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State Level Variation in Opioid Prescribing after Knee Arthroscopy among the Opioid-Naïve in the United States: 2012-2015

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Objective It has been established that most patients prescribed opioids after minor surgery have tablets left over, better understanding the variation in opioid prescribing and variation in dosage of the prescription could guide efforts to reduce excessive prescribing. This study describes the state level variation in opioid prescribing after a knee arthroscopy among opioid naïve patients.

Design Retrospective cohort study.

Setting: Commercial insurance claims data.

Participants: 84.043 individual across the USA with commercial insurance who were opioid naïve and had a knee arthroscopy between 2012 and 2015.

Exposure: Patients who filled an opioid prescription within 3 days of a knee arthroscopy.

Outcome measures: Opioid prescriptions were measured as a pharmacy claim for filling an opioid within 3 days of a knee arthroscopy. We measured the patient and state level opioid prescribing rate, tablet count, morphine milligram equivalent dose per prescription, and risk-adjusted predicted opioid quantity.

Results Overall, 75% of patients filled an opioid prescription with a median tablet count of 40 and median morphine milligram equivalent of 300. Patients with an invasive procedure (27.9% vs 19.2%; p<0.001), higher education level (p<0.001), and fewer comorbidities (0.9 vs 1.2, p<0.001) had higher rates of opioid prescribing. The prescribing rate in the highest state, Nebraska (87%), was double the prescribing rate in the lowest state, South Dakota (41%). Comparing the case mix adjusted expected prescribing rate to the observed prescribing rate displayed that 17 states had observed prescribing rates that were higher than their expected prescribing rates.

Conclusion While 75% of patients were prescribed opioids wide variation in the likelihood of receiving a prescription depending on state of residence (41% to 87%) existed. The dosages prescribed were high and have been associated with transition to long-term use. These findings suggest there is substantial opportunity reduce excessive opioid prescribing for this common minor procedure.

Article Summary (Strengths and limitations of this study):

- This is among the first studies to demonstrate the degree of state-level variation in opioid prescribing rates for a common minor surgical procedure. This provides a clearer view of the degree to which prescribing rates can be reduced given that surgical approaches and pain response is not expected to dramatically vary by state.
- Another strength is the adjustment for demographic and clinical characteristics to account for differences in case-mix across states.
- Our study is a claims-based study does not capture prescriptions that were made but not filled by patients or prescriptions that were paid out of pocket. Furthermore, the demographic and clinical characteristics we could assess are limited.

Introduction

Between 1999 and 2016 opioid prescribing quadrupled to over 259 million prescriptions per year. Opioid related deaths are the leading cause of unintentional death in the United States responsible for at least 63,000 fatalities in 2016.[1] For many procedures opioid analgesics have become the default standard of care for post-operative pain management and are the leading exposure of patients' to opioid prescriptions, particularly among the opioid-naïve, even after low-risk surgical procedures.[2-5] This can be problematic because a single prescription and higher dosage prescriptions have been associated with prolonged opioid use.[6-14] Furthermore, 50-70% of opioid tablets prescribed are never taken posing the risk of misuse and diversion.[15]

Surgical societies have called for more judicious opioid prescribing and have promoted the concept of "opioid stewardship" in post-operative pain.[16-18] As with longstanding efforts to promote antibiotic stewardship, the first step in establishing post-operative opioid stewardship initiatives is to establish baseline use, duration, and variation by procedure and indication.[19] Even though the national levels of prescribing are well documented, limited attention has been given to the regional variation in opioid prescribing for opioid naïve patients after common outpatient surgeries.[4,20-22] Orthopedic arthroscopic procedures account for 2 of the top 3 most common outpatient surgical procedures performed in the U.S., yet there is a dearth of literature benchmarking opioid prescribing rates and dosages for these procedures.[23-25] Knee arthroscopy is the most common outpatient orthopedic procedure in the U.S., with approximately 1 million procedures per year.[26,27] Establishing the baseline variation in opioid prescribing after knee arthroscopy is a critical knowledge gap to fill to establish quality improvement targets. Prescribing targets are essential in reducing excessive prescribing with a large potential public health impact given the volume of this procedure and current lack of consensus for this procedure on post-operative opioid use.

The goal of our study was to describe the patient and state level variation in post-operative opioid prescribing rates and dosages for opioid naïve patients after a knee arthroscopy in the United States (U.S.). Our investigation focused on the prescribing practices among the commercially insured, a relatively unexplored group of individuals in terms of opioid prescribing, but the one with the highest risk of opioid use and abuse.[7] We hypothesized that there would be substantial variation in the state and patient level prescribing rates and dosages, even after accounting for patient characteristics.

Methods

We used the Clinformatics Data Mart Database (OptumInsight) from 2012 through 2015, which comprises commercial insurance claims from a large national U.S. private health insurer covering 7.5 million lives annually represented in every state. We defined an index knee arthroscopy encounter as the earliest visit in which a beneficiary had a knee arthroscopy provider medical claim.[28]

We focused our analysis on opioid-naïve patients and excluded any patients who filled an opioid prescription within the six months preceding the index surgery date. We also excluded patients who did not receive the knee arthroscopy in the outpatient hospital or ambulatory surgical center setting to retain a more homogenous sample. Patients who did not have medical claims for the surgery and the operational facility charge on the same day or the day after were also excluded to mitigate concerns regarding the day of the actual surgery. Lastly, we excluded patients who had multiple knee arthroscopy surgeries to reduce the confounding effect of reoperation on the probability that opioid prescriptions were associated with additional surgeries.

We collected patient demographic information on age, gender, education, household income, ethnicity, and the state where the surgery was performed. We identified the patients' Elixhauser comorbidities, as well as diagnosis codes for drug abuse, alcohol abuse, depression, and psychoses from any medical claims filed in the previous six months. We also used Current Procedural Technology (CPT) codes to classify knee arthroscopy procedures based on involvement of bone (invasive, such as anterior cruciate ligament repair) vs. soft tissue only (non-invasive, such as simple knee arthroscopy) (See Appendix for a description).

No Patient and Public Involvement

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Definition of Opioid Prescription

We identified prescription claims based on the pharmacy claims and identified opioids according to National Drug Codes (excluding methadone and non-tablet formulations) filled within 3 days of the index visit. See Appendix for a description of included opioids. We excluded opioids primarily used for treatment of opioid use disorder. We attributed a filled prescription within 3 days of the surgery to the physician by extracting the encrypted NPI on the pharmacy claim. We also used the pharmacy claim to identify the drug name, strength, number of tablets, and days supplied. We calculate morphine milligram equivalents (MME) per tablet based on conversion factors available from the Center for Medicare & Medicaid Services, which were used to calculate the total MME per prescription.

Outcomes

The goal of the study was to describe the prescription rate, defined as the percent of opioid naïve patients who filled an opioid prescription within 3 days of the knee arthroscopy, and the regional variation of the prescription rate across the U.S. states. Secondary outcomes of interest were the average quantity (in tablets) per prescription, and the total Morphine Milligram Equivalent (MME) of the prescription. To assess the geographic variation, we aggregated all opioid outcomes to the state level, resulting in average outcomes for each state. We also analyzed the primary and secondary outcomes by procedure type (invasive vs. non-invasive). Lastly, we utilized age, race, ethnicity, level of education, comorbidities, procedure, and state information to predict the probability of receiving an opioid prescription within 3 days using a logistic model to understand how observed vs. predicted prescribing patterns vary after adjusting for patient characteristics. We then estimated observed-to-expected state-level prescribing ratios with 95% confidence intervals, with values over 1 indicating patients in that state that were more likely to fill opioids than expected, and less than 1 indicating patients in states that were less likely to fill opioids than expected.

Results

During the study period 194,117 patients underwent knee arthroscopy. After exclusions, 84,043 opioid naïve patients were available for the final analysis (Figure 1) with 21,641 patients undergoing an invasive arthroscopic procedure involving drilling or cutting of bone and 62,402 patients who had a non-invasive arthroscopic procedure in which only soft tissue work was performed. Figure 1 displays that 75% of opioid naïve patients filled a prescription. The prescription rate was slightly higher for invasive vs. non-invasive procedures (82% vs. 73%). Compared to patients who did not fill an opioid prescription in Table 1, patients with an initial opioid prescription were more likely to be younger (45.3 years of age vs 53.0 years of age, p<0.001) and more predominately male (55.8% vs 54.0%, p<0.001). Those who filled an opioid prescription were more likely to be higher educated (have a bachelor's degree or more 23.9% vs 19.7%, p-value<0.001), were more likely to have household incomes above $100,000 (47.7% vs 41.3% p<0.001), were slightly more likely to be white (78.3% vs 76.3%p<0.001), and were more likely to have an invasive procedure relative to a non-invasive procedure (27.9% vs 19.1%, p<0.001**).** In terms of comorbidities, those who received an opioid prescription were more likely to have fewer comorbidities than those who did not receive an opioid (0.9 vs. 1.2 Elixhauser Index score).

