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Safety and Distribution of Opioid Prescribing by U.S. Surgeons

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Abstract

OBJECTIVE: To estimate high-risk prescribing patterns among opioid prescriptions from U.S. surgeons; to characterize the distribution of high-risk prescribing among surgeons

BACKGROUND: National data on the prevalence of opioid prescribing and high risk opioid prescribing by U.S. surgeons are lacking.

METHODS: Using the IQVIA Prescription Database, which reports dispensing from 92% of U.S. pharmacies, we identified opioid prescriptions from surgeons dispensed in 2019 to patients ages ≥12 years. “High-risk” prescriptions were characterized by: days supplied >7, daily dosage ≥50 oral morphine equivalents (OMEs), opioid-benzodiazepine overlap, extended-release/ long-acting opioid. We determined the proportion of opioid prescriptions, total OMEs, and high-risk prescriptions accounted for by “high-volume surgeons” (those in the ≥95th percentile for

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prescription counts). We used linear regression to identify characteristics associated with being a high-volume surgeon.

RESULTS: Among 15,493,018 opioid prescriptions included, 7,036,481 (45.4%) were high-risk. Among 114,610 surgeons, 5,753 were in the 95th percentile or above for prescription count, with ≥520 prescriptions dispensed in 2019. High-volume surgeons accounted for 33.5% of opioid prescriptions, 52.8% of total OMEs, and 44.2% of high-risk prescriptions. Among high-volume surgeons, 73.9% were orthopedic surgeons and 60.6% practiced in the South. Older age, male sex, specialty, region, and lack of affiliation with academic institutions or health systems were correlated with high risk prescribing.

CONCLUSIONS: The top 5% of surgeons account for 33.5% of opioid prescriptions and 45.4% of high-risk prescriptions. Quality improvement initiatives targeting these surgeons may have the greatest yield given their outsized role in high-risk prescribing.

MINI ABSTRACT

Using national prescription dispensing data, we estimate that 45.4% of opioid prescriptions from surgeons in 2019 were high-risk. “High-volume” surgeons in the 95th percentile or above for prescription counts accounted for 33.5% of opioid prescriptions and 44.2% of high-risk prescriptions. Targeting high-volume surgeons in quality improvement initiatives may be warranted.

INTRODUCTION

Several opioid prescribing patterns are associated with an elevated risk of opioid-related adverse events, such as overdose. These patterns include high daily doses of 50 oral morphine equivalents or greater, co-prescribing of opioids with benzodiazepines, initiating opioid-naïve patients on extended-release/long-acting formulations, and providing prolonged durations of opioid therapy for acute pain.[1-11] In the context of surgery, early studies suggest that these high-risk opioid prescribing patterns may occur frequently.[9,12,13] For example, co-prescribing of opioids, benzodiazepines, and skeletal muscle relaxants is common among women undergoing implant-based breast reconstruction, potentially because some guidelines recommended this practice to improve pain and mitigate postoperative muscle contraction.[4,5,14-21] Moreover, recent evidence suggests that surgeon prescribing is one of the primary drivers of postoperative opioid use, and the most modifiable.[22] Given the prevalence of surgical care and perioperative opioid prescribing, reducing high-risk surgical opioid prescribing is a key step towards mitigating prescription opioid-related harms.

Despite this, the frequency of high-risk surgical opioid prescribing and the most common forms of high-risk prescribing have not been systematically evaluated across all payer types using national data. Closing these knowledge gaps could inform efforts to improve the safety of surgical opioid prescribing. In addition, prior studies have demonstrated that opioid prescribing is highly concentrated among a few providers in dentistry and medical subspecialties, but whether this same pattern occurs in surgery is unknown.[23,24] Given that opioid prescribing patterns by surgeons are a modifiable and critical risk factor for postoperative opioid-related morbidity, it is crucial to determine whether a small group of surgeons disproportionately account for prescribing and high-risk prescribing. This

information could inform whether surgical opioid stewardship initiatives should be targeted versus inclusive of all prescribers.

In this study, we examined national prescription dispensing data across the United States in 2019 to estimate the prevalence of high-risk prescribing patterns among opioid prescriptions from surgeons. In addition, we described the distribution of opioid prescribing and high-risk prescribing among surgeons, specifically focusing on surgeons in the 95th percentile of prescribing and above. Finally, we determined the prescriber-level attributes associated with having outlier opioid prescribing practices.

METHODS

Data Source

We conducted a cross-sectional analysis of the IQVIA Longitudinal Prescription Database, which captures 92% of prescriptions dispensed from U.S. retail pharmacies and most prescriptions dispensed from mail-order and long-term care pharmacies. Data elements include patient year of birth, sex, state of residence, 3-digit zip code, method of payment for the prescription, and prescriber information (specialty, zip code and region of practice location). We identified prescriptions for opioid analgesics and benzodiazepines using IQVIA's market definitions (Appendix 1). The definition of opioid analgesics excluded opioids approved for opioid use disorder and opioid cough-and-cold medications.

