The Journal of Arthroplasty 34 (2019) 638–644

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Primary Arthroplasty

Benchmarks of Duration and Magnitude of Opioid Consumption After Total Hip and Knee Arthroplasty: A Database Analysis of 69,368 Patients

David J. Cook, BEng [a,*], Samuel W. Kaskovich, BSA [a], Sean C. Pirkle, BA [a], Megan A. Conti Mica, MD [b], Lewis L. Shi, MD [b], Michael J. Lee, MD [b]

[a] Pritzker School of Medicine, University of Chicago, Chicago, IL
[b] Department of Orthopedic Surgery and Rehabilitative Medicine, University of Chicago Medicine, Chicago, IL

ARTICLE INFO

Article history:
Received 24 October 2018
Received in revised form
9 December 2018
Accepted 16 December 2018
Available online 24 December 2018

Keywords:
opioid
narcotic
prescription
total knee arthroplasty
total hip arthroplasty
orthopedics

ABSTRACT

Background: Opioid prescribing after orthopedic surgeries varies widely, and there is little consensus establishing proper standards of care. This retrospective cohort study examines opioid prescribing trends following total hip (THA) and knee (TKA) arthroplasty and evaluates preoperative opioid use as a predictor of duration and magnitude of postoperative opioid use.
Methods: Patients who underwent THA or TKA in a nationwide insurance database were stratified by preoperative opioid use. Naive, sporadic, and chronic users were defined as 0, 1, or 2+ prescriptions filled 6 months before surgery. Patients were excluded for readmission or subsequent surgery. Duration of opioid use was defined as time between the procedure and the last opioid prescription record, and magnitude of opioid use was defined as quantity of pills filled by 30 days postop.
Results: Naive patients were less likely than chronic users to fill any opioid prescription after surgery (THA: 61.5% naive vs 90.4% chronic, TKA: 72.0% naive vs 95.9% chronic), and they obtained fewer pills (THA: 73 pills naive vs 126 pills chronic, TKA: 86 pills naive vs 126 pills chronic, 5-mg oxycodone equivalent). Between 10% (THA) and 13% (TKA) of naive and between 47% (THA) and 62% (TKA) of chronic users continued opioid use at 1 year postop.
Conclusion: Chronic users obtain more opioids postoperatively and continue filling prescriptions for longer than naive patients. This work benchmarks norms regarding opioid use and furthermore these data highlight the powerful effect of opioid exposure during surgery as 10%-13% of naive patients continued opioids at 1 year postop.

The United States is suffering from a profound opioid crisis, with the Centers for Disease Control and Prevention reporting that the number of deaths involving opioids was 5 times higher in 2016 than in 1999 [1]. On average, 115 Americans die every day from an opioid overdose, and an estimated 40% of these deaths involve a prescription opioid [2]. When used correctly, prescription opioids can serve as a potent and effective pain control method. However, long-term users of these highly addictive medications are at risk for development of opioid use disorders. Often discussed in this nationwide public health emergency is the role that physicians play in prescribing opioid medication, as research shows that 75%-80% of heroin users state they first misused prescription opioids [3,4]. It is estimated that between 8% and 12% of patients who are prescribed opioids for chronic pain eventually develop an opioid use disorder [3–5]. Although the causes of the current opioid crisis are diverse and multivalent, the medical community has acknowledged its position within the issue and is grappling with how it can best play a positive role going forward [6–8].

Orthopedic surgery is the third highest opioid-consuming specialty, as we treat both chronic, osteoarthritic pain, as well as acute pain events such as fractures and dislocations [8]. Previous studies have shown that orthopedic surgeons tend to overprescribe opioids after surgery, and that many patients do not consume all of their prescribed pills [9–15]. Additionally, the amount of opioids

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2018.12.023.

* Reprint requests: David J. Cook, Pritzker School of Medicine, University of Chicago, 924 East 57th Street, Suite 104, Chicago, IL 60637.

https://doi.org/10.1016/j.arth.2018.12.023
0883-5403/

prescribed after orthopedic surgeries varies widely, and few established guidelines exist that standardized acceptable duration and magnitude of opioid use [16,17]. Because patients who utilize opioids for preoperative chronic pain develop a tolerance to the opioid's potency, these patients have unique needs after surgery and require a distinct course of postoperative opioid prescription after surgery when compared to opioid-naive patients.

Previously published work has examined opioid prescription trends at the provider level or single center level after an orthopedic procedure [9,15,18–21]. Additionally, a small number of insurance database studies utilize claims information to provide a rudimentary examination of large-scale trends in opioid prescription, and these studies perform a multivariate analysis to examine individual demographic and diagnostic risk factors that predict prolonged opioid use [22–25]. Because previous studies have focused on multivariate analysis of risk factors, this was not a goal of this study. Although these database studies have used some rudimentary methods to examine the number of consecutive postoperative opioid prescriptions, they are not able to quantify the amount of opioids these patients obtain across variety of opioid formulations and strengths [22–29]. Our work sought to expand upon previous large-scale, multicenter database work performed by evaluating both magnitude and duration of patients' opioid use following total knee arthroplasty (TKA) and total hip arthroplasty (THA) to meet the following objectives:

(1) Assess the prevalence of opioid prescription after TKA/THA for up to 1 year postop.
(2) Determine the duration of opioid prescription filling after TKA/THA for both those who take opioids preoperatively and opioid-naive patients.
(3) Quantify the average size of opioid prescription(s) these patients receive in the 30 days following TKA/THA.