Variation in Patient Level Opioid Prescribing

Patient variations were observed in opioid prescribing in terms of the number of tablets, the day's supply, and total MME for the 75% of patients who filled a prescription within 3 days of the index surgery (Figure 2). The median prescription was for 40 tablets (IQR 30-60), 300 MME (200-400), with a duration of 5 days (IQR 4-7) (Appendix Table 1). At the 90th percentile, a total of 5,341 patients filled a prescription with more than 60 tablets with a duration of at least 10 days and an MME of more than 563 MME.

Translating the dosage to MME per day suggests that the median patient received an average daily dosage of 60 MME, which is above the 50 MME level identified as increasing the risks for overdose death by the Center for Disease Control (CDC). In terms of differences in prescribing by procedure type, invasive procedures resulted in a slightly higher average quantity, MME, and day's supply than non-invasive procedures, however, these findings are not-statistically different from each other (Appendix Table 1 and Appendix Figure 1).

State Level Variation

State level variation in the percent of patients who filled an opioid prescription within 3 days of the index date was also observed (Figure 3). The observed prescription fill rate ranged from 41 percent in South Dakota to 87 percent in Nebraska (see also Appendix Table 2). Figure 3 also highlights states in red and blue that had statistically different observed prescribing rates either above or below the expected prescribing rate adjusted for case mix and covariates. Several states had observed prescribing rates well below the expected rate. South Dakota, North Dakota, West Virginia, and Minnesota had prescribing rates that were between 30 to 40 percent lower than expected based on patient characteristics. In contrast, Rhode Island, Iowa, Nebraska, and Massachusetts exhibited prescribing rates that were 10 percent higher than the expected rates. These results highlight significant variation in terms of prescribing even after adjusting for patient characteristics.

Little differences emerged in observed relative to expected in terms of MME and tablet count. The average tablet count for all states was 42.63 with a median of 42.80 (IQR=40.72 tablets to 45.01 tablets). Tablet count per prescription varied from 32.63 in Vermont to 49.17 in D.C. The average state level MME per prescription varied from 202 MME in Vermont to 457 MME in Alaska, with an average MME of 310 MME and a median MME of 304 MME (IQR = 283 MME to 326 MME) (Appendix Figures 2-4).

Discussion

In a sample of over 84,000 opioid naive commercially insured patients who underwent an outpatient knee arthroscopy between 2012 and 2015, we found high rates of opioid prescribing and large variation in patient and state level opioid prescribing rates, even after adjusting for key patient characteristics. Over 75% of patients filled an opioid prescription within 3 days of the surgery date, where the median patient received a 6-day supply, a median tablet count of 45 tablets, and a dosage of 325 MME. There was twofold state level variation prescribing between the highest prescribing rate (87% in Nebraska) compared to the state with the lowest prescribing rate (41% in South Dakota), and this variation persisted even after adjustment for patient characteristics.

The significant variation in prescribing rates and dosages indicates there is ample room to reduce prescribing as we do not expect the pathophysiology of pain to be markedly different across state lines for these common outpatient procedures. The observed dosage suggests that the median patient received an average daily dosage of 60 MME, which is above the 50 MME level identified as increasing the risks for overdose death by the Center for Disease Control.[29] Therefore, these prescribing levels may pose adverse health risks when alternative strategies may be equally effective for many patients.[30,31] Over 264,000 MME per day could have been prevented from being distributed if the MME level would not have exceeded the CDC's maximum recommended dosage of 50 MME per day. A growing general consensus outlines that prescriptions should not be written for more than 50 MME per day and no more than 6 days (i.e. 300 MME). Nevertheless, 50% of patients who filled a prescription received a dosage that is higher than the recommended threshold.[28]

Our results expand previous work by examining more broadly the prescribing patterns after minor surgeries among opioid naïve patients who are commercially insured. Using data from a national commercial insurer allowed us to investigate the prescribing rates among a younger population that has a documented higher risk of opioid dependence and misuse.[7,32,33] To date, the existing evidence has predominately focused on inpatient procedures among single institutions or has focused on specific groups such as the military population or the elderly.[5,13,34]

In terms of the existing literature evaluating opioid prescribing after surgical procedures, our results imply similarly high rates of prescribing compared to those reported for inpatient procedures. Opioid prescribing after orthopedic surgery is very common and orthopedic surgery has one of the highest frequency of opioid claims among Medicare patients. This highlights limitations in opioid prescribing guidelines for minor surgeries and our results suggest that opioids seem to be written independent of type of procedure and expected pain.[5] This is especially worrisome in a time of an ongoing opioid epidemic that highlights excessive opioid prescribing and that the use of any opioids increases the risk of long-term opioid use.[22] Therefore, guidelines and regulations for orthopedic opioid prescription limits can significantly reduce the number of excessive opioids written, and patients at risk of opioid addiction and misuse.[2,3] Our findings also imply that post-operative pain management relies heavily on opioids, while more conservative treatments may be possible, especially for less severe cases, though few guidelines exist.[30,31]

Our findings also have implications for policymakers. The evidence of wide variation in opioid prescribing across states suggests that these differences may reflect different regulatory environments, prescribing preferences and practice patterns of physicians. Thus, state specific guidelines, over national guidelines, seem to drive prescribing decisions of physicians. Implementation of Prescription Drug Monitoring Programs (PDMP) and prescribing limits may have contributed to the low levels of prescribing for some states, though many of were not in effect and mostly target non-opioid naïve populations. It also highlights that prescribing limits and other regulations remain an important tool to limit the supply of opioids and the risk of long-term opioid use among patients. Discussion regarding a 3-day supply limit highlights the continuously excessive level of prescribing without further guidance. In many cases, dispensed tablets are also not taken as prescribed resulting in large number of left over tablets, and increase the potential for diversion.[32,35,36] Thus, reducing the initial supply of opioids is also crucial to fight opioid diversion and the illegal use of opioids.

Our results also have implications for clinicians, surgeons and health systems. Despite existing efforts by state officials, a large number of physicians prescribe opioids with a duration of greater than 7 days. Thus, it is clinically relevant to not only reduce the number of tablets, which are commonly left over and are at risk of diversion, but also to address the issue of dosage. From the health system perspective, it seems promising to implement lower electronic default guidelines to a pre-specified acceptable quantity and dosage, which has recently been shown to reduce opioid prescribing.[37,38]

Future research should aim at understanding how many opioid tablets are actually needed to control pain and to optimize and guide prescribing levels that minimize the opportunity for left over opioids and subsequent opioid diversion. Studies are also needed to identify whether a MME threshold level exists that is associated with prolonged use and other long-term unintended health outcomes and consequences on overall patient-care needs.[24,25] Finally, understanding how state policies, guidelines, and culture contribute to the state-level variation in prescribing rates, particularly in low prescribing states is important in making appropriate recommendations for opioid prescribing. These factors could be translated to high prescribing states, reduce potentially excessive prescribing without harming patients.

Limitations

This study has several limitations. First, the study can only speak to filled prescriptions (not prescribed prescriptions) obtained within the population that generated an insurance bill, and cannot speak to the number of consumed tables, or measure opioid prescriptions obtained through other channels. We potentially underestimated the prescribing rate, as unfilled prescriptions and filled prescription paid out of pocket were not captured. Second, unmeasured differences between patients, such as access to different provider networks, co-payments and coinsurance may have contributed to the observable variation in opioid prescribing. Third, limitations in data do not allow us to decisively attribute patients to physicians. Excluding patients without a knee arthroscopy and an opioid prescription within a 3-day window should improve patient-physician match. Fourth, more recent data may have displayed lower prescribing rates given the extensive regulatory efforts to curb excessive prescribing, such as prescribing guidelines, and the large increase in illicit opioid use availability. [39-41] Lastly, our results are only generalizable to the general commercially insured opioid naïve population who received a knee arthroscopy, though our adjusted observed vs. expected prescribing rate has the potential for unobservable confounding to affect our estimates.

Conclusions

Our findings suggest that large variations in opioid prescribing among the opioid naïve exist and that the observed levels of prescribing can be described as excessive. While this is an important finding, excessive prescribing has additional long-term consequences for patient health. An important next step for future research is to understand how outpatient knee arthroscopies impact long-term opioid use, especially among the opioid naïve, whether the prescription level affects the probability of long-term use, and whether a prescription may impact the patient's general long-term healthcare utilization pattern, and long-term health.

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Competing Interests: All authors declare no conflicts of interest.

Contributions: BU and MKD conceived the study. YH acquired the data. BU and MKD conducted the analysis. MKD supervised the analysis. All authors interpreted the results. BU and MKD drafted the manuscript. All authors contributed to the critical revision of the manuscript. BU takes responsibility for the manuscript as a whole.

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Data Availability Statement: Data is not available due to data sharing restrictions. Data can be purchased from Optum (please visit the website for more information: https://www.optum.com/solutions/data-analytics.html). Statistical code available upon request.