We used two additional databases to gather further information on surgeon characteristics. First, we queried the IQVIA OneKey database, which reports demographic and practice characteristics of approximately 92% of U.S. providers. Data elements used in analyses included age, practice size, teaching hospital affiliation, and corporate parent name. Second, we examined the National Plan and Provider Enumeration System (NPPES), a comprehensive database of all providers with a national provider identifier (NPI) number. We used NPPES to gather data on surgeon sex, as rates of missing data were slightly lower in NPPES compared with OneKey. We linked the two provider databases to the IQVIA Longitudinal Prescription Database using NPI and IQVIA's encrypted provider identifiers. Because data were de-identified, analyses were exempted from human subjects review by the Institutional Review Board of the University of Michigan Medical School.

Study Cohort

Using the IQVIA Longitudinal Prescription Database, we identified opioid prescriptions written by surgeons dispensed in 2019 to patients in one of the 50 U.S. states or the District of Columbia. We defined surgeons as those in any of the following specialties: cardiothoracic, colorectal, general, hand, neurosurgery, ophthalmology, orthopedic, otolaryngology, pediatric, plastic, thoracic, transplant, urology, and vascular. Although advanced practice providers account for 20% of perioperative opioid prescriptions[25], we did not consider these providers in this analysis, as our focus was on surgeons.

We excluded prescriptions from surgeons who practiced outside of the 50 U.S. states and the District of Columbia. We also excluded opioid prescriptions dispensed to patients ages 11 and younger, as some of our high-risk metrics may not apply to young children (e.g., those

based on thresholds of oral milligram equivalents (OMEs), a standardized measure of opioid potency). Finally, we excluded prescriptions with missing or invalid dosing data.

High-Risk Prescribing Practices

We considered 4 measures of high-risk prescribing practices. First, we calculated the proportion of opioid prescriptions with days supplied > 7. This cutoff was selected based on evidence that patients undergoing surgery rarely require durations beyond 7 days and that prolonged durations of opioid therapy after surgery are associated with increased risk of opioid-related adverse events.[3,4,9] Second, we calculated the proportion of prescriptions with daily opioid dosages of 50 OMEs or higher, a threshold associated with an increased risk of opioid overdose.[4,7] We calculated daily OMEs by multiplying strength, quantity, and published OME conversion factors, then dividing by days supplied.[26] Third, we calculated the proportion of opioid prescriptions that overlapped with a benzodiazepine prescription for at least one day, a strong risk factor for opioid overdose.[5] Fourth, we calculated the proportion of opioid prescriptions that were for extended-release/long-acting formulations, as these would not be indicated for acute pain and are associated with increased overdose risk.[10] We classified an opioid prescription as “high-risk” if it met any of the 4 criteria above.

Distribution of Opioid Prescribing and High-Risk Prescribing

For surgeons with at least one dispensed opioid prescription in the sample, we counted the total number of dispensed prescriptions they accounted for in 2019. We defined a “high-volume” surgeon as those with prescription counts in the 95th percentile or above, following prior research.[24,27] We calculated the proportion of all opioid prescriptions, total OMEs, and high-risk prescriptions accounted for by high-volume surgeons versus other surgeons.

Opioid Prescribing Patterns Among High-Volume Surgeons Versus Other Surgeons

We calculated the mean number of opioid prescriptions and mean size of opioid prescriptions among high-volume surgeons and other surgeons. We calculated the proportion of opioid prescriptions from high-volume surgeons and other surgeons classified as high-risk. Finally, we examined the proportion of opioid prescriptions from high-volume surgeons and other surgeons that were provided to opioid-naïve patients (those lacking prescription opioid fills in the prior 90 days).

Characteristics of High-Volume Surgeons

We examined surgeon age (based on year of birth), sex, specialty, region of practice location (categorized as Northeast, Midwest, South, or West), and urban or rural practice location (based on mapping practice zip code to the Rural-Urban Continuum codes). In addition, we examined practice size, defined as the number of physicians at the practice. We examined whether surgeons had an academic affiliation. Per IQVIA’s recommendations, academic affiliation was defined as having a teaching hospital affiliation or working in a setting affiliated with a corporation that owns an academic facility (e.g., an outpatient center affiliated with the University of Michigan Health System). Finally, we captured whether

surgeons had a health system affiliation using the OneKey identifiers in the Agency for Healthcare Research and Quality's Compendium of U.S. Health Systems.[28] We used the 2018 version of the Compendium, the most recent data available.

Statistical Analysis

We used descriptive statistics to characterize the sample of opioid prescriptions and surgeon prescribers. In these analyses, we treated missing data as a separate category. For additional context, we also described the characteristics of all surgeons contained in the OneKey database, regardless of whether they accounted for any dispensed opioid prescriptions in the IQVIA Longitudinal Prescription Database.

To identify characteristics associated with being a high-volume surgeon, we fitted linear regression models (linear probability models). In these models, coefficients represent absolute percentage-point changes in probability, facilitating interpretation compared with odds ratios. To account for missing data, we performed multiple imputation with chained equations and 30 iterations. Analyses were conducted using SAS 9.4, Stata 15.1 MP, and two-sided hypothesis tests with $\alpha = 0.05$.