These objectives are tested using the following hypotheses:

(1) Greater than 75% of all patients will fill an opioid prescription after TKA/THA. Patients who take opioids preoperatively will be more likely to fill an opioid prescription after the procedure than patients with no preoperative history of opioid use.
(2) Patients who take opioids preoperatively will have a higher duration of opioid use after TKA/THA when compared to opioid-naive patients.
(3) Patients who take opioids preoperatively will fill prescriptions for a larger quantity of medication in the 30 days following surgery when compared to opioid-naive patients.

Methods

A retrospective cohort study of lower extremity surgeries was conducted using PearlDiver's Research Program (PearlDiver Inc, Colorado Springs, CO), which queries Humana's insurance claims database from January 2007 through the third quarter of 2016. This database represents 16 million patients and includes records from both Humana private insurance plans, as well as Medicare and Medicare Advantage plans. Because these records are protected by the Health Insurance Portability and Accountability Act (HIPAA), the raw data that comprise the database is blinded to users, and the dataset is queried via a search platform. Although it is not possible to analyze metrics such as missing data for individual patients in the Humana database, the validity of the dataset is externally confirmed by Humana at the standards they require for their billing practices.

Patients who had undergone lower extremity procedures were identified in the Humana database using Current Procedural Terminology (CPT) codes identifying primary total knee arthroplasty (CPT-27447) and primary total hip arthroplasty (CPT-27130).

To ensure that patients remained active in the insurance claims database for the observed period, patients were excluded if they were not active for at least 6 months prior to, and 18 months following, the index date of surgery. Patients were also excluded if they had any record of hospital readmission in the 18 months following the index date of surgery or if they had any subsequent orthopedic surgical procedure in the 12 months following surgery. Patient records were then stratified into those who filled 0, 1, or 2+ opioid prescriptions in the 6 months prior to surgery. Patients filling 0 prescriptions were considered "opioid-naive," patients filling only 1 prescription were considered "sporadic users," and patients filling 2 or more prescriptions were considered "chronic users." All common oral and transdermal forms of opioid prescriptions were included, with the exception of tramadol and opioids indicated for cough suppression, such as hydrocodone with pseudoephedrine. The list of included opioids comprised all dosages of generic and brand-name formulations of oxycodone, hydrocodone, oxymorphone, hydromorphone, morphine, fentanyl, and methadone. Tramadol was not included during analysis following the methodology of prior work, and due to studies that show a decreased potential for physical tolerance and dependence compared to other opioids [22,23,28,30,31].

The duration of opioid use after surgery was defined as the time between the index date of the surgery and the last record of a filled opioid prescription within the active period of 18 months after surgery. Percentiles for the duration of use (in days) were generated and depicted as survival curves. If no records for an opioid prescription were found during this analysis, it could be inferred that the patient forwent filling any opioid prescription.

The magnitude of opioid use was examined for 30 days following each surgery to approximate the "post-discharge" amount prescribed. Prescriptions in the Humana database are indexed by their National Drug Code (NDC), which uniquely identifies each formulation and dose of drug, and records include number of prescriptions filled and pills obtained at each filling. The Pandas Data Analysis Library Package in Python was used to match database NDC codes to the NDC list maintained by the Food and Drug Administration [32]. The quantity of each drug was converted into a milligram morphine equivalent (MME) according to a standard conversion factor, reproduced in Appendix A [33]. Methadone was excluded from this section of the magnitude analysis as its MME conversion factor varies based on the amount taken per day. The average "post-discharge" MME dispensed per patient was defined as the total MME for each procedure divided by the total number of patients who filled at least one prescription within 30 days of surgery. The standardized MME per patient data was then converted using the same method to number of 5 mg oxycodone tablets for easy interpretation. In the Humana database, categories that include a group of less than 11 patients are hidden due to HIPAA regulations, so any NDC code with hidden data was excluded.

The proportion of patients who did not fill a prescription after surgery was statistically compared between preoperative opioid status groups using a chi-squared test. Survival curves depicting the duration of opioid prescription filling were statistically compared between groups by a log rank test. During analysis, statistical significance was determined by a P-value of .05. Due to the limitations in access to raw data regarding the size of opioid prescriptions filled, statistics such as the distribution or standard deviation of prescription size are unavailable, and only a mean number of pills are reported.