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Figure 1 – Flowchart of Sample

Notes: Figure 1 displays the flowchart from the full sample that leads to our final sample after sample exclusion restrictions

Figure 2 – Details on the Prescriptions Filled within 3 Days of the Index Date

Notes: Figure 2 displays the distribution of the opioid fill for members who filled an opioid within 3 days of the index date for the quantity, MME, and days supply.

Figure 3 – Observed to Expected Opioid Prescribing Rate

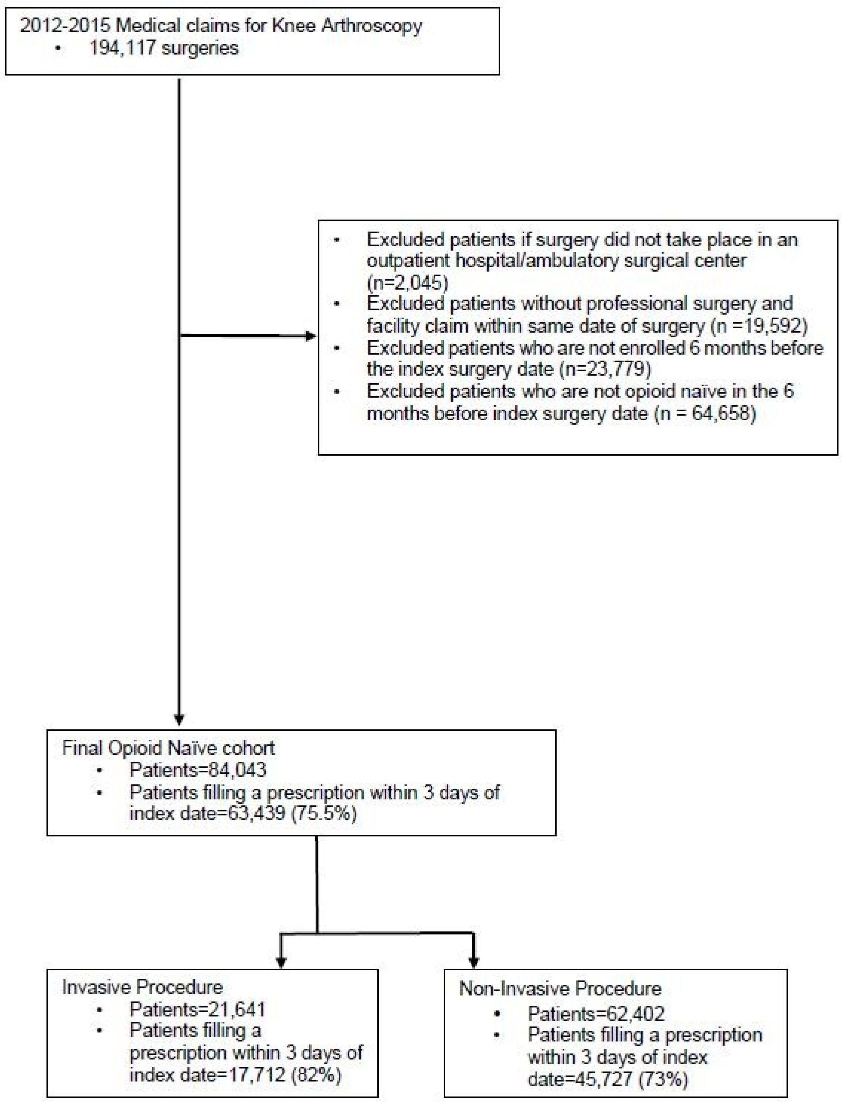
Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 75%. The observed prescribed rate is displayed within each state. States with higher-than-expected prescribing rates based on covariates are highlighted in red and those with lower-than-expected prescribing rates are shown in blue. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

Table 1 – Patient Characteristics Stratified by Filled Prescription within 3 Days of Surgery

Patient Characteristics	Opioid Naïve (n = 20,604)	Opioid Naïve and Opioid Prescription (n=63,439)	*P*
Age (Mean, SD)	53.03 (17.19)	45.29 (17.18)	<0.001
Gender			
Male	11119 (54.0%)	35402 (55.8%)	<0.001
Female	9478 (46.0%)	28031 (44.2%)	
Unknown	7 (0.0%)	6 (0.0%)	
Education level			<0.001
No High School Degree	32 (0.2%)	113 (0.2%)	
High School Degree	4651 (22.6%)	12740 (20.1%)	
Some College	11073 (53.7%)	34427 (54.3%)	
Bachelor's Degree or More	4051 (19.7%)	15160 (23.9%)	
Unknown	797 (3.9%)	999 (1.6%)	
Procedure Type			
Invasive	3929 (19.1%)	17712 (27.9%)	<0.001
HH Income			<0.001
Less than 40k HH Income	2404 (12.1%)	5273 (8.4%)	
40-49k HH Income	1197 (6.0%)	2951 (4.7%)	
50-59k HH Income	1284 (6.5%)	3393 (5.4%)	
60-74k HH Income	1945 (9.8%)	5692 (9.1%)	
75-99k HH Income	2958 (14.9%)	9139 (14.6%)	
100k and More	8196 (41.3%)	29849 (47.7%)	

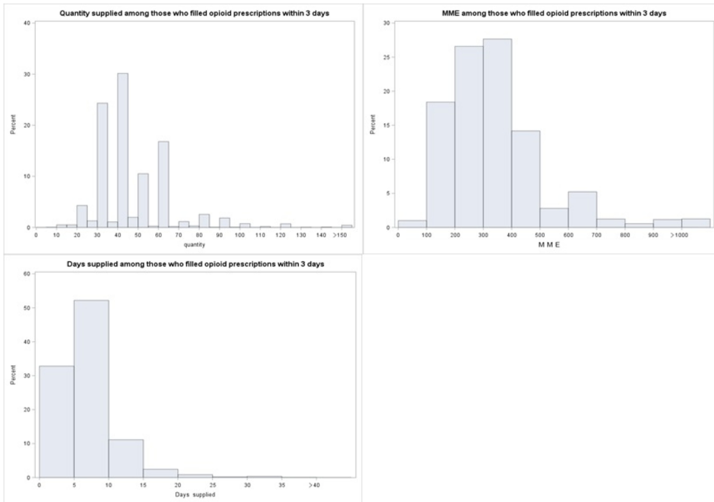
Unknown	1880 (9.5%)	6332 (10.1%)	
Ethnicity			<0.001
Asian	442 (2.1%)	1580 (2.5%)	
Black	1377 (6.7%)	4112 (6.5%)	
Hispanic	1550 (7.5%)	4925 (7.8%)	
White	15725 (76.3%)	49654 (78.3%)	
Unknown	1510 (7.3%)	3168 (5.0%)	
Comorbidity			
Mean No. of Elixhauser Comorbidities (SD)	1.24 (1.50%)	0.90 (1.26%)	<0.001
Hypertension (%)	7300 (35.4%)	15748 (24.8%)	<0.001
Chronic pulmonary disease (%)	2001 (9.7%)	5329 (8.4%)	<0.001
Depression (%)	1714 (8.3%)	4868 (7.7%)	0.003
Diabetes (%)	2258 (11.0%)	4771 (7.5%)	<0.001
Psychoses (%)	74 (0.4%)	156 (0.2%)	0.009
Alcohol abuse (%)	110 (0.5%)	346 (0.5%)	0.888
Drug abuse (%)	117 (0.6%)	239 (0.4%)	<0.001
Median No. Tablets (IQR)	-	40 (30 - 60)	
Days supplied, median (IQR)	-	5 (4 - 7)	
MME/prescription, mean (SD)	-	305.48 (189.01)	