Sensitivity analysis

To limit to prescriptions likely written by attendings rather than residents, the latter of whom may not have full autonomy over opioid prescribing decisions, we excluded prescriptions written by surgeons aged ≤34 years old (i.e., just over seven years after the average age of a surgical intern, or 26.5 years[29]). Our database did not directly report trainee status, necessitating the use of this age-based cutoff.

RESULTS

Sample characteristics

The IQVIA Longitudinal Prescription Database included database contained 145,177,953 opioid prescriptions dispensed to U.S. patients in 2019, of which 15,736,103 (10.8%) were written by surgeons practicing in the U.S. Of these, 243,085 (1.5%) were excluded, leaving 15,493,018 prescriptions (Appendix 2 describes inclusion and exclusion criteria).

Of the 15,493,018 opioid prescriptions, 4,623,787 (29.8%) were for patients ages 65 and older, 8,436,017 (54.5%) were for female patients, and 13,169,278 (85.0%) were for opioid-naïve patients (Table 1). The most common method of payment was commercial insurance (9,225,030; 59.5%), followed by Medicare (3,955,237; 25.5%), Medicaid or other public insurance (1,358,763; 8.8%), and cash (953,988; 6.2%). Hydrocodone was the most common opioid (6,419,767; 41.4%), followed by oxycodone (5,040,369; 32.5%), tramadol (2,687,650; 17.3%), and codeine (1,005,441; 6.5%). Out of the total 15,493,018 prescriptions, 6,406,198 (41.4%) were hydrocodone-acetaminophen formulations, 11,909 (0.07%) were hydrocodone-ibuprofen and 1660 (0.01%) were hydrocodone bitartrate.

Prescriptions were most commonly provided by orthopedic surgeons (7,322,687; 47.3%), followed by general surgeons (2,973,540; 19.2%). Mean prescription size was 284 (SD 535.5) OMEs, roughly equal to 57 tablets of 5 mg hydrocodone; median prescription size

was 160 (25^{th}-75^{th} percentile: 100 - 300) OMEs. Mean days supplied was 7.4 (SD 7.0). More prescriptions were provided to individuals residing in urban (10,927,746; 70.5%) than rural areas (4,565,468; 29.5%).

Prevalence of high-risk opioid prescribing

Among the 15,493,018 prescriptions, 3,341,945 (21.6%) exceeded a 7-day supply, 3,402,345 (22.0%) had daily dosage ≥50 OME, 1,671,292 (10.8%) overlapped with a benzodiazepine prescription for ≥1 day, and 145,819 (0.9%) were for extended-release/long-acting opioids (Table 2). Overall, 7,036,481 (45.4%) were considered high-risk by any of the 4 metrics, and 1,328,170 (8.6%) were considered high-risk by 2 or more metrics. Of these latter prescriptions, the most common combination of high-risk criteria were days supplied > 7 and daily dosage ≥50 OME.

Distribution of opioid prescribing and high-risk prescribing

A total of 114,610 surgeons accounted for at least one prescription in our sample. Of the 114,610 surgeons, 5,753 (5.0%) were high-volume surgeons in the 95^{th} percentile or above for prescription count in 2019, corresponding to 520 prescriptions or more. High volume surgeons provided 5,184,378 (33.5%) of the 15,493,018 opioid prescriptions, 2,324,991,687 (52.8%) of the 4,406,498,425 OMEs prescribed by surgeons, and 3,112,373 (44.2%) of the 7,036,481 high-risk prescriptions. In contrast, surgeons in the 80^{th} percentile or above for prescription count in 2019 provided 10,673,549 (68.9%) of the 15,493,018 opioid prescriptions, 3,531,448,319 (80.1%) of the 4,406,498,425 OMEs prescribed by surgeons, and 5,388,665 (76.6%) of the 7,036,481 high-risk prescriptions.

Among specialties, the proportion of opioid prescriptions accounted for by high-volume surgeons was highest among orthopedic surgery (53.4%), followed by hand surgery (40.1%) and neurosurgery (39.1%) (Figure 1; Appendix 3). The proportion of total OME and high-risk prescriptions accounted for by high-volume surgeons was also highest among these three specialties (Appendix 3).

Opioid Prescribing Patterns Among High-Volume Surgeons Versus Other Surgeons

High-volume surgeons prescribed a mean of 901 (SD 650) prescriptions and mean prescription size was 448 OMEs (SD 749), compared with 95 (SD 115) prescriptions and 202 (SD 358) OMEs among other surgeons in 2019. Opioid prescriptions were more likely to be high-risk according to any of the 4 metrics if written by high-volume surgeons (60.0%) compared with other surgeons (38.1%). Moreover, for each of the 4 metrics, performance for high-volume surgeons was worse than for other surgeons (Table 2). A lower proportion of prescriptions from high-volume surgeons were provided to opioid-naive patients compared with other surgeons (73.6% vs 90.8%). Table 1 displays other characteristics of prescriptions from high-volume versus other surgeons.