Results

Between 2007 and 2016, after application of exclusion criteria, a total of 46,667 patients underwent TKA and 22,701 underwent

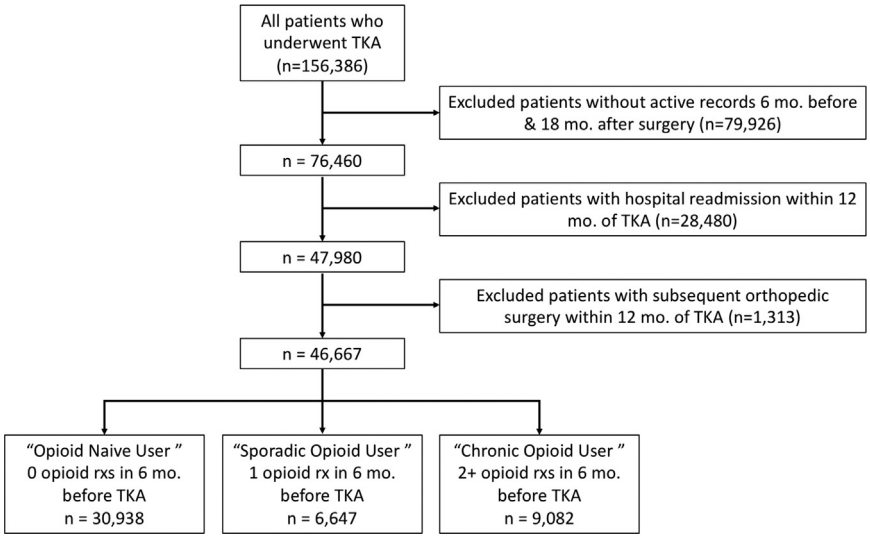

Fig. 1. Flow diagram depicting application of inclusion criteria for patients who underwent total knee arthroplasty. rxs, prescriptions.

THA, as shown in Figures 1 and 2. Of patients who underwent a TKA, 66% met the criteria for opioid-naive patients, 14% for sporadic users, and 20% for chronic users. Of patients who underwent a THA, 60% met the criteria for opioid-naive patients, 15% for sporadic users, and 25% for chronic users. Demographic information of these patients is shown in Table 1.

Magnitude of Use

Following each surgery, only some patients filled an opioid prescription, as shown in Figure 3. The differences in filling rates between groups were all statistically significant at $P < .001$. Opioid-naive patients filled any opioid prescription after surgery at the lowest rates, whereas chronic users filled a prescription at the highest rates. Of the patients who filled a postoperative opioid prescription, the per-patient average quantity of opioids obtained in the 30 days following surgery, standardized to 5 mg oxycodone pills, is shown in Figure 4. For both TKA and THA, chronic opioid users filled prescriptions for more pills than did opioid-naive or sporadic users.

Duration of Use

If a patient filled an opioid prescription following surgery, we examined the time between each patient's date of surgery and their last record of filling an opioid prescription, depicted in Figure 5. This plot can be interpreted as the proportion of patients who have not filled their last opioid prescription at each given time point. For each opioid use group, a subset of patients continues to fill opioid prescriptions at 12 months after surgery. The majority of opioid-naive patients and sporadic users discontinue opioid use at 12 months after surgery, but the majority of chronic users continue to fill prescriptions. For patients who underwent a TKA, the opioid-naive patients and sporadic user groups' duration of use was not

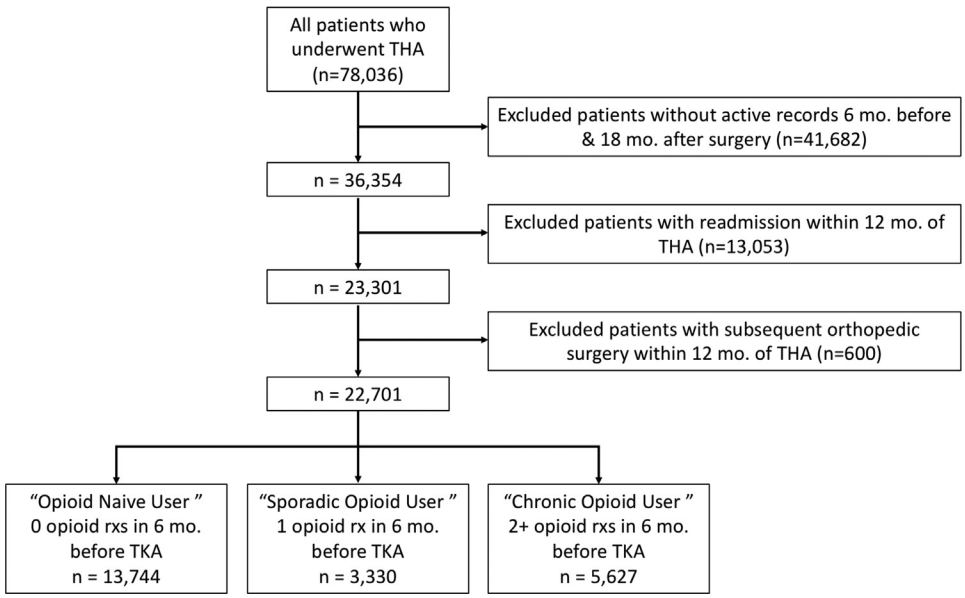

Fig. 2. Flow diagram depicting application of inclusion criteria for patients who underwent total hip arthroplasty. rxs, prescriptions.