Figure 1 – Flowchart of Sample



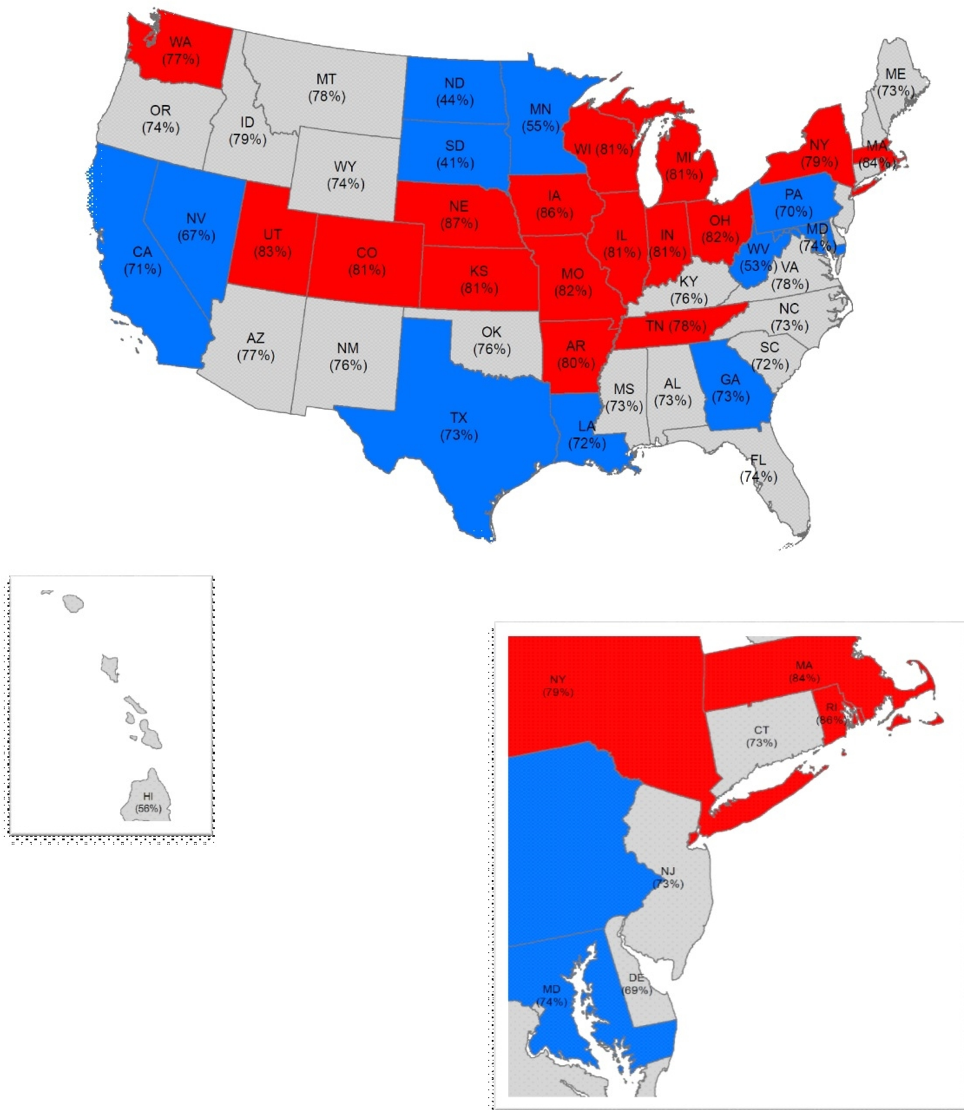
Notes: Figure 1 displays the flowchart from the full sample that leads to our final sample after sample exclusion restrictions

112x142mm (144 x 144 DPI)



Notes: Figure 2 displays the distribution of the opioid fill for members who filled an opioid within 3 days of the index date for the quantity, MME, and days supply.

203x114mm (144 x 144 DPI)



Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 75%. The observed prescribed rate is displayed within each state. States with higher-than-expected prescribing rates based on covariates are highlighted in red and those with lower-than-expected prescribing rates are shown in blue. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

203x232mm (144 x 144 DPI)

APPENDIX

Definition of new Arthroscopy by CPT code:

Arthroscopic procedures with significant bony work or expected increased pain (i.e. total synovectomy) involved: 29876, 29885, 29886, 29887, 29888, 29889

Arthroscopic procedures that do not involve significant bony work:

29870, 29871, 29873, 29874, 29875, 29877, 29879, 29880, 29881, 29882, 29883, 29884

Opioid classes identified in pharmacy claims and included: Codeine, Dihydrocodeine, Fentanyl, Hydrocodone, Hydromorphone, Meperidine, Morphine, Oxcyodone, Oxymorphone, Tapentadol, Tramadol

Appendix Table 1 – Opioid Prescribing Information for filled Prescription within 3 days of Surgery Date (N=63,439)

Quantity	Mean	Min	10%	Median	90%	95%	Max
Total	45.53 (25.31)	3	30	40 (IQR 30-60)	60	80	1500
Non-Invasive	42.96 (21.15)	21.15	3	15 (IQR 30-50)	20	30	30
Invasive	52.16 (32.82)	32.83	4	20 (IQR 40-60)	30	30	40

MME	Mean	Min	10%	Median	90%	95%	Max
Total	325.14 (221.87)	13.5	150	300 (IQR 200-400)	562.5	675	11250
Non-Invasive	293.71 (182.25)	182.25	13.5	90 (IQR 200-375)	125	150	200
Invasive	406.28 (285.37)	285.37	25	100 (IQR 225-450)	150	187.5	225

Days Supply	Mean	Min	10%	Median	90%	95%	Max
Total	6.13 (3.66)	1	3	5 (IQR 4-7)	10	13	40
Non-Invasive	5.81 (3.36)	3.37	1	2 (IQR 4-7)	3	3	4
Invasive	6.99 (4.30)	4.30	1	2 (IQR 5-8)	3	3	5

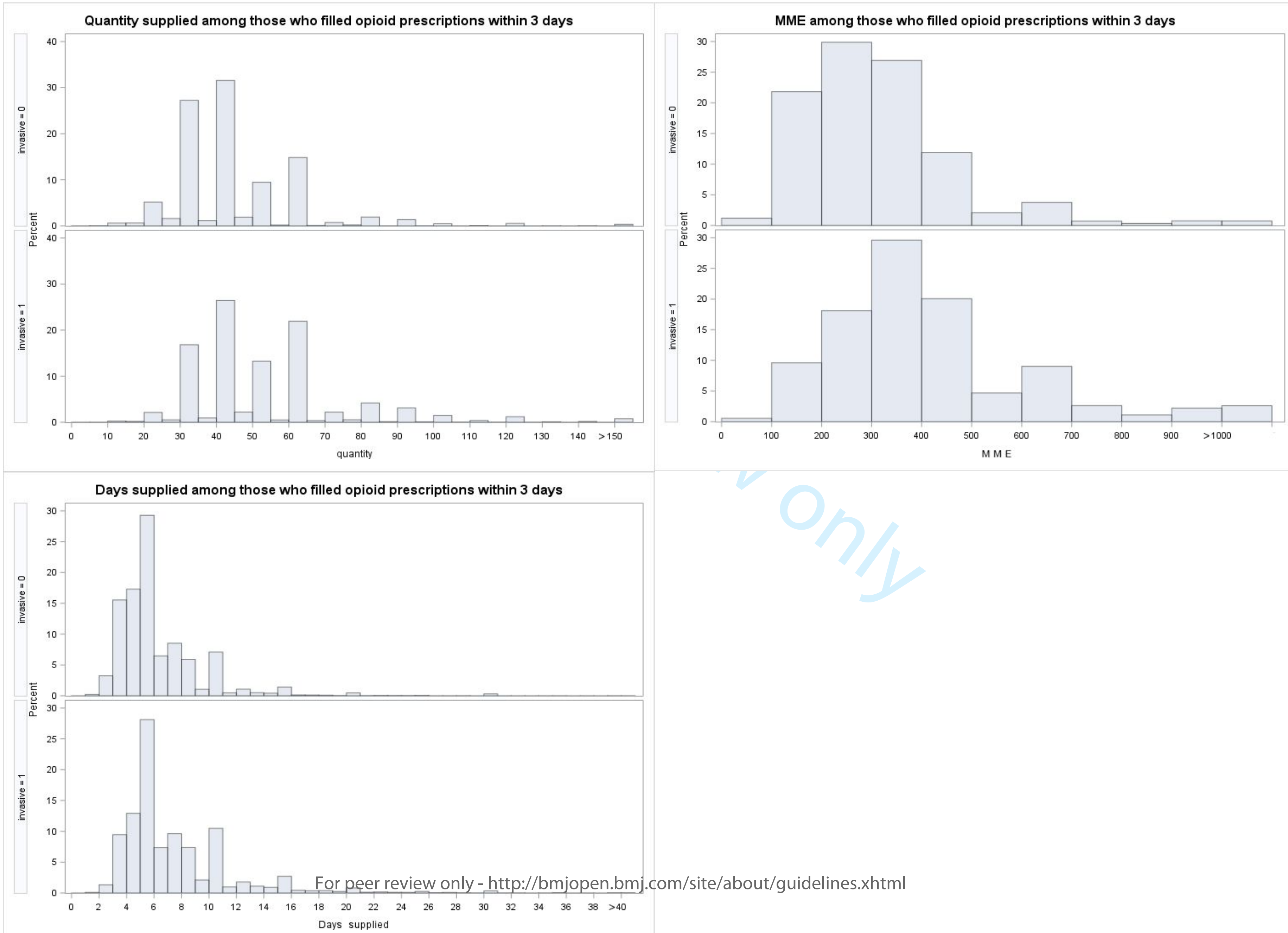
Notes: Mean opioid prescribing information for quantity, MME, and days supply are displayed for those members who filled an opioid within 3 days.. Information on the minimum, medium, maximum, and the 10, 90, and 95 percentile are also reported.

