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The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Primary Hip

High-Risk Prescribing Increases Rates of New Persistent Opioid Use in Total Hip Arthroplasty Patients



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ARTICLE INFO

Article history:

Received 20 January 2020

Received in revised form

2 April 2020

Accepted 7 April 2020

Available online 14 April 2020

Keywords:

high-risk prescribing
prescribing characteristics
persistent opioid use
total hip arthroplasty
opioid prescribing

ABSTRACT

Background: The association between surgeon prescribing practices and new persistent postoperative opioid use is not well understood. We examined the association between surgeon prescribing and new persistent use among total hip arthroplasty (THA) patients.

Methods: A retrospective analysis of Medicare claims in Michigan was performed. The study cohort consisted of orthopedic surgeons performing THAs from 2013 to 2016 and their opioid-naïve patients, aged >65 years. High-risk prescribing included high daily doses, overlapping benzodiazepine prescriptions, concurrent opioid prescriptions, prescriptions from multiple providers, or long-acting opioid prescriptions. The occurrence of a preoperative prescription, initial prescription size, and 30-day prescription dosage were examined as individual exposures. Surgeons were categorized into quartiles by prescribing practices, and multilevel hierarchical logistic regression was used to examine associations with postoperative new persistent opioid use.

Results: Surgeons exhibited high-risk prescribing for 66% of encounters. Patients of surgeons with the highest rates of high-risk prescribing were more likely to develop persistent use compared with patients of surgeons with the lowest rates (adjusted rates: 9.7% vs 4.6%, $P = .011$). Patients of surgeons with initial prescription sizes in the “high” (third) quartile (adjusted odds ratio, 2.91; 95% confidence interval, 1.53–5.51), and of surgeons in the “highest” (fourth) quartile of 30-day prescription dosage (adjusted odds ratio, 1.93; 95% confidence interval, 1.03–3.61), were more likely to develop persistent opioid use compared with patients of surgeons with low initial and 30-day prescription sizes, respectively.

Conclusion: The development of persistent opioid use after surgery is multifactorial, and surgeon prescribing patterns play an important role. Reducing prescribing and encouraging opioid alternatives could minimize postoperative persistent opioid use.

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Disclosure of Funding: This work was supported by National Institutes of Health, R01 DA042859 – OPIOIDS: Prevention of Iatrogenic Opioid Dependence after Surgery.

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.2020.04.019>.

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<https://doi.org/10.1016/j.arth.2020.04.019>

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In the United States, an estimated 1.7 million people suffer from opioid use disorder. For many, a healthcare prescription is the first introduction to opioids [1–3]. Although this public health issue is multifactorial, one of the most common opportunities for opioid prescribing is during the perioperative period. Over 36% of prescriptions written by surgeons are for opioids, second only to prescribing frequency among chronic pain specialists [4,5]. Furthermore, orthopedic surgeons specifically have been identified as providing the first prescription for more than 8% of chronic opioid users [6].

Although opioids provide effective pain management, new persistent use has been described among opioid-naïve patients

undergoing surgery, defined as continued prescription fills outside of the expected perioperative period [3,7,8]. However, to date, the relationship between specific prescribing characteristics at the surgeon level and the risk of persistent opioid use following surgery is not well understood. High-risk prescribing is common, and prior definitions include prescribing patterns such as high prescription sizes, overlapping prescriptions, prescriptions from multiple providers, co-prescribing with benzodiazepines, and the new initiation of long-acting opioids [9–12]. Previous studies have demonstrated the impact of high-risk prescribing on opioid-related morbidity and mortality in the emergency department and other settings, but effects in surgical prescribing remain unclear [13,14]. In addition, other aspects of prescribing specific to postoperative care, such as total 30-day dosage, initial prescription size, and preoperative opioid prescriptions, could affect new persistent use. Further understanding of prescribing patterns in surgical care may identify potentially modifiable, provider-level risk factors by which interventions to reduce new persistent use following surgery could be targeted.

In order to further target interventions and improve care, it is essential to understand the specific prescribing characteristics linked to the poor patient outcome of new persistent opioid use. Total hip arthroplasty (THA) is one of the most common procedures performed in the United States, and rates are predicted to rise with the aging population, as the majority of patients undergoing this procedure are aged 65 years and older [15–18]. In this context, we sought to characterize prescribing patterns in the perioperative period, identify high-risk characteristics of opioid prescribing, and quantify the extent to which these characteristics increase the risk of patient new persistent opioid use postoperatively, in a group of providers performing a standardized procedure of THAs. We examined patients in the state of Michigan who underwent THA from 2013 to 2016 and hypothesized that surgeons with greater rates of high-risk prescribing would be associated with greater rates of patient new persistent opioid use following surgery.