Table 1
Patient Demographic Information and Preoperative Opioid Use.

Total Patients	Total Knee Arthroplasty (n = 46,667)						Total Hip Arthroplasty (n = 22,701)					
	Opioid-Naive		Sporadic User		Chronic User		Opioid-Naive		Sporadic User		Chronic User	
	30,938		6647		9082		13,744		3330		5627	
Age												
0-19	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
20-29	0	0%	0	0%	0	0%	0	0%	0	0%	0	0%
30-39	12	0%	0	0%	12	0%	39	0%	0	0%	18	0%
40-49	252	1%	131	2%	239	3%	275	2%	68	2%	201	4%
50-59	1843	6%	967	15%	1394	15%	1009	7%	318	10%	792	14%
60-69	9846	32%	2220	33%	3505	39%	3850	28%	1001	30%	1824	32%
70-79	15,501	50%	3084	46%	3500	39%	6415	47%	1425	43%	2170	39%
80-89	3969	13%	666	10%	653	7%	2084	15%	423	13%	630	11%
90+	602	2%	88	1%	85	1%	397	3%	79	2%	122	2%
Gender												
Female	19,157	62%	4364	66%	6055	67%	7927	58%	1949	59%	3384	60%
Male	11,781	38%	2283	34%	3027	33%	5817	42%	1381	41%	2243	40%
Race												
White	25,048	81%	5312	80%	7347	81%	11,080	81%	2607	78%	4542	81%
Black	2467	8%	638	10%	958	11%	825	6%	227	7%	487	9%
Asian	124	0%	33	0%	22	0%	19	0%	0	0%	0	0%
Hispanic	340	1%	74	1%	81	1%	74	1%	17	1%	31	1%
Other	285	1%	60	1%	68	1%	74	1%	24	1%	32	1%
Unknown	2624	8%	514	8%	576	6%	1656	12%	440	13%	526	9%
Year												
2007	1234	4%	216	3%	272	3%	469	3%	95	3%	169	3%
2008	2553	8%	460	7%	648	7%	1086	8%	225	7%	377	7%
2009	3032	10%	571	9%	770	8%	1304	9%	307	9%	435	8%
2010	3626	12%	704	11%	892	10%	1495	11%	344	10%	558	10%
2011	4002	13%	809	12%	1141	13%	1636	12%	394	12%	657	12%
2012	4748	15%	946	14%	1365	15%	2078	15%	469	14%	853	15%
2013	5329	17%	1164	18%	1660	18%	2430	18%	579	17%	1052	19%
2014	5698	18%	1245	19%	2018	22%	2676	19%	657	20%	1283	23%
2015	2195	7%	494	7%	726	8%	1012	7%	234	7%	438	8%
2016	385	1%	29	0%	118	1%	124	1%	0	0%	32	1%

statistically significant ($P = .21$), but the chronic user group was ($P < .001$). Similarly, it is true for patients who underwent a THA, as the opioid-naive patients and sporadic user groups' duration of use was not statistically significant ($P = .14$), but was for the chronic user group ($P < .001$).

Discussion

In this study, we utilized a large national insurance claims database to examine opioid prescribing trends after TKA and THA. Specifically, we quantified both the duration and the magnitude of opioid use after surgical procedures for both patients with preoperative opioid use and for opioid-naive patients. Results show that opioid-naive patients fill prescriptions at a lower rate and obtain fewer opioids (TKA: 72%, 86 pills 5 mg oxycodone equivalent; THA: 61%, 73 pills) than do chronic opioid users (TKA: 96%, 126 pills, THA: 90%, 126 pills). This work establishes normative reference data that can serve as a useful benchmarking tool to assist providers in managing their patients' postoperative pain.

Analgesic tolerance quickly develops when using opioids, and a higher dose may be required to effectively treat pain in patients with a history of preoperative opioid use [34,35]. It is not known whether the observed increase in prescription filling rate amounts stem from the provider or the patient. Although possible that providers see chronic opioid users as requiring more opioids, and thus choose to prescribe more, it is also plausible that opioid users are more comfortable using opioids or require more opioids for adequate pain control, so they pursue filling a prescription more often. Reality is likely a combination of these two situations.

As over 25% of TKA patients and nearly 40% of THA patients filled no opioid prescription after surgery, strong consideration should be given to alternative pain control methods. It is well-documented that many patients who fill an opioid prescription do not use any pills [9], thus the true proportion of patients who require opioids following surgery is likely lower than the proportion of those who fill a prescription.