Appendix Table 2 – Average Observed Prescribing Rates, Quantity, and MME by State

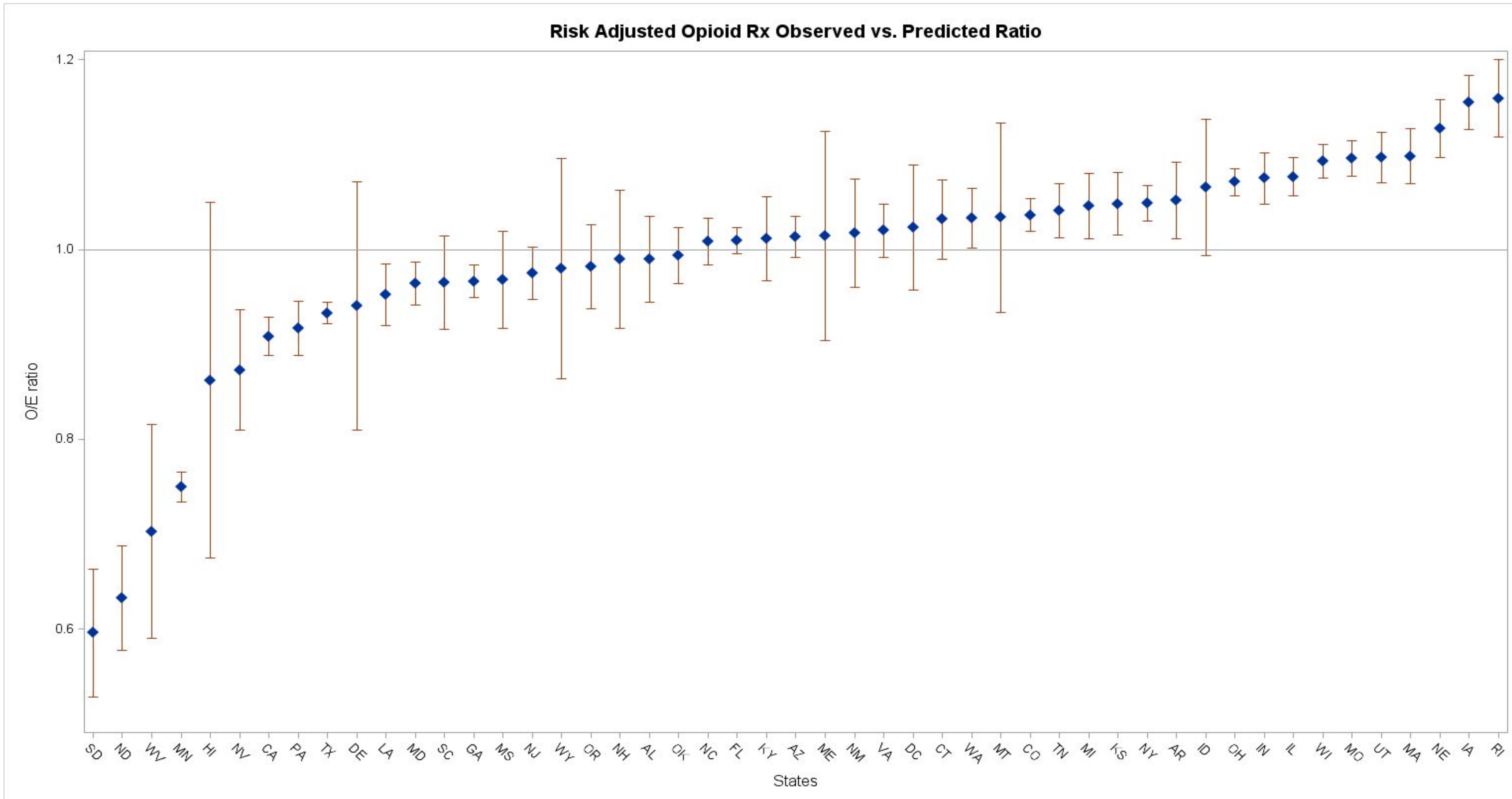
State	Prescribing Rate	Tablets	MME
Alaska	0.52	47.06	457.94
Alabama	0.73	39.88	326.81
Arkansas	0.80	39.37	318.40
Arizona	0.77	42.30	293.89
California	0.71	46.54	349.71
Colorado	0.81	39.27	282.30
Connecticut	0.73	35.56	256.02
D.C.	0.81	49.17	384.64
Delaware	0.69	47.10	319.15
Florida	0.74	43.25	315.58
Georgia	0.73	41.26	325.12
Hawaii	0.56	35.97	210.16
Iowa	0.86	40.85	279.07
Idaho	0.79	46.66	409.32
Illinois	0.81	41.34	276.02
Indiana	0.81	45.01	301.75
Kansas	0.81	44.33	320.70
Kentucky	0.76	46.40	360.57
Louisiana	0.72	41.53	350.16
Massachusetts	0.84	44.17	302.66
Maryland	0.74	42.60	304.63
Maine	0.73	40.59	258.13
Michigan	0.81	45.02	304.58
Minnesota	0.55	39.88	259.07
Missouri	0.82	44.73	291.65
Mississippi	0.73	37.05	307.16
Montana	0.78	41.89	294.48
North Carolina	0.73	46.14	343.04
North Dakota	0.44	37.84	269.32
Nebraska	0.87	44.04	297.32
New Hampshire	0.74	38.08	260.10
New Jersey	0.73	37.57	273.93
New Mexico	0.76	42.24	303.73
Nevada	0.67	49.37	389.56
New York	0.79	44.80	308.36
Ohio	0.82	46.23	301.26
Oklahoma	0.76	44.78	378.17
Oregon	0.74	45.35	329.20
Pennsylvania	0.70	42.40	289.84
Rhode Island	0.86	42.19	291.07

South Carolina	0.72	45.53	373.65
South Dakota	0.41	43.77	263.02
Tennessee	0.78	38.76	315.16
Texas	0.73	42.80	317.44
Utah	0.83	42.50	351.69
Virginia	0.78	43.05	304.13
Vermont	0.77	32.63	202.68
Washington	0.77	43.74	308.70
Wisconsin	0.81	42.94	284.22
West Virginia	0.53	42.40	282.45
Wyoming	0.74	46.33	316.12

Appendix Figure 1 – Distribution on the Filled Prescriptions within 3 Days of the Index Date by Invasive vs. Non-invasive Procedure