Characteristics of High-Volume Surgeons

Among the 114,610 surgeon prescribers, 29,746 (26.0%) were general surgeons and 27,088 (23.6%) were orthopedic surgeons. However, among the 5,753 high-volume surgeons, 460 (8.0%) were general surgeons and 4,254 (73.9%) were orthopedic surgeons (Table 3). The

proportion of surgeons in each specialty that were high-volume surgeons was highest among orthopedic surgery (15.7%), followed by hand surgery (13.9%) and neurosurgery (4.6%) (Figure 2; Appendix 4).

Compared with other surgeons, high-volume surgeons were more likely to be older (40-49 years: 30.9% vs. 21.3%; 50-59 years: 31% vs. 20.4%; 60-69 years: 17.9% vs. 16.3%), male (97.5% vs. 81.2%), and were more likely to practice in the South (60.6% vs. 36.0%). High volume surgeons were less likely to have an academic affiliation (20.3% vs. 39.0%) or health system affiliation (25.0% vs. 44.1%) (Table 3).

Factors Independently Associated with Being a High-Volume Surgeon

In the regression model that includes surgeons of all ages, factors that were positively associated with being a high-volume surgeon included older age (e.g., 50-59 versus 20-29: +5.5 percentage points, 95% CI: 4.8-6.1), male sex (+1.7 percentage points, 95% CI: 1.3-2.0), being an orthopedic surgeon (+12.8 percentage points, 95% CI: 12.5-13.2) or hand surgeon (+10.7 percentage points, 95% CI: 9.8-11.6) compared with being a general surgeon, and practice outside of the Northeast (e.g., South versus Northeast, +6.1 percentage points, 95% CI: 5.8-6.5). Factors that were negatively associated with being a high-volume surgeon included academic affiliation (−0.8 percentage points, 95% CI: −1.3, −0.4) and health system affiliation (−1.6 percentage points: 95% CI: −2.0, −1.1). Urban or rural practice was not associated with being a high-volume surgeon, and there was not a consistent relationship with practice size and being a high-volume surgeon (Table 4).

Sensitivity analysis

The sensitivity analyses excluded 951,123 (6.1%) opioid prescriptions written by surgeons ages ≤34 years. Among the remaining 14,541,765 prescriptions, 6,748,742 (46.4%) were high-risk. High-volume surgeons wrote 2,867,447 (42.5%) of the 6,748,472 high-risk prescriptions and 4,660,155 (32.0%) of all 14,541,765 opioid prescriptions. These results were similar to those in the main analysis.

DISCUSSION

In this study of 2019 national prescription dispensing data, nearly one-half of opioid prescriptions from surgeons were considered high-risk by any of 4 metrics. Moreover, high-volume surgeons – those in the 95th percentile or above by prescription – accounted for 1 in 3 opioid prescriptions written by surgeons, half of total opioid dosage, and nearly half of high-risk prescriptions. While efforts to improve the safety of surgical opioid prescribing would ideally include all surgeons, the outsized role of high-volume surgeons in risky prescribing suggests that initiatives targeting these prescribers may be an efficient approach.

By demonstrating the high prevalence of high-risk prescribing patterns and the frequency of individual high-risk patterns, this analysis can both motivate and inform policy and clinical efforts to improve surgical opioid prescribing. To date, the bulk of such efforts have focused on limiting the duration and size of opioid prescriptions through regulatory restrictions and implementation of procedure-specific opioid prescribing guidelines based on data on patient-reported opioid consumption. However, in this analysis, opioid prescriptions

from surgeons with elevated daily dosages were slightly more common than those with long durations, and 1 in 10 overlapped with a benzodiazepine prescription. These findings suggest that surgical opioid stewardship initiatives must include efforts to ensure appropriate daily dosages and avoid opioid-benzodiazepine overlap, rather than only focus on reducing excessive prescribing. While use of extended-release/long-acting formulations was rare in our analysis, efforts could also be implemented to eliminate this use, for example by precluding prescribing of these formulations after surgery in electronic health record systems.

Our findings on the distribution of opioid prescribing and high-risk prescribing among surgeons align with previous literature.[23,24,30,31] In a recent analysis of administrative claims data from a large commercial insurer, the top 1% of prescribers for adults accounted for 49% of all opioid doses in a single year.[23] In our prior studies, we found that the top 5% of prescribers of opioid prescriptions to children accounted for just over half of all opioid prescriptions and high-risk prescriptions in this age group, while the top 5% of dentists accounted for just under half of all dental opioid prescriptions and high-risk prescriptions.[24] Although our analysis focused on the cohort of surgeons with the greatest deviation of prescribing from their peers at the 95th percentile, our findings suggest that quality improvement efforts that focus more broadly on surgeons who prescribe beyond expected norms could have high value in reducing excessive prescribing.

We found that the majority of high-volume surgeons were orthopedic surgeons and clinicians who practiced in the South. This finding is consistent with prior studies showing that opioid prescribing is common among orthopedic surgeons and that prescribers in the South are more likely to have high volumes of opioid prescribing.[32,33] The over-representation of orthopedic surgeons among the ranks of high-volume surgeons does not necessarily imply that the prescribing patterns of orthopedic surgeons are more likely to be inappropriate compared with other surgical specialties. For example, given that orthopedic surgeons frequently perform particularly painful procedures such as total knee and hip arthroplasty, it might be expected that they account for more long-duration opioid prescriptions than other specialties. Despite this, our findings suggest that additional attention to the prescribing practices of orthopedic surgeons could be warranted.