As a benchmark, at 90 days after surgery many opioid-naive (74%-81%) and sporadic user (59%-69%) patients have discontinued filing opioid prescriptions. A 3-month follow-up visit could serve as a

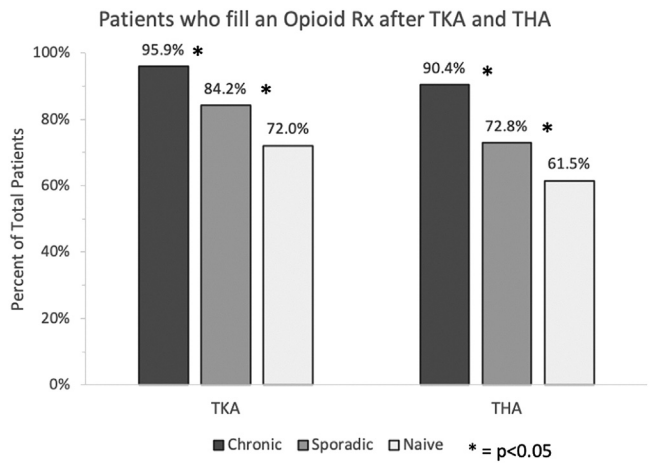

Fig. 3. Proportion of patients with record of filling any opioid prescription after surgery. All differences between columns are statistically significant ($P < .05$).

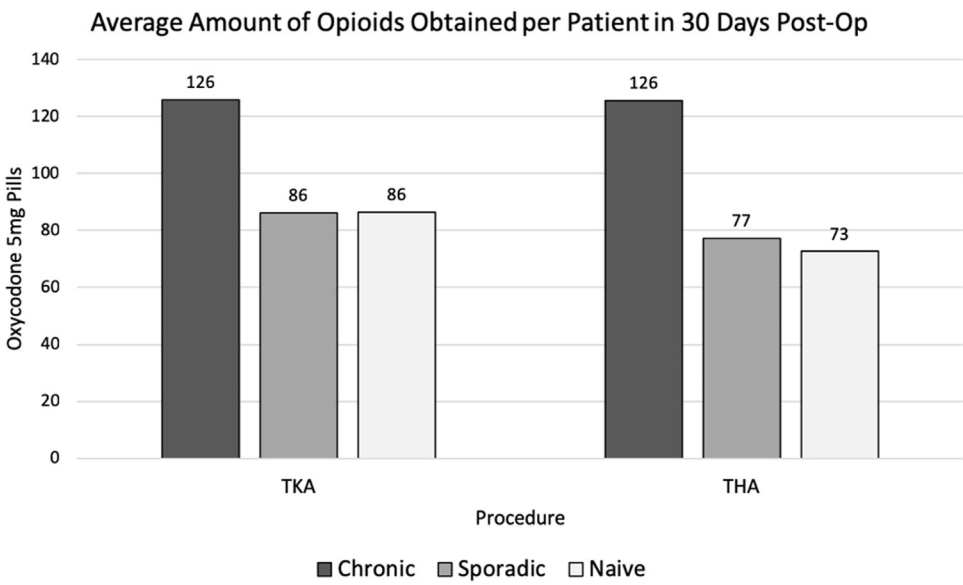

Fig. 4. Magnitude of opioid pills dispensed on a per-patient basis within the 30 days after surgery. Patient populations received a variety of opioid formulations and doses, all of which were standardized to 5-mg oxycodone pills via conversion to milligram morphine equivalents.

possible time for physicians to institute a standard examination of their patients' opioid use and pain management success.

Across all procedures, between 10% (TKA) and 13% (THA) of opioid-naive patients continue to fill opioid prescriptions at 1 year postop, which shows a conversion of patients once naive to opioids into chronic users. It must be emphasized that these patients had no recent history of opioid use before surgery. This observation is supported by literature that shows that 8%-12% of patients who are prescribed opioids by a physician develop an opioid use disorder [3–5].

The amount of opioids a physician prescribes after surgery has been shown to vary greatly depending on both provider and procedure [10]. Figure 4 depicts current opioid prescription practices after common procedures and may serve to create a normative reference. It is possible that a true "appropriate" amount of opioid therapy may differ greatly from current prescription trends described in our study; however, that insight is beyond the scope of a retrospective database study such as ours.