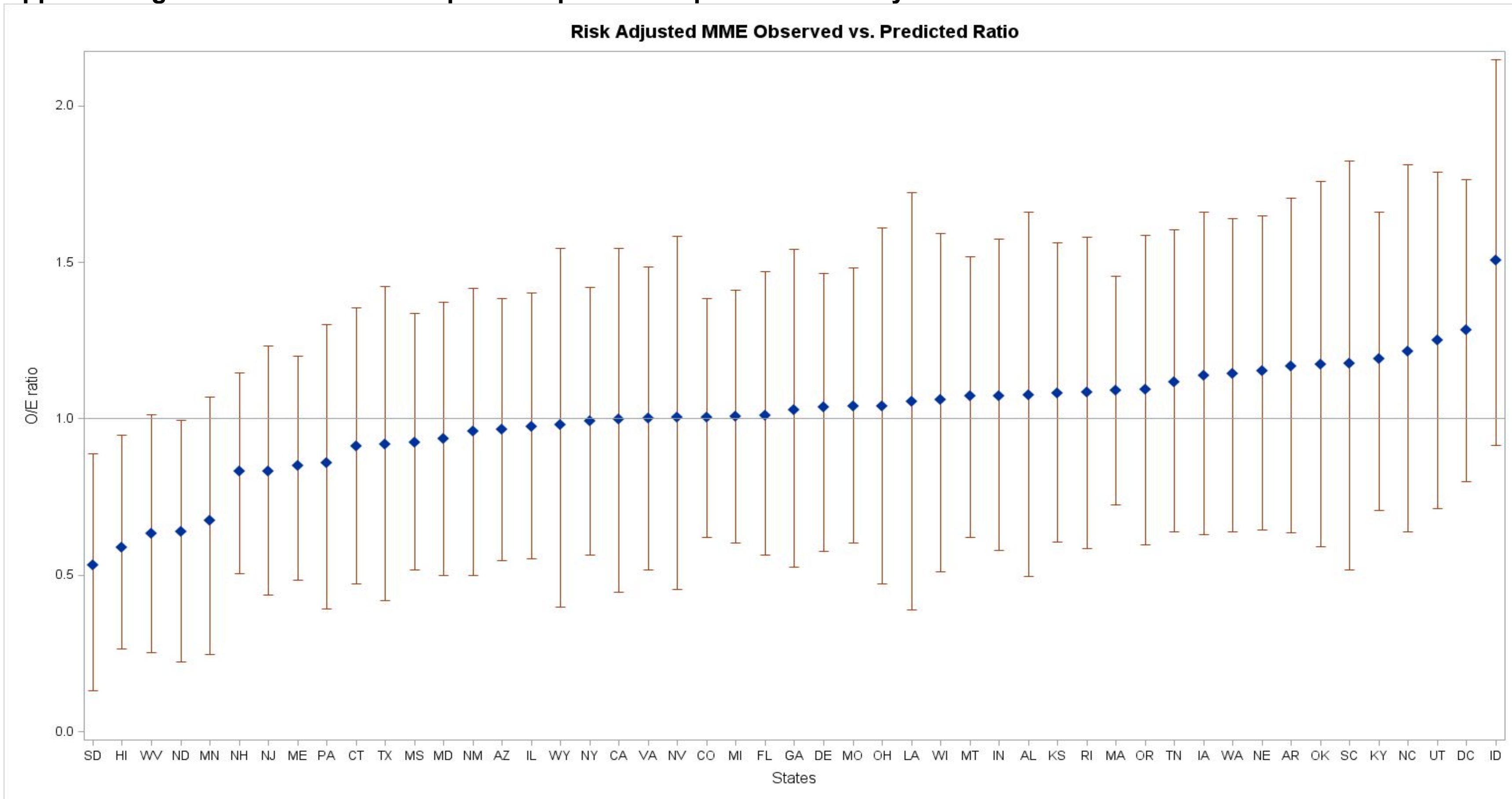


Appendix Figure 2 – Observed to Expected Opioid Prescribing Rate by State



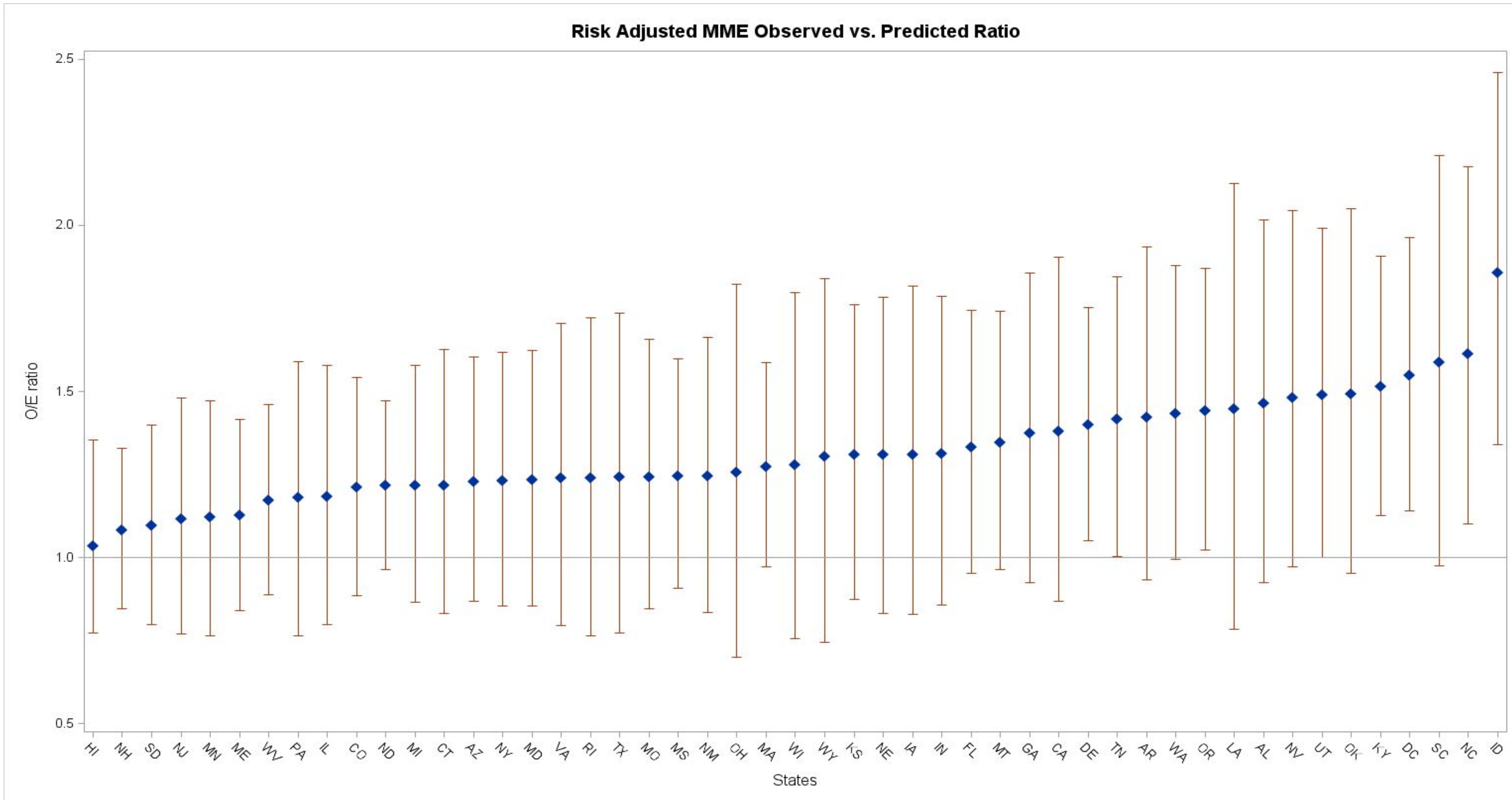
Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 75%. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

Appendix Figure 3 – Observed to Expected Opioid MME per Encounter by State



Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 75%. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

Appendix Figure 4 – Observed to Expected Opioid MME per Prescription by State



Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 75%. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*5-6*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	5-6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	16
		(c) Consider use of a flow diagram	16
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	16
Outcome data	15*	Report numbers of outcome events or summary measures	5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	7-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

State Level Variation in Opioid Prescribing after Knee Arthroscopy among the Opioid-Naïve in the United States: 2015-2019

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State Level Variation in Opioid Prescribing after Knee Arthroscopy among the Opioid-Naïve in the United States: 2015-2019

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Word Count: 2,687

Objective It has been established that most patients prescribed opioids after minor surgery have tablets left over, better understanding the variation in opioid prescribing and variation in dosage of the prescription could guide efforts to reduce prescribing. This study describes the state level variation in opioid prescribing after a knee arthroscopy among opioid naïve patients.

Design Retrospective cohort study.

Setting: Commercial insurance claims data.

Participants: 98,623 individual across the USA with commercial insurance who were opioid naïve and had a knee arthroscopy between 2015 and 2019.

Exposure: Patients who filled an opioid prescription within 3 days of a knee arthroscopy.

Outcome measures: Opioid prescriptions were measured as a pharmacy claim for filling an opioid within 3 days of a knee arthroscopy. We measured the patient and state level opioid prescribing rate, tablet count, morphine milligram equivalent dose per prescription, and risk-adjusted predicted opioid quantity.

Results Overall, 72% of patients filled an opioid prescription with a median tablet count of 40 and median morphine milligram equivalent of 250. Patients with an invasive procedure (27.9% vs 22.4%; p<0.001), higher education level (p<0.001), and fewer comorbidities (0.9 vs 1.2, p<0.001) had higher rates of opioid prescribing. The prescribing rate in the highest state, Nebraska (85%), was double the prescribing rate in the lowest state, South Dakota (40%). Comparing the case mix adjusted expected prescribing rate to the observed prescribing rate displayed that 18 states had observed prescribing rates that were higher than their expected prescribing rates.

Conclusion Wide variation in the likelihood of receiving a prescription, depending on state of residence, was observed. The dosages prescribed were high and have been associated with transition to long-term use. These findings suggest there is substantial opportunity for the development of guidelines to reduce variability in opioid prescribing for this common ambulatory procedure.

Article Summary (Strengths and limitations of this study):

- This is among the first studies to demonstrate the degree of state-level variation in opioid prescribing rates for a common minor surgical procedure. This provides a clearer view of the degree to which prescribing rates can be reduced given that surgical approaches and pain response is not expected to dramatically vary by state.
- Another strength is the adjustment for demographic and clinical characteristics to account for differences in case-mix across states.
- Our study is a claims-based study does not capture prescriptions that were made but not filled by patients or prescriptions that were paid out of pocket. Furthermore, the demographic and clinical characteristics we could assess are limited.

