in patient demographics

and comorbidities between groups. These findings agreed with other literature showing that opioid prescribing

**Table 5****Total Index Cost Predictive Factors**

Variable	Estimate (\$)	95% CI Lower Bound	95% CI Upper Bound	P Value
Age	0.92	-0.37	2.21	0.163
Body mass index	2.13	0.39	3.88	<b>0.017</b>
Male sex	-4.60	-22.15	12.96	0.608
Joint (knee versus hip)	42.66	25.24	60.08	<b>&lt;0.001</b>
All opioids with no tramadol	73.90	45.36	102.44	<b>&lt;0.001</b>
Tramadol only	38.85	6.18	71.53	<b>0.020</b>

CI = confidence interval  
 Bold denotes statistical significance.

**Table 6****Total Postacute Care Cost Predictive Factors**

Variable	Estimate (%)	95% CI Lower Bound	95% CI Upper Bound	P Value
Age	1.04	1.03	1.05	<b>&lt;0.001</b>
Body mass index	1.01	1.00	1.02	0.050
Male sex	0.81	0.73	0.90	<b>&lt;0.001</b>
Joint (knee versus hip)	2.47	2.23	2.74	<b>&lt;0.001</b>
All opioids with no tramadol	1.70	1.44	2.02	<b>&lt;0.001</b>
Tramadol only	1.48	1.22	1.80	<b>&lt;0.001</b>

CI = confidence interval  
 Bold denotes statistical significance.

is more common among younger adults.<sup>23,24</sup> Younger patients are likely healthier, explaining the difference in comorbidities. When we controlled for these differences through a multivariate analysis, we were still able to demonstrate a significant relationship between preoperative opioid use and EOC costs.

This study had several limitations that should be considered. First, the study was dependent on the willingness of the patient to truthfully divulge their medications and the accuracy of documentation because preoperative opioid usage was manually recorded

from the last outpatient note before surgery or preadmission testing notes. Second, preoperative opioid usage was reported as binary all or none because we were unable to determine true dosage, duration, and frequency of preoperative opioid consumption. Third, we did not record functional outcomes. Fourth, our study cohort only included Medicare patients and not patients with private insurance. Finally, this cost model only accounted for a small proportion of cost variation among patients; however, costs are multifactorial and depends on a wide variety of factors. Despite

these limitations, we were able to demonstrate that preoperative opioid use is significantly associated with increased EOC costs.

In conclusion, preoperative opioid use, whether full or partial opioid agonists, is associated with higher total episode costs, higher total index costs, higher PAC costs, longer LOS, and increased nonhome discharge in primary, elective TJA patients. In the era of bundled payments, limiting or eliminating opioids for preoperative pain management before joint replacement could be one avenue to reduce the overall cost of care.

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