Methods

Study Cohort

We examined Medicare insurance claims in the state of Michigan to identify patients aged 65 years and older who underwent THA (Current Procedural Terminology code: 27130) from 1/1/2013 to 6/30/2016. A high percentage of patients are known to be previously opioid exposed when presenting for arthroplasty [19–21]. As such, the cohort was composed of opioid-naïve patients, defined as patients who did not have claims for a prescription opioid fill in the 11 months to 31 days before surgery. We included only patients who were continuously enrolled in Medicare Part A, Part B, and Part D in both the year before surgery and 6 months after discharge. To ensure that we uniformly captured outpatient prescribing, patients were only included if they were discharged to home. Additionally, patients were excluded if their surgery was not attributed to an orthopedic surgeon, they had a hospital length of stay longer than 30 days, or they had an anesthesia code within 180 days of discharge from surgery. Surgeons were identified from claims data of the surgical procedures, and only surgeons who performed more than 5 cases during the study period were included, in order to accurately capture surgeon-specific trends in prescribing.

Outcomes

The primary outcome was new persistent opioid use, defined as filling an opioid prescription during the perioperative period, as well as an additional fill from 91 to 180 days after discharge from

surgery [3]. Definitions of new persistent opioid use have varied in the literature, but we chose to use this standardized outcome for consistency with prior work [7,22,23]. The perioperative period was defined as within 30 days before admission and within 3 days of discharge from surgery. Opioid prescriptions were identified with National Drug Codes from pharmaceutical claims. Prescription amount was standardized by converting all opioid doses to oral morphine equivalents (OMEs) using previously described conversion factors by the Centers for Disease Control [24].

Exposure

Our primary exposure was the occurrence of a high-risk prescribing behavior by surgeons in the perioperative period. Consistent with previous work, high-risk prescribing was defined by exhibiting one of the following prescribing patterns: (1) an average daily dose of more than 100 OMEs, (2) overlapping opioid and benzodiazepine prescriptions, (3) concurrent or overlapping opioid prescriptions, (4) prescriptions from more than one provider, and (5) new prescriptions for long-acting or extended-release opioid. In addition to the traditional definition of high-risk prescribing, the occurrence of a preoperative opioid prescription, high daily dosage, initial prescription size, and total 30-day prescription dosage were examined as individual exposures at the surgeon level. Both overall high-risk prescribing and the above-mentioned individual prescribing behaviors were used to distribute surgeons into quartiles. For each surgeon, we calculated the proportion of all cases for which they exhibited high-risk prescribing, and then evenly distributed surgeons into quartiles based on rates of high-risk prescribing, named highest (fourth), high (third), moderate (second), and low (first). Quartiles were used to quantify surgeon prescribing attributes and patient exposure and subsequently determine whether patients cared for by these surgeons had higher rates of new persistent use.

Patient Factors

Demographic variables included age, sex, race/ethnicity, and Medicaid eligibility. The State Reported Dual Eligible Status Code was used to define Medicaid eligibility. Patient comorbidities, mental health diagnoses, and pain disorders were included in the analysis and identified from claims in the 12 months before surgery. Tobacco use was identified using the International Classification of Disease, Ninth and Tenth Revision, Clinical Modification (ICD-9/ICD-10) diagnosis codes (ICD-9 codes 305.1 and V15.82; ICD-10 codes F17, Z87891, Z72). The Charlson comorbidity index was used to quantify patient comorbid conditions [25]. The Agency of Healthcare Research and Quality Clinical Classification System was used to identify mental health diagnoses, including anxiety disorders, mood disorders, and other diagnoses. ICD-9 and ICD-10 diagnosis codes were used to identify pain disorders which were categorized as arthritis, back, neck, and other pain conditions.

Analysis

We used descriptive statistics to display the patient attributes of the cohort. For high-risk prescribing behaviors, we examined the occurrence of high-risk prescribing for patients undergoing THA, at the surgeon level. Multilevel logistic regression was used to determine the likelihood of new persistent use among patients treated by the 4 quartiles of high-risk prescribers, adjusting for patient characteristics. Odds ratios (ORs) were reported with 95% confidence intervals (CIs) for each of the independent variables, with an alpha error set at 5%. Analyses were conducted using SAS

9.4 (SAS Institute, Inc, Cary, NC) and Stata 15 (StataCorp, College Station, TX).