Introduction

Between 1999 and 2016 opioid prescribing quadrupled to over 259 million prescriptions per year. Opioid related deaths are the leading cause of unintentional death in the United States responsible for at least 47,000 fatalities in 2018.[1] For many procedures opioid analgesics have become the default standard of care for post-operative pain management and are the leading exposure of patients' to opioid prescriptions, particularly among the opioid-naïve, even after low-risk surgical procedures.[2-5] This can be problematic because a single prescription and higher dosage prescriptions have been associated with prolonged opioid use.[6-14] Furthermore, 50-70% of opioid tablets prescribed are never taken posing the risk of misuse and diversion.[15]

Surgical societies have called for more judicious opioid prescribing and have promoted the concept of "opioid stewardship" in post-operative pain.[16-18] As with longstanding efforts to promote antibiotic stewardship, the first step in establishing post-operative opioid stewardship initiatives is to establish baseline use, duration, and variation by procedure and indication.[19] Even though the national levels of prescribing are well documented, limited attention has been given to the regional variation in opioid prescribing for opioid naïve patients after common outpatient surgeries.[4,20-22] Orthopedic arthroscopic procedures account for 2 of the top 3 most common outpatient surgical procedures performed in the U.S., yet there is a dearth of literature benchmarking opioid prescribing rates and dosages for these procedures.[23-25] Knee arthroscopy is the most common outpatient orthopedic procedure in the U.S., with approximately 1 million procedures per year.[26,27] A new report from National Academies of Sciences, Engineering, and Medicine highlight knee arthroscopy as a priority indication for establishing evidence-based opioid prescribing guidelines.[28] Establishing the baseline variation in opioid prescribing after knee arthroscopy is a critical knowledge gap to fill to establish quality improvement targets. Prescribing targets are essential in reducing prescribing with a large potential public health impact given the volume of this procedure and current lack of consensus for this procedure on post-operative opioid use.

The goal of our study was to describe the patient and state level variation in post-operative opioid prescribing rates and dosages for opioid naïve patients after a knee arthroscopy in the United States (U.S.). Our investigation focused on the prescribing practices among the commercially insured, a relatively unexplored group of individuals in terms of opioid prescribing, but the one with the highest risk of opioid use and abuse.[7] We hypothesized that there would be substantial variation in the state and patient level prescribing rates and dosages, even after accounting for patient characteristics.

Methods

We used the Clinformatics Data Mart Database (OptumInsight) from January 2015 through June 2019, which comprises commercial insurance claims from a large national U.S. private health insurer covering 7.5 million lives annually represented in every state. We defined an index knee arthroscopy encounter as the earliest visit in which a beneficiary had a knee arthroscopy provider medical claim.[29]

We focused our analysis on opioid-naïve patients and excluded any patients who filled an opioid prescription within the six months preceding the index surgery date. We also excluded patients who did not receive the knee arthroscopy in the outpatient hospital or ambulatory surgical center setting to retain a more homogenous sample. Patients who did not have medical claims for the surgery and the operational facility charge on the same day or the day after were also excluded to mitigate concerns regarding the day of the actual surgery. Lastly, we excluded patients who had multiple knee arthroscopy surgeries to reduce the confounding effect of reoperation on the probability that opioid prescriptions were associated with additional surgeries.

We collected patient demographic information on age, gender, education, household income, ethnicity, and the state where the surgery was performed. We identified the patients' Elixhauser comorbidities, as well as diagnosis codes for drug abuse, alcohol abuse, depression, and psychoses from any medical claims filed in the previous six months. We also used Current Procedural Technology (CPT) codes to classify knee arthroscopy procedures based on involvement of bone (invasive, such as anterior cruciate ligament repair) vs. soft tissue only (non-invasive, such as simple knee arthroscopy) (See Appendix for a description).

No Patient and Public Involvement

This research was done without patient involvement. Patients were not invited to comment on the study design and were not consulted to develop patient relevant outcomes or interpret the results. Patients were not invited to contribute to the writing or editing of this document for readability or accuracy.

Definition of Opioid Prescription

We identified prescription claims based on the pharmacy claims and identified opioids according to National Drug Codes (excluding methadone and non-tablet formulations) filled within 3 days of the index visit. See Appendix for a description of included opioids. We excluded opioids primarily used for treatment of opioid use disorder. We attributed a filled prescription within 3 days of the surgery to the physician by extracting the encrypted NPI on the pharmacy claim. We also used the pharmacy claim to identify the drug name, strength, number of tablets, and days supplied. We calculate morphine milligram equivalents (MME) per tablet based on conversion factors available from the Center for Medicare & Medicaid Services, which were used to calculate the total MME per prescription.

Outcomes

The goal of the study was to describe the prescription rate, defined as the percent of opioid naïve patients who filled an opioid prescription within 3 days of the knee arthroscopy, and the regional variation of the prescription rate across the U.S. states. Secondary outcomes of interest were the average quantity (in tablets) per prescription, and the total Morphine Milligram Equivalent (MME) of the prescription. To assess the geographic variation, we aggregated all opioid outcomes to the state level, resulting in average outcomes for each state. We also analyzed the primary and secondary outcomes by procedure type (invasive vs. non-invasive). Lastly, we utilized age, race, ethnicity, level of education, comorbidities, procedure, and state information to predict the probability of receiving an opioid prescription within 3 days using a logistic regression model to understand how observed vs. predicted prescribing patterns vary after adjusting for patient characteristics. We then follow previously established methods by Delgado et al. and estimated observed-to-expected state-level prescribing ratios with 95% confidence intervals, with values over 1 indicating patients in that state that were more likely to fill opioids than expected, and less than 1 indicating patients in states that were less likely to fill opioids than expected.[14]

Results

During the study period 225,277 patients underwent knee arthroscopy. After exclusions, 98,623 opioid naïve patients were available for the final analysis (Figure 1) with 26,011 patients undergoing an invasive arthroscopic procedure involving drilling or cutting of bone and 72,612 patients who had a non-invasive arthroscopic procedure in which only soft tissue work was performed. Figure 1 displays that 72% of opioid naïve patients filled a prescription. The prescription rate was only slightly higher for invasive vs. non-invasive procedures (76% vs. 71%). Compared to patients who did not fill an opioid prescription in Table 1, patients with an initial opioid prescription were more likely to be younger (46.7 years of age vs 52.3 years of age, p<0.001) and more predominately male (54.4% vs 53.0%, p<0.001). Those who filled an opioid prescription were more likely to be higher educated (have a bachelor's degree or more 23.4% vs 21.6%, p-value<0.001), were more likely to have household incomes above $100,000 (41.3% vs 38.4% p<0.001), were slightly more likely to be white (73.2% vs 71.9%p<0.001), and were more likely to have an invasive procedure relative to a non-invasive procedure (27.9% vs 22.4%, $p<0.001$**).** In terms of comorbidities, those who received an opioid prescription were more likely to have fewer comorbidities than those who did not receive an opioid (0.9 vs. 1.2 Elixhauser Index score).

Patient Level Variation in Dosages of Opioid Prescriptions

We observed wide variation in opioid prescribing in terms of the number of tablets, the day's supply, and total MME for the 72% of patients who filled a prescription within 3 days of the index surgery (Figure 2). The median prescription was for 40 tablets (IQR 30-50), 250 MME (150-375), with a median duration of 5 days (IQR 4-7) (Appendix Table 1). At the 90th percentile, a total of 4,789 patients filled a prescription with more than 60 tablets with a duration of at least 13 days and an MME of more than 733 MME.

Translating the dosage to MME per day suggests that the median patient received an average daily dosage of 50 MME, which is the same as the 50 MME level identified as increasing the risks for overdose death by the Center for Disease Control (CDC).[30] In terms of differences in prescribing by procedure type, invasive procedures resulted in a slightly higher average quantity, MME, and day's supply than non-invasive procedures, however, these findings are not-statistically different from each other (Appendix Table 1 and Appendix Figure 1).

State Level Variation in Opioid Prescribing Rates and Dosages

We also observed wide variation in the state level in the proportion of patients who filled an opioid prescription within 3 days of the index date was also observed (Figure 3). The observed prescription fill rate ranged from 40 percent in South Dakota to 85 percent in Nebraska (see also Appendix Table 2). Figure 3 also highlights states that had statistically different observed prescribing rates either above (shown in red)or below the expected prescribing rate (blue) adjusted for case mix and covariates. Several states had observed prescribing rates well below the expected rate. North Dakota, South Dakota, Nevada, Kentucky, and West Virginia, had prescribing rates that were between 20 to 40 percent lower than expected based on patient characteristics. In contrast, Alabama, Rhode Island, Utah, and Nebraska exhibited prescribing rates that were 10 percent higher than the expected rates. Overall, 18 states had prescribing rates that were higher than expected based on patient case mix (Appendix Figures 2-4). These results highlight significant variation in terms of prescribing even after adjusting for patient characteristics.

While we found variation in observed to expected opioid prescription dosages at the state level, it was less dramatic than the variation in the prescription rate. The median tablet count for all states was 40 (IQR=36-42 tablets). Tablet count per prescription varied from 24.1 in Vermont to 44.9 in Oklahoma. The median state level MME was 277 MME (IQR = 245 MME to 300 MME) per prescription and varied from 157 MME in Vermont to 371 MME in Oklahoma (Appendix Table 2).