Our findings have important implications for quality improvement efforts to enhance opioid stewardship within surgical care. Current efforts to guide opioid prescribing during surgical care have focused broadly on procedure type rather than on outlier prescribers.[34] Although these strategies have resulted in overall declines in opioid prescribing, our data suggest that they could also be coupled with strategies aimed at encouraging outlier prescribers to adopt best practices. Such strategies could include academic detailing, which provides education and coaching to providers on an individual basis, and has been correlated with improved adherence to clinical guidelines in other prescribing contexts.[35] In addition, provider audit-and-feedback initiatives could be effective to highlight outlier or risky patterns.[36,37] Our findings also highlight an opportunity to understand the differences in the factors that motivate prescribers at the highest and lowest ranges of prescribing. Comparison of peer norms can be a powerful influence to change clinical practice, and future studies that examine variation in prescribing across specialty and procedure could

illuminate opportunities to align prescribing with guidelines. Finally, several metrics of high-risk opioid prescribing, such as co-prescribing with benzodiazepines, could be assessed using state prescription drug monitoring program databases. As such, these databases could be used to identify surgeons who disproportionately account for high-risk prescribing, and quality improvement initiatives could be deployed to mitigate high-risk prescribing by these surgeons. In addition, review of prescribing patterns for high-prescribing providers by peer mechanisms within an institution or regulatory bodies at the state level could be effective in encouraging providers to prescribe within evidence-based guidelines which have recently emerged for many procedures and specialties. Notably, we observed that high-volume surgeons were substantially less likely than other surgeons to have academic affiliations or health system affiliations, suggesting that efforts focused on high-volume surgeons must extend beyond these settings.

Our study has several notable strengths. We used a national dispensing database that includes prescriptions across all methods of payment, including cash. We linked this dispensing database to two comprehensive provider databases, allowing us to identify characteristics associated with being a high-volume surgeon. Though not the study's primary purpose, our analyses also provide detailed data on the characteristics of the U.S. surgeon work force.

However, our study has limitations. First, although the dispensing database is comprehensive, it does not report dispensing from all pharmacies in the U.S. Second, the dispensing database lacks information regarding the clinical context of prescribing, such as procedure type, the occurrence of complications, and patient risk factors. Third, the database lacks information on case mix and volume, factors that could be associated with the volume of opioid prescribing and high-risk prescribing by a surgeon. In addition, we are not able to determine if a surgeon linked to a prescription is in training. While we estimated completion of training to occur roughly at age 34, this may not reflect additional fellowship or postgraduate training. Fourth, we did not assess opioid prescribing by surgical nurse practitioners or physician assistants, but plan to do so in future work.

Finally, the database did not allow us to link opioid prescriptions written by residents under the supervision of attending surgeons in a teaching setting. Consequently, we may have failed to classify surgeons whose residents account for a large number of opioid prescriptions as high-volume surgeons. At the same time, we may have classified residents who account for a large number of opioid prescriptions as high-volume surgeons, even if the residents' opioid prescribing patterns reflected the preferences of their attendings instead of their own preferences. These concerns, however, are somewhat mitigated by the fact that just 6% of opioid prescriptions in the sample were written by surgeons ages ≤34 years, and by the fact that excluding these prescriptions did not meaningfully change estimates of the prevalence of high-risk opioid prescribing or of the degree to which opioid prescribing and high-risk prescribing are concentrated among individual surgeons.

CONCLUSION

Our findings suggest that efforts to align surgical opioid prescribing with best practices may be efficient if they focus on high-volume surgeons. A challenge for these efforts is that high-volume surgeons may be entrenched in their prescribing practices, as prior studies demonstrate that prescribers accounting for a high volume of opioid prescriptions in one year are also likely to do so in subsequent years.[23] Thus, assessing which strategies are most likely to succeed in changing the behavior of high-volume surgeons is an important direction for future research.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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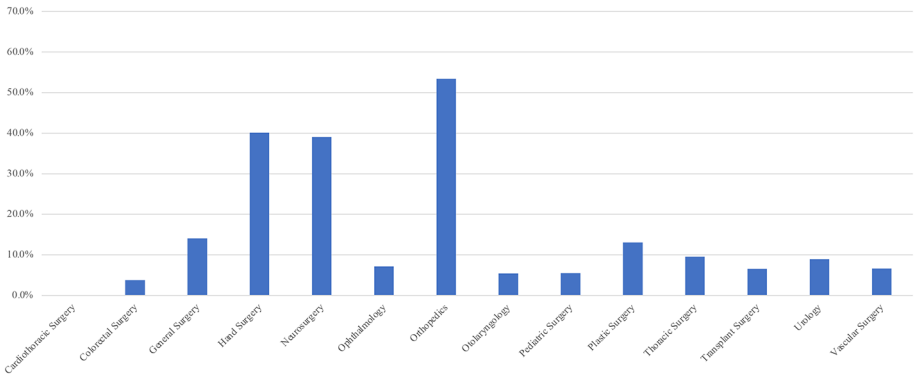

Figure 1. Proportion of opioid prescriptions written by high-volume surgeons, by specialty.
High-volume surgeons were those accounting for at least 520 dispensed opioid prescriptions to patients aged ≥12 years in 2019, corresponding to the 95th percentile or above. The raw numbers for this figure is included in Appendix 3.