Results

The study cohort included 1403 opioid-naïve patients above the age of 65 in the state of Michigan who underwent THA by 1 of 111 surgeons between 1/1/2013 and 6/30/2016. The indication for surgery was arthritis for 97.4% of the cohort, with fracture (0.8%) and other diagnoses (1.8%) as the indication in the remainder of the patients. In this cohort, 57.3% were female and 42.7% were male patients. Approximately 94% of cohort was comprised of white patients, and 4% were black patients. The remaining demographic characteristics are outlined in [Table 1](#). Surgeons performed between 6 and 50 cases during this time period, with the 79% of surgeons performing 15 cases or fewer.

In this cohort of 111 surgeons, the average rate of high-risk prescribing during the perioperative period was 66%, but varied widely, ranging from 0% to 100% of the cases performed. The most common types of high-risk prescribing exposed to patients included overlapping opioid and benzodiazepine prescriptions (56.5%), average daily dose >100 OMEs (12.8%), concurrent opioid prescriptions (7.3%), prescriptions from more than one provider (5.9%), and long-acting opioid prescriptions (1.7%). In this cohort, 64.3% of patients were exposed to at least 1 type of high-risk prescribing. All but one of the surgeons had at least 1 case of high-risk prescribing. Notably, 8 surgeons exhibited high-risk prescribing for all of their cases during this time period. Among these 8 surgeons, the high-risk prescribing characteristics exhibited were variable. The single high-risk prescribing characteristic that every prescriber exhibited at least once, but not necessarily for every case, was the

Table 1
Patient Demographic Descriptive Statistics.

Patient Characteristics	N (%)
Age	
65-69	395 (28.2)
70-74	456 (32.5)
75-79	295 (21)
80-84	191 (13.6)
≥85	66 (4.7)
Gender	
Female	804 (57.3)
Male	599 (42.7)
Race	
White	1317 (93.9)
Black	49 (3.5)
Other	19 (1.4)
Unknown	18 (1.3)
No dual enrollment	1368 (97.5)
Year of discharge from surgery	
2013	267 (19)
2014	405 (28.9)
2015	475 (33.9)
2016	256 (18.3)
Tobacco use	132 (9.4)
Charlson score, mean (standard deviation)	0.76 (1.25)
Mental health disorders	
Anxiety disorder	58 (4.1)
Mood disorder	46 (3.3)
Other mental health disorders ^a	14 (1.0)
Pain disorders	
Arthritis pain	1174 (83.7)
Back pain	244 (17.4)
Neck pain	38 (2.7)
Other pain	127 (9.05)

^a Other mental health disorders include adjustment disorder, psychosis disorders, and miscellaneous mental health disorders.

initiation of a new opioid prescription for patients with concurrent benzodiazepine prescriptions.

Association Between High-Risk Prescribing and New Persistent Use

The overall rate of new persistent use in this cohort was 6.9%. Of the 902 patients exposed to high-risk prescribing, 7.9% ($P = .058$) developed new persistent opioid use. Of the 501 patients who were not exposed to new persistent use, 5.2% developed new persistent use. Surgeons were divided into quartiles with respect to high-risk prescribing, named low (first), moderate (second), high (third), and highest (fourth) quartiles. Quartile 1 included surgeons who had a high-risk prescribing rate of 0%-52%; quartile 2 included surgeons who had high-risk prescribing rate of 53%-67%; quartile 3 included surgeons who had high-risk prescribing rate of 68%-83%; and quartile 4 included surgeons who had a high-risk prescribing rate of ≥84%.

In the “highest” quartile of high-risk prescribing, average rates were 93%, compared with the lowest quartile, in which high-risk prescribing rates were 37% ([Table 2](#)). Patients cared for by surgeons in the highest quartile of high-risk prescribing had a new postoperative persistent use rate of 9.7%, compared with a new persistent use rate of 4.6% in patients cared for by surgeons in the lowest quartile of high-risk prescribing (9.7% vs 4.6%, $P = .011$; [Fig. 1](#)).

Association Between Specific Prescribing Behaviors and Risk of New Persistent Use

Initial Prescription Size

In this cohort, the initial prescription dosage ranged from 54 to 1175 OMEs, with an average prescription size of 470 OMEs, equivalent to 94 tablets of 5-mg hydrocodone or 62 tablets of 5-mg oxycodone. We observed that the initial prescription size was independently associated with new persistent opioid use. Specifically, patients who were cared for by surgeons with greater average initial prescription sizes were more likely to develop new persistent use compared with patients cared for by surgeons with lower initial opioid prescription sizes ([Fig. 2](#)). The highest new persistent opioid use rate was 10.54% (adjusted OR, 2.91; 95% CI, 1.53-5.51) and was exhibited in patients exposed to surgeons in the “high” (third) quartile, with an average initial prescription size of 497 OMEs. The “highest” (fourth) quartile of initial prescription sizes, representing an average initial prescription size of 720 OMEs, was not significantly correlated with patient new persistent use compared to the lowest quartile of initial prescription sizes. Continuous data are provided in [Supplemental Figures 1-3](#).