Much of the previously published work in the area focuses on single-center studies or database studies with less rigorous methodologies. To our knowledge, this is the first large-scale database study that comprehensively details both the duration and magnitude of postoperative opioid use following TKA and THA. Thus, it is important to acknowledge limitations of our work. First, because this study utilized HIPAA-limited data, individual patients could not be tracked. Per-patient calculations were averaged across patient

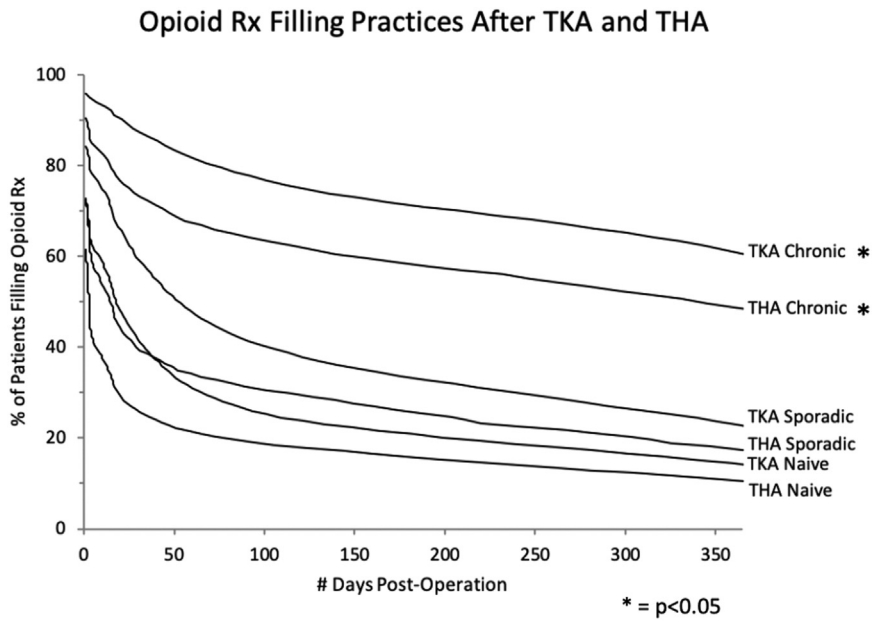

Fig. 5. Time between date of surgery and last record of opioid prescription refill for opioid-naive patients, opioid sporadic users, and opioid chronic users. Asterisk denotes statistical significance at $P < .05$ (between TKA chronic and TKA sporadic, between THA chronic and THA sporadic).

groups and thus statistical distributions were limited. Second, our exclusion criteria were not broad enough to encompass all possible pain events that could necessitate prescription opioid therapy. Thus a patient may have obtained an opioid prescription after surgery for an issue unrelated to their orthopedic procedure. Although this possibility was minimized by excluding patients who underwent a subsequent orthopedic procedure or were readmitted following their surgery, the criteria could not be all-inclusive. That said, all opioid use following a large surgery is important to characterize as regular opioid consumption for any reason could indicate misuse. Finally, the definitions for "chronic user," "sporadic user," and "opioid-naive" were adopted from previously published methodologies; however, these definitions have not been comprehensively validated.

The decision against including tramadol and opioid formulations intended for cough suppression may have affected study results by classifying some patients with these prescriptions as "opioid-naive," and this limitation must be acknowledged. In a post hoc analysis of "opioid-naive" patients, only 0.39% (TKA) and 0.37% (THA) of patients had one prescription record for hydrocodone cough suppression medication. It is highly uncommon for patients to receive prescriptions for hydrocodone cough syrup for the same duration or dose as patients receiving opioids for chronic pain, and the small proportion of patients with these prescriptions is unlikely to substantially contribute to overall results. The ability of tramadol to induce physical tolerance and dependence in the same manner as other opioids is currently unclear. Tramadol was initially marketed as a weak μ-opioid agonist with minimal tolerance and abuse potential [30,31]. However, case reports have since described rare instances of tramadol dependence, which has reopened the discussion of tramadol's effects [36,37]. This ongoing debate led the authors to exclude tramadol as a classical opioid prescription, which may have misclassified some tramadol users as "opioid-naive."

Patient demographics in this database were not compared to the general patient population, and thus these results are not fully generalizable without further work. Additionally, the study methods excluded any patients who underwent revision of their primary implant or were hospitalized due to any postoperative complications. These patients may be the heaviest postoperative users of opioids due to a difficult and prolonged recovery, and these results cannot be generalized to this subset of patients. Recently, robust national discussions have occurred regarding the opioid crisis and physician prescribing habits. A temporal study of the differences in prescription habits between the earliest (2007) and latest (2016) database claims could examine the effectiveness of system-level efforts thus far.

In summary, patients with chronic preoperative opioid use fill post-operative opioid prescriptions more often than opioid-naive patients. They also receive larger average prescriptions and continue opioid use for a longer duration after surgery. This work moves toward creating a systematic prescribing framework for orthopedic surgeons to benchmark postoperative opioid use for TKA and THA. By understanding common trends, providers can better identify patients in their practice who may be struggling with postoperative pain management or opioid dependence.

References

[1] Rudd RA, Aleshire N, Zibbell JE, Gladden RM. Increases in drug and opioid overdose deaths—United States, 2000-2014. MMWR Morb Mortal Wkly Rep 2016;64:1378–82. https://doi.org/10.15585/mmwr.mm6450a3.

[2] Understanding the epidemic | Drug overdose | CDC injury center. Centers for disease control and prevention 2018. https://www.cdc.gov/drugoverdose/epidemic/index.html [accessed 16.04.18].