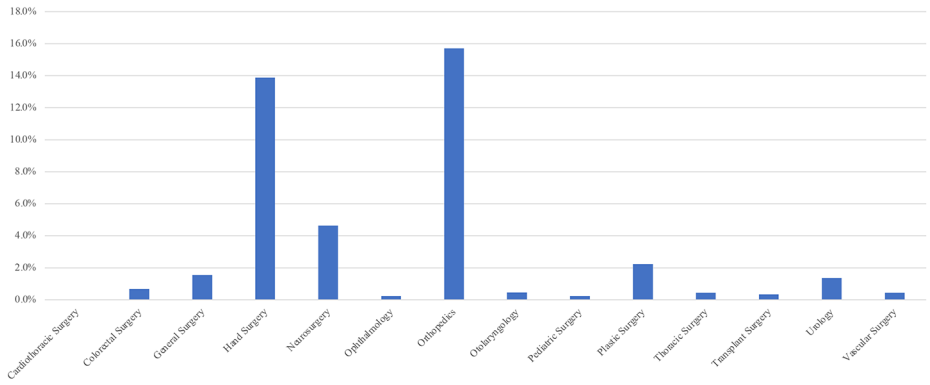

Figure 2. Proportion of opioid prescribers that are high-volume surgeons, by specialty.

High-volume surgeons were those accounting for at least 520 dispensed opioid prescriptions to patients aged ≥12 years in 2019, corresponding to the 95th percentile or above. The raw numbers for this figure is included in Appendix 4.

Table 1.

Characteristics of dispensed opioid prescriptions from U.S. surgeons in 2019, overall and among prescriptions written by high-volume and other surgeons

	All prescriptions	Prescriptions from high-volume surgeons	Prescriptions from other prescribers
	N=15,493,018	N=5,184,378	N=10,308,640
Patient age group (years)	No. (%)	No. (%)	No. (%)
12-17	315,027 (2.0)	69,049 (1.3)	245,978 (2.4)
18-34	1,994,357 (12.9)	465,128 (9.0)	1,529,229 (14.8)
35-44	2,030,124 (13.1)	579,123 (11.2)	1,451,001 (14.1)
45-54	2,767,684 (17.9)	954,120 (18.4)	1,813,564 (17.6)
55-64	3,762,039 (24.3)	1,423,307 (27.5)	2,338,732 (22.7)
65 and older	4,623,787 (29.8)	1,693,651 (32.7)	2,930,136 (28.4)
Sex			
Male	7,040,729 (45.4)	2,288,591 (44.1)	4,752,138 (46.1)
Female	8,436,017 (54.5)	2,892,581 (55.8)	5,543,436 (53.8)
Unknown/missing	16,272 (0.1)	3,206 (0.1)	13,066 (0.1)
Region of patient residence			
Northeast	1,748,148 (11.3)	300,923 (5.8)	1,447,225 (14.0)
Midwest	3,259,817 (21.0)	983,641 (19.0)	2,276,176 (22.1)
South	7,660,679 (49.4)	3,278,304 (63.2)	4,382,375 (42.5)
West	2,824,374 (18.2)	621,510 (12.0)	2,202,864 (21.4)
Urban/rural patient residence			
Urban	10,927,476 (70.5)	3,525,449 (68.0)	7,402,027 (71.8)
Rural	4,565,468 (29.5)	1,658,917 (32.0)	2,906,551 (28.2)
Unknown/missing	74 (0.0)	12 (0.0)	62 (0.0)
Method of payment			
Commercial	9,225,030 (59.5)	2,954,412 (57.0)	6,270,618 (60.8)
Medicare	3,955,237 (25.5)	1,533,722 (29.6)	2,421,515 (23.5)
Medicaid/other public	1,358,763 (8.8)	372,957 (7.2)	985,806 (9.6)
Cash	953,988 (6.2)	323,287 (6.2)	630,701 (6.1)
Opioid type			
Hydrocodone	6,419,767 (41.4)	2,120,265 (40.9)	4,299,502 (41.7)
Oxycodone	5,040,369 (32.5)	1,560,610 (30.1)	3,479,759 (33.8)
Tramadol	2,687,650 (17.3)	1,058,188 (20.4)	1,629,462 (15.8)
Codeine	1,005,441 (6.5)	296,730 (5.7)	708,711 (6.9)
Other	339,791 (2.2)	148,585 (2.9)	191,206 (1.9)
Long-acting/extended release formulation	145,819 (0.9)	94,382 (1.8)	51,437 (0.5)
Specialty			
Cardiothoracic Surgery	7,310 (0.0)	0 (0.0)	7,310 (0.1)