Postoperative Total 30-Day Prescription Dosage

The total prescription dosage over 30 days ranged from 0 to 1400 OMEs, with a mean total of 603 OMEs (standard deviation [SD], 254.06). In this cohort, surgeons in the “highest” quartile of 30-day prescription dosage prescribed 951 OMEs (SD, 169.07) on average, the equivalent of 126 tablets of 5-mg oxycodone or 190 tablets of 5-mg hydrocodone. The patients exposed to this “highest” quartile of surgeons had a resultant new persistent opioid use rate of 9.00% (9.0% vs 4.9%, $P = .04$; adjusted OR, 1.93; 95% CI, 1.03-3.61; [Fig. 3](#)). Other surgeon prescribing characteristics that included a preoperative opioid prescription or a prescription for a high daily dose were not individually associated with new persistent use among patients.

Table 2
Prescribing Characteristics and New Persistent Use.

High-Risk Prescribing Rates	Surgeon # in Each Quartile	Mean Rate of High-Risk Prescribing Among Surgeons	Median Rate of High-Risk Prescribing Among Surgeons	Min. Rate of High-Risk Prescribing Among Surgeons	Max. Rate of High-Risk Prescribing Among Surgeons	New Persistent Use by High-Risk Prescribing	With Persistent Use # Patients (%)	Without Persistent Use # Patients (%)	Total # Patients
Quartile 1	28	0.37	0.4	0	0.52	Quartile 1	18 (4.60)	373 (95.4)	391
Quartile 2	29	0.61	0.6	0.53	0.67	Quartile 2	33 (9.54)	313 (90.46)	346
Quartile 3	34	0.77	0.78	0.69	0.83	Quartile 3	26 (5.65)	434 (94.35)	460
Quartile 4	20	0.93	0.91	0.86	1	Quartile 4	20 (9.71)	186 (90.29)	206
Total	111	0.66	0.67	0	1	Total	97 (6.91)	1306 (93.09)	1403
Initial Prescription Size (OMEs)	Surgeon # in Each Quartile	Mean Initial Prescription Size	Median Initial Prescription Size	Min. Initial Prescription Size	Max. Initial Prescription Size	New Persistent Use by Initial Prescription Size	With Persistent Use # Patients (%)	Without Persistent Use # Patients (%)	Total # Patients
Quartile 1	28	273	295	54	338	Quartile 1	16 (4.35)	352 (95.65)	368
Quartile 2	28	398	399	344	446	Quartile 2	25 (6.79)	343 (93.21)	368
Quartile 3	28	497	491	450	563	Quartile 3	35 (10.54)	297 (89.46)	332
Quartile 4	27	720	669	567	1175	Quartile 4	21 (6.27)	314 (93.73)	335
Total	111	470	446	54	1175	Total	97 (6.91)	1306 (93.09)	1403
Total Prescription Dosage (OMEs) in 30 d	Surgeon # in Each Quartile	Mean Total Prescription Dosage	Median Total Prescription Dosage	Min. Total Prescription Dosage	Max. Initial Prescription Dosage	New Persistent Use by Total Prescription Dosage in 30 d	With Persistent Use # Patients (%)	Without Persistent Use # Patients (%)	Total # Patients
Quartile 1	32	335	374	0	450	Quartile 1	22 (4.94)	423 (95.06)	445
Quartile 2	24	512	514	453	582	Quartile 2	21 (6.8)	288 (93.2)	309
Quartile 3	28	654	647	582	734	Quartile 3	27 (7.74)	322 (92.26)	349
Quartile 4	27	951	917	737	1400	Quartile 4	27 (9.00)	273 (91.00)	300
Total	111	603	582	0	1400	Total	97 (6.91)	1306 (93.09)	1403

Min., minimum; Max., maximum; OMEs, oral morphine equivalents.

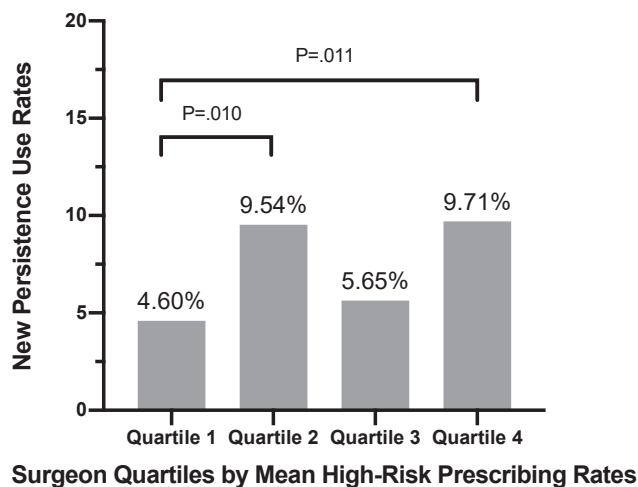


Fig. 1. New persistent opioid use rates among increasing rates of high-risk prescribing.