[3] Muhuri PK, Gfroerer JC, Davies C. Associations of nonmedical pain reliever use and initiation of heroin use in the United States. In: CBHSQ data review. Rockville, MD: Substance Abuse and Mental Health Services Administration; 2013.

[4] Cicero TJ, Ellis MS, Surratt HL, Kurtz SP. The changing face of heroin use in the United States: a retrospective analysis of the past 50 years. JAMA Psychiatry 2014;71:821–6. https://doi.org/10.1001/jamapsychiatry.2014.366.

[5] Carlson RG, Nahhas RW, Martins SS, Daniulaityte R. Predictors of transition to heroin use among initially non-opioid dependent illicit pharmaceutical opioid users: a natural history study. Drug Alcohol Depend 2016;160:127–34. https://doi.org/10.1016/j.drugalcdep.2015.12.026.

[6] Florence CS, Zhou C, Luo F, Xu L. The economic burden of prescription opioid overdose, abuse, and dependence in the United States, 2013. Med Care 2016;54:901–6. https://doi.org/10.1097/MLR.0000000000000625.

[7] Dart RC, Surratt HL, Cicero TJ, Parrino MW, Severtson SG, Bucher-Bartelson B, et al. Trends in opioid analgesic abuse and mortality in the United States. N Engl J Med 2015;372:241–8. https://doi.org/10.1056/NEJMsa1406143.

[8] Volkow ND, McLellan TA, Cotto JH, Karithanom M, Weiss SRB. Characteristics of opioid prescriptions in 2009. JAMA 2011;305:1299–301. https://doi.org/10.1001/jama.2011.401.

[9] Sabatino MJ, Kunkel ST, Ramkumar DB, Keeney BJ, Jevsevar DS. Excess opioid medication and variation in prescribing patterns following common orthopaedic procedures. J Bone Joint Surg Am 2018;100:180–8. https://doi.org/10.2106/JBJS.17.00672.

[10] Boylan MR, Suchman KI, Slover JD, Bosco JA. Patterns of narcotic prescribing by orthopedic surgeons for medicare patients. Am J Med Qual 2018;33:637–41. https://doi.org/10.1177/1062860618771190.

[11] O'Neill DF, Webb Thomas C. Less is more: limiting narcotic prescription quantities for common orthopedic procedures. Phys Sportsmed 2014;42:100–5. https://doi.org/10.3810/psm.2014.11.2096.

[12] Thiels CA, Anderson SS, Ubl DS, Hanson KT, Bergquist WJ, Gray RJ, et al. Wide variation and overprescription of opioids after elective surgery. Ann Surg 2017;266:564–73. https://doi.org/10.1097/SLA.0000000000002365.

[13] Attum B, Rodriguez-Buitrago A, Harrison N, Evans A, Obremskey W, Sethi MK, et al. Opioid prescribing practices by orthopaedic trauma surgeons after isolated femur fractures. J Orthop Trauma 2018;32:e106–11. https://doi.org/10.1097/BOT.0000000000001046.

[14] Merrill HM, Dean DM, Mottla JL, Neufeld SK, Cuttica DJ, Buchanan MM. Opioid consumption following foot and ankle surgery. Foot Ankle Int 2018;39:649–56. https://doi.org/10.1177/1071100718757527.

[15] Hernandez NM, Parry JA, Taunton MJ. Patients at risk: large opioid prescriptions after total knee arthroplasty. J Arthroplasty 2017;32:2395–8. https://doi.org/10.1016/j.arth.2017.02.060.

[16] Bedard NA, Sierra RJ, Mabry T. Opioids after orthopaedic surgery: there is a need for universal prescribing recommendations. J Bone Joint Surg Am 2018;100:e17. https://doi.org/10.2106/JBJS.17.01480.

[17] Scully RE, Schoenfeld AJ, Jiang W, Lipsitz S, Chaudhary MA, Learn PA, et al. Defining optimal length of opioid pain medication prescription after common surgical procedures. JAMA Surg 2018;153:37–43. https://doi.org/10.1001/jamasurg.2017.3132.

[18] Zywiel MG, Stroh DA, Lee SY, Bonutti PM, Mont MA. Chronic opioid use prior to total knee arthroplasty. J Bone Joint Surg Am 2011;93:1988–93. https://doi.org/10.2106/JBJS.J.01473.

[19] Sing DC, Barry JJ, Cheah JW, Vail TP, Hansen EN. Long-acting opioid use independently predicts perioperative complication in total joint arthroplasty. J Arthroplasty 2016;31:170–174.e1. https://doi.org/10.1016/j.arth.2016.02.068.

[20] Dwyer MK, Tumpowsky CM, Hiltz NL, Lee J, Healy WL, Bedair HS. Characterization of post-operative opioid use following total joint arthroplasty. J Arthroplasty 2018;33:668–72. https://doi.org/10.1016/j.arth.2017.10.011.