	All prescriptions	Prescriptions from high-volume surgeons	Prescriptions from other prescribers
	N=15,493,018	N=5,184,378	N=10,308,640
Colorectal Surgery	199,842 (1.3)	7,487 (0.1)	192,355 (1.9)
General Surgery	2,973,540 (19.2)	416,926 (8.0)	2,556,614 (24.8)
Hand Surgery	621,085 (4.0)	249,110 (4.8)	371,975 (3.6)
Neurosurgery	697,971 (4.5)	272,686 (5.3)	425,285 (4.1)
Ophthalmology	226,842 (1.5)	16,207 (0.3)	210,635 (2.0)
Orthopedics	7,322,687 (47.3)	3,909,543 (75.4)	3,413,144 (33.1)
Otolaryngology	880,620 (5.7)	47,820 (0.9)	832,800 (8.1)
Pediatric Surgery	46,499 (0.3)	2,553 (0.0)	43,946 (0.4)
Plastic Surgery	997,394 (6.4)	130,382 (2.5)	867,012 (8.4)
Thoracic Surgery	118,568 (0.8)	11,270 (0.2)	107,298 (1.0)
Transplant Surgery	7,978 (0.1)	523 (0.0)	7,455 (0.1)
Urology	1,207,231 (7.8)	107,544 (2.1)	1,099,687 (10.7)
Vascular Surgery	185,451 (1.2)	12,327 (0.2)	173,124 (1.7)

Table 2.

Prevalence of high-risk prescribing patterns among opioid prescriptions from all surgeons, high-volume surgeons, and other surgeons

Metric	All prescriptions	Prescriptions from high-volume surgeons	Prescriptions from other surgeons
	N=15,493,018	N=5,184,378	N=10,308,640
	No. (%)	No. (%)	No. (%)
Days supplied >7 days	3,341,945 (21.6)	1,946,664 (37.6)	1,395,281 (13.5)
Daily OME ≥ 50	3,402,345 (22.0)	1,357,615 (26.2)	2,044,730 (19.8)
Overlap with a benzodiazepine prescription for ≥ 1 day	1,671,292 (10.8)	627,309 (12.1)	1,043,983 (10.1)
Extended-release/long-acting opioids	145,819 (0.9)	94,382 (1.8)	51,437 (0.5)
Any of the above	7,036,481 (45.4)	3,112,373 (60.0)	3,924,108 (38.1)

Table 3.

Characteristics of all surgeons who prescribed opioids in 2019, high-volume surgeons, other surgeons, and all surgeons in the OneKey database

	All prescribers	High-volume surgeons	Other surgeons	All surgeons in the OneKey database[a]
	N=114,610	**N=5,753**	**N=108,857**	**N=158,730**
Age	No. (%)	No. (%)	No. (%)	No. (%)
20-29	5,117 (4.5)	0 (0.0)	5,117 (4.7)	7,016 (4.4)
30-39	28,015 (24.4)	736 (12.8)	27,279 (25.1)	35,071 (22.1)
40-49	24,982 (21.8)	1,778 (30.9)	23,204 (21.3)	31,231 (19.7)
50-59	24,025 (21.0)	1,784 (31.0)	22,241 (20.4)	30,468 (19.2)
60-69	18,790 (16.4)	1,028 (17.9)	17,762 (16.3)	28,618 (18.0)
>=70	7,751 (6.8)	281 (4.9)	7,470 (6.9)	24,159 (15.2)
Unknown	5,930 (5.2)	146 (2.5)	5,784 (5.3)	2,167 (1.4)
Sex				
Female	20,441 (17.8)	137 (2.4)	20,304 (18.7)	29,094 (18.3)
Male	93,984 (82.0)	5,611 (97.5)	88,373 (81.2)	129,630 (81.7)
Unknown	185 (0.2)	5 (0.1)	180 (0.2)	6 (0.0)
Surgical specialty				
Cardiothoracic	214 (0.2)	0 (0.0)	214 (0.2)	317 (0.2)
Colorectal Surgery	1,757 (1.5)	12 (0.2)	1,745 (1.6)	2,056 (1.3)
General Surgery	29,746 (26.0)	460 (8.0)	29,286 (26.9)	41,580 (26.2)
Hand Surgery	2,407 (2.1)	334 (5.8)	2,073 (1.9)	2,780 (1.8)
Neurosurgery	5,900 (5.1)	274 (4.8)	5,626 (5.2)	8,091 (5.1)
Ophthalmology	10,441 (9.1)	24 (0.4)	10,417 (9.6)	23,315 (14.7)
Orthopedics	27,088 (23.6)	4,254 (73.9)	22,834 (21.0)	32,476 (20.5)
Otolaryngology	10,431 (9.1)	48 (0.8)	10,383 (9.5)	13,095 (8.2)
Pediatric Surgery	1,771 (1.5)	4 (0.1)	1,767 (1.6)	2,736 (1.7)
Plastic Surgery	7,694 (6.7)	171 (3.0)	7,523 (6.9)	9,305 (5.9)
Thoracic Surgery	2,941 (2.6)	13 (0.2)	2,928 (2.7)	5,227 (3.3)
Transplant Surgery	293 (0.3)	1 (0.0)	292 (0.3)	477 (0.3)
Urology	10,506 (9.2)	143 (2.5)	10,363 (9.5)	12,846 (8.1)
Vascular Surgery	3,421 (3.0)	15 (0.3)	3,406 (3.1)	4,429 (2.8)
Urban/Rural location				
Urban	112,690 (98.3)	5,625 (97.8)	107,065 (98.4)	156,032 (98.3)
Not urban	1,783 (1.6)	127 (2.2)	1,656 (1.5)	2,558 (1.6)
Unknown	137 (0.1)	1 (0.0)	136 (0.1)	140 (0.1)
Region of practice				
Northeast	22,855 (19.9)	383 (6.7)	22,472 (20.6)	33,834 (21.3)