Patient Characteristics and Risk of New Persistent Use

After adjusting for covariates in a multilevel regression, patient characteristics including age, gender, race, Charlson comorbidity index, mental health disorders, and pain disorders were not associated with persistent opioid use after surgery in this cohort (Table 3). However, compared to patients discharged in 2013, patients discharged in 2016 exhibited a lower risk of developing persistent use (adjusted OR, 0.453; 95% CI, 0.21–0.97). Notably, throughout these time periods, rates of high-risk prescribing did not decrease. Finally, we observed that patients cared for by surgeons in “moderate” (second) quartile (adjusted OR, 2.82; 95% CI, 1.22–4.26) and “highest” (fourth) quartile (adjusted OR, 2.47; 95% CI, 1.23–4.95) were more likely to develop new persistent use compared with patients cared for by surgeons in lowest quartile.

Discussion

Among patients undergoing THA, high-risk prescribing practices are common and correlated with new persistent opioid use among opioid-naïve THA patients. Opioid-naïve patients cared for

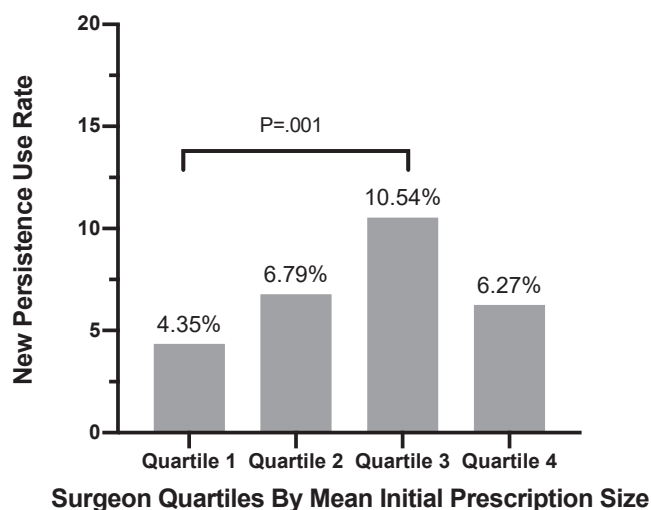


Fig. 2. New persistent opioid use rates among increasing initial postoperative prescription sizes.

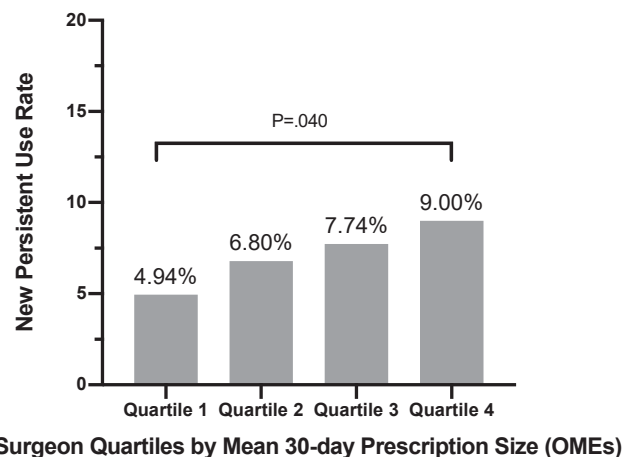


Fig. 3. New persistent opioid use rates among increasing total 30-day prescription sizes. OMEs, oral morphine equivalents.

by surgeons exhibiting high-risk prescribing practices, a high initial postoperative prescription, or an increased 30-day total OME dose were significantly more likely to develop prolonged opioid use. These findings identify an opportunity for improvement in current practice by highlighting the potential hazard that high-risk prescribing poses to patients and the importance of judicious prescribing in our effort to provide safe and effective pain management after surgery. Although the spotlight on provider contribution to the opioid epidemic has resulted in numerous policy initiatives at the national and state level to curtail prescribing, current policies are not tailored to provider behavior or patient risk [26–28].