[21] Gupta A, Kumar K, Roberts MM, Sanders AE, Jones MT, Levine DS, et al. Pain management after outpatient foot and ankle surgery. Foot Ankle Int 2018;39:149–54. https://doi.org/10.1177/1071100717738495.

[22] Bedard NA, Pugely AJ, Dowdle SB, Duchman KR, Glass NA, Callaghan JJ. Opioid use following total hip arthroplasty: trends and risk factors for prolonged use. J Arthroplasty 2017;32:3675–9. https://doi.org/10.1016/j.arth.2017.08.010.

[23] Bedard NA, Pugely AJ, Westermann RW, Duchman KR, Glass NA, Callaghan JJ. Opioid use after total knee arthroplasty: trends and risk factors for prolonged use. J Arthroplasty 2017;32:2390–4. https://doi.org/10.1016/j.arth.2017.03.014.

[24] Cancienne JM, Patel KJ, Browne JA, Werner BC. Narcotic use and total knee arthroplasty. J Arthroplasty 2018;33:113–8. https://doi.org/10.1016/j.arth.2017.08.006.

[25] Politzer CS, Kildow BJ, Goltz DE, Green CL, Bolognesi MP, Seyler TM. Trends in opioid utilization before and after total knee arthroplasty. J Arthroplasty 2018;33:S147–153.e1. https://doi.org/10.1016/j.arth.2017.10.060.

[26] Steiner SRH, Cancienne JM, Werner BC. Narcotics and knee arthroscopy: trends in use and factors associated with prolonged use and postoperative complications. Arthroscopy 2018;34:1931–9. https://doi.org/10.1016/j.arthro.2018.01.052.

[27] Bedard NA, DeMik DE, Dowdle SB, Owens JM, Liu SS, Callaghan JJ. Does preoperative opioid use increase the risk of early revision total hip arthroplasty? J Arthroplasty 2018;33:S154–6. https://doi.org/10.1016/j.arth.2018.01.018.

[28] Bedard NA, DeMik DE, Dowdle SB, Callaghan JJ. Trends and risk factors for prolonged opioid use after unicompartmental knee arthroplasty. Bone Joint J

2018;100-B(1 Suppl A):62–7. https://doi.org/10.1302/0301-620X.100B1.BJJ-2017-0547.R1.
[29] Anthony CA, Westermann RW, Bedard N, Glass N, Bollier M, Hettrich CM, et al. Opioid demand before and after anterior cruciate ligament reconstruction. Am J Sports Med 2017;45:3098–103. https://doi.org/10.1177/0363546517719226.
[30] Miranda HF, Pinardi G. Antinociception, tolerance, and physical dependence comparison between morphine and tramadol. Pharmacol Biochem Behav 1998;61:357–60. https://doi.org/10.1016/S0091-3057(98)00123-3.
[31] Barth H, Durra S, Giertz H, Goroll D, Flohé L. Long-term administration of the centrally acting analgesic tramadol did not induce dependence or tolerance. Pain 1987;30:S231. https://doi.org/10.1016/0304-3959(87)91523-5.
[32] Drug approvals and databases - National drug code directory. US FDA n.d. https://www.fda.gov/drugs/informationondrugs/ucm142438.htm [accessed 20.06.18].
[33] Dowell D, Haegerich TM, Chou R. CDC guideline for prescribing opioids for chronic pain—United States, 2016. JAMA 2016;315:1624. https://doi.org/10.1001/jama.2016.1464.
[34] Morris BJ, Mir HR. The opioid epidemic: impact on orthopaedic surgery. J Am Acad Orthop Surg 2015;23:267–71. https://doi.org/10.5435/JAAOS-D-14-00163.
[35] Vowles KE, McEntee ML, Julnes PS, Frohe T, Ney JP, van der Goes DN. Rates of opioid misuse, abuse, and addiction in chronic pain: a systematic review and data synthesis. Pain 2015;156:569–76. https://doi.org/10.1097/01.j.pain.0000460357.01998.f1.
[36] Ojha R, Bhatia SC. Tramadol dependence in a patient with no previous substance history. Prim Care Companion J Clin Psychiatry 2010;12. https://doi.org/10.4088/PCC.09100779ecr.
[37] Pollice R, Casacchia M, Bianchini V, Mazza M, Conti CM, Roncone R. Severe tramadol addiction in a 61 year-old woman without a history of substance abuse. Int J Immunopathol Pharmacol 2008;21:475–6. https://doi.org/10.1177/039463200802100230.

Appendix

Appendix A
Common Opioids and MME Conversion Factors [33].

	Quantity	Equivalent MME
Fentanyl	1 mcg/h	2.4
Oxycodone	1 mg	1.5
Hydrocodone	1 mg	1
Morphine	1 mg	1
Oxymorphone	1 mg	3
Hydromorphone	1 mg	4

MME, milligram morphine equivalent.