	All prescribers	High-volume surgeons	Other surgeons	All surgeons in the OneKey database[a]
	N=114,610	**N=5,753**	**N=108,857**	**N=158,730**
Midwest	25,735 (22.5)	1,166 (20.3)	24,569 (22.6)	33,745 (21.3)
South	42,655 (37.2)	3,486 (60.6)	39,169 (36.0)	55,539 (35.0)
West	23,365 (20.4)	718 (12.5)	22,647 (20.8)	35,612 (22.4)
Practice size				
1	7,209 (6.3)	363 (6.3)	6,846 (6.3)	9,620 (6.1)
2-5	5,649 (4.9)	357 (6.2)	5,292 (4.9)	24,476 (15.4)
6-9	27,012 (23.6)	1,540 (26.8)	25,472 (23.4)	14,762 (9.3)
10-19	13,989 (12.2)	1,187 (20.6)	12,802 (11.8)	16,531 (10.4)
20-50	11,122 (9.7)	1,158 (20.1)	9,964 (9.2)	13,591 (8.6)
51-99	5,004 (4.4)	363 (6.3)	4,641 (4.3)	6,500 (4.1)
>=100	31,068 (27.1)	522 (9.1)	30,546 (28.1)	52,088 (32.8)
Unknown	13,557 (11.8)	263 (4.6)	13,294 (12.2)	21,162 (13.3)
Academic affiliation	43,652 (38.1)	1,168 (20.3)	42,484 (39.0)	64,127 (40.4)
Health system affiliation	49,421 (43.1)	1,437 (25.0)	47,984 (44.1)	70,387 (44.3)

[a]This column includes all surgeons in the OneKey database, regardless of whether they could be linked to a dispensed opioid prescription in the 2019 IQVIA Longitudinal Prescription Database. The column is provided for contextual purposes and for readers who may be interested in the characteristics of the U.S. surgeon workforce.

Table 4.

Factors associated with high-volume surgeon status

	Characteristic	Coefficient (95% CI)
Age group	20-29	Reference
	30-39	1.9 (1.2, 2.5)
	40-49	5.3 (4.7, 6.0)
	50-59	5.5 (4.8, 6.1)
	60-69	3.5 (2.8, 4.1)
	>=70	1.8 (1.1, 2.6)
Sex	Female	Reference
	Male	1.7 (1.3, 2.0)
Surgical specialty	General surgery	Reference
	Cardiothoracic Surgery	−3.5 (−6.2, −0.7)
	Colorectal Surgery	−1.8 (−2.9, −0.8)
	Hand Surgery	10.7 (9.8, 11.6)
	Neurosurgery	2.2 (1.6, 2.8)
	Ophthalmology	−3.1 (−3.7, −2.6)
	Orthopedics	12.8 (12.5, 13.2)
	Otolaryngology	−2.1 (−2.6, −1.7)
	Pediatric Surgery	−2.1 (−3.1, −1.1)
	Plastic Surgery	−0.6 (−1.1, −0.1)
	Thoracic Surgery	−2.1 (−2.9, −1.4)
	Transplant Surgery	−1.9 (−4.3, 0.5)
	Urology	−1.3 (−1.7, −0.8)
	Vascular Surgery	−1.9 (−2.6, −1.2)
Urban/rural practice location	Urban	Reference
	Rural	0.1 (−0.9, 1.1)
Region	Northeast	Reference
	Midwest	2.9 (2.5, 3.2)
	South	6.1 (5.8, 6.5)
	West	0.8 (0.4, 1.2)
Number of physicians in practice	1	Reference
	2-5	0.9 (0.3, 1.4)
	6-9	0.3 (−0.3, 0.9)
	10-19	1.2 (0.7, 1.9)
	20-50	2.1 (1.5, 2.7)
	51-99	0.6 (−0.2, 1.3)
	>=100	−1.0 (−1.6, −0.5)
Academic affiliation	No	Reference
	Yes	−0.8 (−1.3, −0.4)

	Characteristic	Coefficient (95% CI)
Affiliated with health system	No	Reference
	Yes	−1.6 (−2.0, −1.1)