The association between surgeon prescribing behaviors and new persistent use is complex and multifactorial. Although there was an overall effect between traditionally defined high-risk prescribing and new persistent use, this varied across level suggesting that other factors contribute to this relationship not captured in claims. The exposure of total 30-day prescription dosage following surgery demonstrated the most consistent relationship between prescribing patterns and new persistent use. We also observed higher rates of new persistent use among patients cared for by surgeons in the “high” and “moderate” quartiles of initial prescription size; however, the rates observed in the highest quartile were not significantly different, potentially due to greater variability in this group.

Prior studies have demonstrated that at the patient level, new persistent use is associated with the number of fills and cumulative prescription dose in first month, extended length of the initial prescription, long-acting opioids, preoperative opioids, and high daily doses [29–32]. In this analysis, we more closely examined the effect at the surgeon level. Although we observed that patients cared for by surgeons in the highest quartile of high-risk prescribing were more likely to develop new persistent opioid use, it is possible that other mechanisms could contribute to this phenomenon. For example, providers classified as high risk may have a more generous approach to refills in the late postoperative period, which is captured as persistent use, but may not necessarily reflect patient need. It may also be that high-risk prescribing in the early postoperative period creates tolerance and increases analgesic requirements among patients. It is also possible that high initial prescribers may be less likely to use opioid alternatives early on and thus are less likely to encourage these alternatives later in the postoperative period. Nonetheless, our results further support the notion that prescribing practices are an important factor associated with prolonged postoperative opioid use, and further attention should be given to reduce high-risk prescribing practices following surgery.

Table 3
Multilevel Logistic Regression: High-Risk Prescribing and New Persistent Use.

Patient Characteristics	Odds Ratio	P Value	95% Confidence Interval	
Age (ref group: 65-69)				
70-74	1.723	.077	0.942	3.150
75-79	1.756	.094	0.909	3.391
80-84	1.807	.106	0.881	3.704
≥85	1.244	.708	0.397	3.903
Gender (ref group: female)				
Male	0.906	.662	0.580	1.414
Race (ref group: white)				
Black	1.836	.199	0.727	4.639
Other	3.293	.074	0.891	12.167
Unknown	2.898	.188	0.595	14.126
No dual enrollment	0.745	.609	0.240	2.308
Year of discharge from surgery (ref group: 2013)				
2014	0.973	.924	0.550	1.720
2015	0.609	.102	0.337	1.103
2016	0.453	.041	0.212	0.967
High-risk prescribing category of surgeon (ref group: quartile 1)				
Quartile 2	2.282	.010	1.222	4.263
Quartile 3	1.339	.377	0.700	2.562
Quartile 4	2.466	.011	1.228	4.952
Tobacco use	0.880	.748	0.403	1.921
Charlson score	1.134	.115	0.970	1.325
Mental health disorders				
Anxiety disorder	1.360	.559	0.485	3.811
Mood disorder	1.253	.702	0.395	3.974
Other mental health disorders	1.055	.961	0.127	8.733
Pain disorders				
Arthritis pain	0.787	.398	0.452	1.371
Back pain	0.906	.742	0.505	1.626
Neck pain	1.489	.489	0.483	4.591
Other pain	0.650	.316	0.281	1.508
Random Effects Parameter	Estimate	SE	95% Confidence Interval	
Surgeon variance	0.054125	0.152334	0.0002176	13.46134

Ref, reference; SE, standard error.

Consistent with prior studies, we observed that there was a wide range of prescription sizes, suggesting that consensus guidelines are needed to optimize postoperative prescribing to prevent unnecessary opioid exposure [33,34]. It is possible that certain aspects of opioid prescribing exacerbate underlying risk of prolonged use, such as prescription refills enabling the use of opioids as anxiolytics or sleep aids, in patients who may have an undocumented anxiety disorder. This is a particular concern in a procedure with high postoperative pain, such as THAs, where anticipation of pain has been documented to dissuade patients from receiving the surgery [35]. Therefore, creating guidelines that minimize excess opioid prescribing is a critical opportunity to reduce patient risk of prolonged opioid use. For example, in March 2016, the CDC published guidelines regarding opioid use in chronic pain control, with additional nonspecific recommendations for acute and postoperative pain [36–38]. In our analysis, patients discharged in 2016 had a lower risk of developing new persistent use regardless of which risky prescribing practices they were exposed to. Interestingly, we did not observe declines in high-risk prescribing rates over this time period. However, it is possible that the recent rise in multimodal pain management regimens through enhanced recovery after surgery pathways play a role. It is also possible that greater awareness of the risks of opioid analgesics during this time influenced this trend.

Our study has several limitations. First, the prescriptions filled by patients were used as a proxy for opioid consumption, as the latter was not quantifiable with these data. Second, our study examines only Medicare patients undergoing THA and may not fully represent a surgeon's entire practice. Surgeons included in this study may represent a variety of subspecialties, as we did not have

granular data regarding surgeon subspecialty training. Although our analysis captures Medicare beneficiaries in Michigan, this may not be generalizable to all cohorts of older patients. Third, this analysis was performed at the level of the original surgeon, with all opioid prescriptions attributed solely to the surgeon who performed the procedure, although it is possible that further prescribing in the postoperative period may have occurred that was not captured in claims. Although our analysis adjusted for the distribution of risk factors available in claims data across surgeons, there could be unmeasured confounders that are not uniformly distributed across surgeons and account for some of the effects we observed. Finally, this study did not examine provider characteristics beyond prescribing patterns. As further knowledge about the contribution of prescribing characteristics to new persistent opioid use is developed, additional research into provider biases may be warranted.

Patients exposed to surgeons who prescribed an average initial prescription size of 497 OMEs (the equivalence of about 100 tablets of 5-mg hydrocodone or 66 tablets of 5-mg oxycodone) had an almost 3 times greater odds of developing new persistent use compared to those exposed to an average initial prescription size of 273 OMEs (the equivalence of about 54 tablets of 5-mg hydrocodone or 36 tablets of 5-mg oxycodone). Federal, state, and local stakeholders are uniquely positioned to improve public health by accelerating the changes to current prescribing practice. Moreover, clinician and patient contributions to these recommendations are critical. Prescribing guidelines should be procedure-specific, patient-centered, and evidence-based. Education for providers regarding opioid prescribing and best practices is an equally important and potentially quicker way to enable provider

self-regulation of their own prescribing practices. Providers are aware that inadequate pain control is not only uncomfortable for the patient and associated with lower patient satisfaction but also associated with poor outcomes, such as increased risk of complications, cognitive dysfunction, slowed rehabilitation, and longer hospital length of stay [35,39]. However there is growing evidence that opioid prescribing following orthopedic procedures can be reduced without compromising pain control [40,41]. As such, national, institutional, and departmental education regarding procedure-appropriate prescribing, as well as risk-associated practices, is an important component of change. For example, Michigan Opioid Prescribing Engagement Network recommends a total initial prescription size of 240 OMEs or less for acute post-THA pain, based on patient-reported data for the amount of pills consumed postoperatively [42]. This has recently been incorporated into the Michigan Arthroplasty Registry Collaborative Quality Initiative Pain Management Protocol [43].

In addition, prescribing recommendations include the avoidance of co-prescribing with benzodiazepines [36,43]. In this study, we observed that the co-prescribing opioids with benzodiazepines was common, occurring in 57% of high-risk prescribing encounters. Although claims data do not provide sufficient granularity to discern the chronicity and dose of individuals who may have been on benzodiazepines in this cohort, concurrent opioid and benzodiazepine use is considered high risk due to the potential for respiratory depression, and the provision of a prescription for naloxone should be considered for these patients [9,36,43].

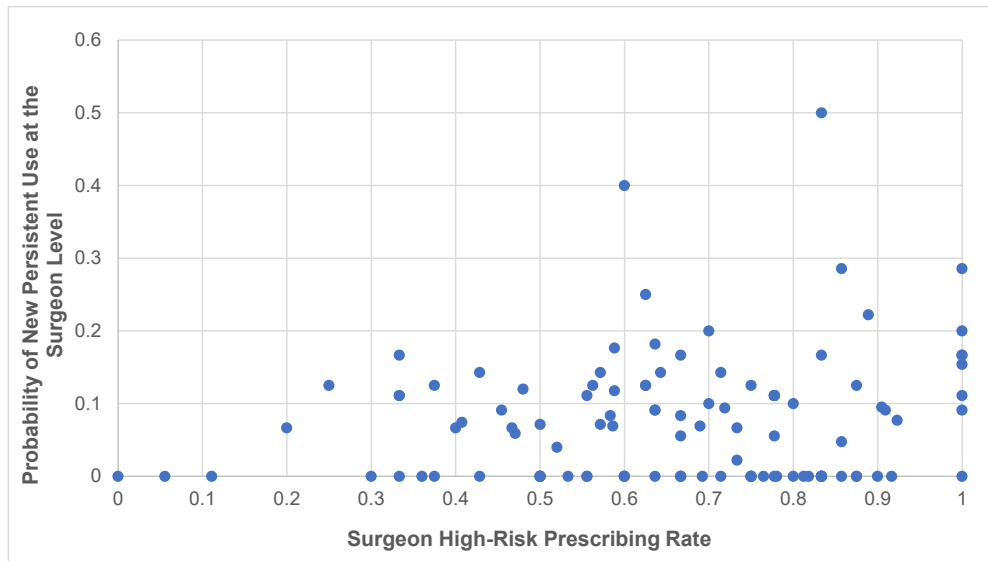
High-risk prescribing increases the risk of new persistent opioid use regardless of patient characteristics. These results indicate that new persistent opioid use among patients exposed to surgeons with the highest rates of high-risk opioid prescribing is almost double the rate of previously documented postoperative persistent use [3]. This is of particular concern because although the number of physicians initiating opioid prescriptions is declining nationally, rates of high-risk prescribing have stayed constant [44]. The variability in prescribing rates shown by these results highlights the need for change in current postoperative prescribing practices, as well as an opportunity to act. Current policies to limit opioid prescriptions target all providers; however, there is evidence to suggest that targeting high-volume prescribers may have more of an impact [45]. These results indicate that future provider education, guidelines, and policies may be most effective if high-risk prescribing characteristics are targeted to be further understood in a procedure-specific approach.

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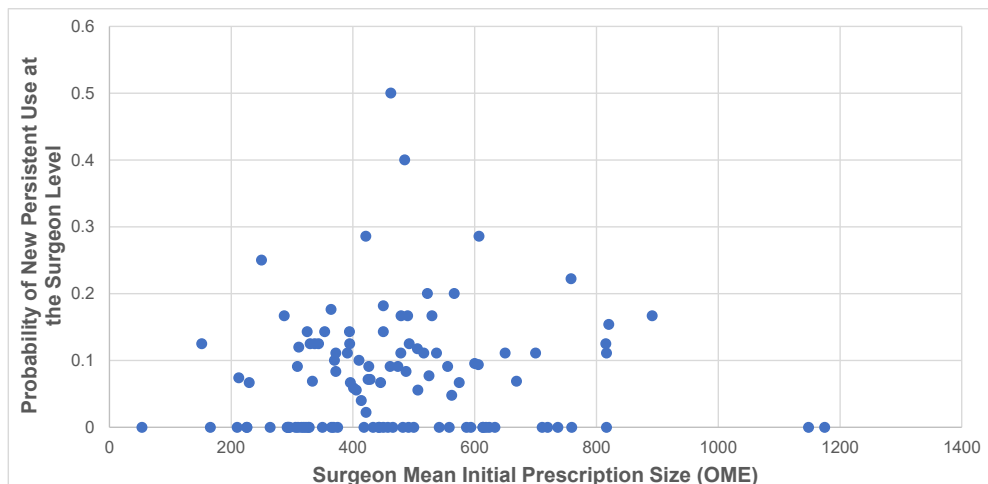
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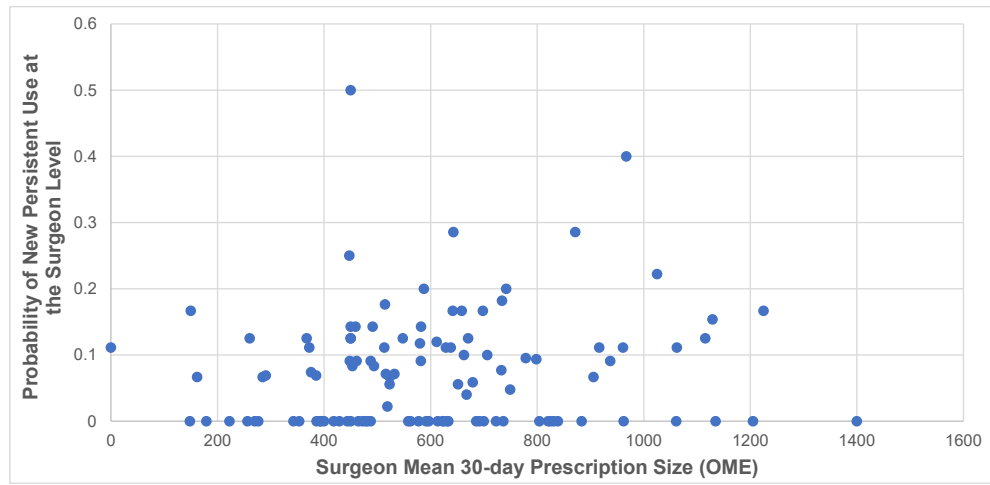
Appendix



Supplemental Fig. 1. The relationship of individual surgeon high-risk prescribing rates with the probability of new persistent use.



Supplemental Fig. 2. The relationship of individual surgeon initial postoperative prescription size with the probability of new persistent use.



Supplemental Fig. 3. The relationship of individual surgeon 30-day prescription size with the probability of new persistent use.