Discussion

In a U.S. sample of over 98,000 opioid naive commercially insured patients who underwent an outpatient knee arthroscopy between 2015 and 2019, we found high rates of opioid prescribing and large variation in patient and state level opioid prescribing rates, even after adjusting for key patient characteristics. Over 72% of patients filled an opioid prescription within 3 days of the surgery date, where the median patient received a 5-day supply, a median tablet count of 40 tablets, and a dosage of 250 MME. There was twofold state level variation prescribing between the highest prescribing rate (85% in Nebraska) compared to the state with the lowest prescribing rate (40% in South Dakota), and this variation persisted even after adjustment for patient characteristics.

The significant variation in prescribing rates and dosages indicates there could be ample room to reduce variation in prescribing as we do not expect the pathophysiology of pain to be markedly different across state lines for these common outpatient procedures. The observed dosage suggests that the median patient received an average daily dosage of 50 MME, which is equal to the 50 MME level identified as increasing the risks for overdose death by the Center for Disease Control.[30] Nevertheless, these prescribing levels may pose adverse health risks when alternative strategies may be equally effective for many patients.[31,32] Over 5 million MME could have been prevented from being distributed if the MME level would not have exceeded the median total MME dosage in each year (Appendix Table 3). A growing general consensus outlines that prescriptions should not be written for more than 50 MME per day and no more than 6 days (i.e. 300 MME).[30] Nevertheless, 36% of patients who filled a prescription received a dosage that is higher than the recommended threshold.

Our results expand previous work by examining more broadly the prescribing patterns after minor surgeries among opioid naïve patients who are commercially insured. Using data from a national commercial insurer allowed us to investigate the prescribing rates among a younger population that has a documented higher risk of opioid dependence and misuse.[7,33,34] To date, the existing evidence has predominately focused on inpatient procedures among single institutions or has focused on specific groups such as the military population or the elderly.[5,13,35]

In terms of the existing literature evaluating opioid prescribing after surgical procedures, our results imply similarly high rates of prescribing compared to those reported for inpatient procedures. Opioid prescribing after orthopedic surgery is very common and orthopedic surgery has one of the highest frequency of opioid claims among Medicare patients.[3] Our results mirror prior studies suggesting that post-operative opioids continue to be prescribed at high amounts independent of type of procedure and expected pain intensity and duration.[5] This is an opportunity for improvement given that excessive opioid prescribing among the opioid-naïve is associated with the risk of long-term opioid use[22] and left over tablets can be diverted and misused.[33,36,37]

Our findings demonstrate that post-operative knee arthroscopy pain management relies heavily on opioids, while more conservative treatments may be sufficient, especially for less severe cases, though few guidelines exist.[30,31] The National Academies of the Sciences, Engineering, and Medicine highlighted knee arthroscopy as a high priority procedure that would benefit from evidence based guidelines for post-operative opioid prescribing.[28] Orthopedic specific opioid prescribing guidelines could have a significant impact on reducing excessive variation in prescribing and reducing risks of long term use and misuse.[2,3] Health systems could implement lower electronic default opioid dosage based on these guidelines. These strategy has been shown to reduce opioid prescribing while still preserving clinician autonomy.[38,39]

Future research should aim at understanding how many opioid tablets are actually needed to control pain after knee arthroscopy and to optimize and guide prescribing levels that minimize the opportunity for left over opioids and subsequent opioid diversion. Studies are also needed to identify whether there is a dosage threshold level that is associated with prolonged use and other long-term unintended health outcomes and consequences on overall patient-care needs.[24,25]

From a policy research perspective it is critical to understand how differences in state opioid prescribing limits, policies on mandated Prescription Drug Monitoring Program (PDMP) use, guidelines, and culture contribute to the state-level variation in prescribing rates and dosages and associated downstream and local health outcomes. Insights gleaned from lower prescribing states could be applied to help reduce variation in higher prescribing states with the potential to safely reduce excessive prescribing.

Limitations

This study has several limitations. First, we were only able to measure filled prescriptions (not prescribed prescriptions) obtained within the population that generated an insurance bill, and cannot speak to the number of consumed tablets, or measure opioid prescriptions obtained through other channels. We potentially underestimated the prescribing rate, as unfilled prescriptions and filled prescription paid out of pocket were not captured. Second, unmeasured differences between patients, such as access to different provider networks, co-payments and coinsurance may have contributed to the observable variation in opioid prescribing. Third, limitations in data do not allow us to decisively attribute patients to physicians. Excluding patients without a knee arthroscopy and an opioid prescription within a 3-day window should improve patient-physician match. Fourth, we cannot make any statements regarding how state policies may have already reduced prescribing, such as prescribing guidelines, or how effective policies may be. [40-42] Lastly, our results are only generalizable to the general commercially insured opioid naïve population who received a knee arthroscopy.

Conclusions

Our findings using U.S. data from 2015-2019 suggest there is still wide patient and state level variation in post-operative opioid prescribing for opioid naïve patients undergoing knee arthroscopy. This suggests substantial opportunities to reduce practice variation with the development and implementation of knee arthroscopy specific opioid prescribing guidelines. Development of such guidelines is urgently needed because of the potential health consequences associated with the current dosages being prescribed.

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Competing Interests: All authors declare no conflicts of interest.

Contributions: BU and MKD conceived the study. YH acquired the data. BU and MKD conducted the analysis. MKD supervised the analysis. All authors (BU, YH,BS, and MKD) interpreted the results. BU and MKD drafted the manuscript. All authors (BU, YH,BS, and MKD) contributed to the critical revision of the manuscript. BU takes responsibility for the manuscript as a whole.

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Data Availability Statement: Data is not available due to data sharing restrictions. Data can be purchased from Optum (please visit the website for more information: https://www.optum.com/solutions/data-analytics.html). Statistical code available upon request.

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Figure 1 – Flowchart of Sample

Notes: Figure 1 displays the flowchart from the full sample that leads to our final sample after sample exclusion restrictions

Figure 2 – Details on the Prescriptions Filled within 3 Days of the Index Date

Notes: Figure 2 displays the distribution of the opioid fill for members who filled an opioid within 3 days of the index date for the quantity, MME, and days supply.

Figure 3 – Observed to Expected Opioid Prescribing Rate

Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 72%. The observed prescribed rate is displayed within each state. States with higher-than-expected prescribing rates based on covariates are highlighted in red and those with lower-than-expected prescribing rates are shown in blue. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

Table 1 – Patient Characteristics Stratified by Filled Prescription within 3 Days of Surgery

Patient Characteristics	**Opioid Naïve (n = 27,433)**	**Opioid Naïve and Opioid Prescription (n=71.190)**	***P***
Age (Mean, SD)	52.28 (18.82	46.71 (17.77)	<0.001
Gender			
Male	12894 (47.0%)	32445 (45.6%)	<0.001
Female	14537 (53.0%)	38741 (54.4%)	
Unknown	2 (0.0%)	4 (0.0%)	
Education level			<0.001
No High School Degree	46 (0.2%)	120 (0.2%)	
High School Degree	5208 (19.0%)	12934 (18.2%)	
Some College	14011 (51.1%)	36685 (51.5%)	
Bachelor's Degree or More	5915 (21.6%)	16680 (23.4%)	
Unknown	87 (0.3%)	223 (0.3%)	
Procedure Type			
Invasive	6135 (22.4%)	19876 (27.9%)	<0.001
HH Income			<0.001
Less than 40k HH Income	2699 (9.8%)	6536 (9.2%)	
40-49k HH Income	1077 (3.9%)	2766 (3.9%)	
50-59k HH Income	1367 (5.0%)	3186 (4.5%)	
60-74k HH Income	2155 (7.9%)	5104 (7.2%)	
75-99k HH Income	3874 (14.1%)	9487(13.3%)	
100k and More	10528 (38.4%)	29415 (41.3%)	

Unknown	2166 (13.0%)	4548 (14.3%)	
Ethnicity			<0.001
Asian	559 (2.0%)	1738 (2.4%)	
Black	1650 (6.0%)	4303 (6.0%)	
Hispanic	2306 (8.4%)	5797 (8.1%)	
White	19714 (71.9%)	52106 (73.2%)	
Unknown	3204 (11.7%)	7246 (10.2%)	
Comorbidity			
Mean No. of Elixhauser Comorbidities (SD)	1.20 (1.59)	0.91 (1.35)	<0.001
Hypertension (%)	8708 (31.7%)	17165 (24.1%)	<0.001
Chronic pulmonary disease (%)	161(0.6%)	278 (0.4%)	<0.001
Depression (%)	2181 (8.0%)	5268 (7.4%)	0.003
Diabetes (%)	1199 (4.4%)	2285 (3.2%)	<0.001
Psychoses (%)	65 (0.2%)	117 (0.2%)	0.009
Alcohol abuse (%)	187 (0.7%)	436 (0.6%)	0.888
Drug abuse (%)	207 (0.8%)	300 (0.4%)	<0.001
Median No. Tablets (IQR)	-	40 (30 - 50)	
Days supplied, median (IQR)	-	5 (4 - 7)	
MME/prescription, median (IQR)	-	250 (150-375)	

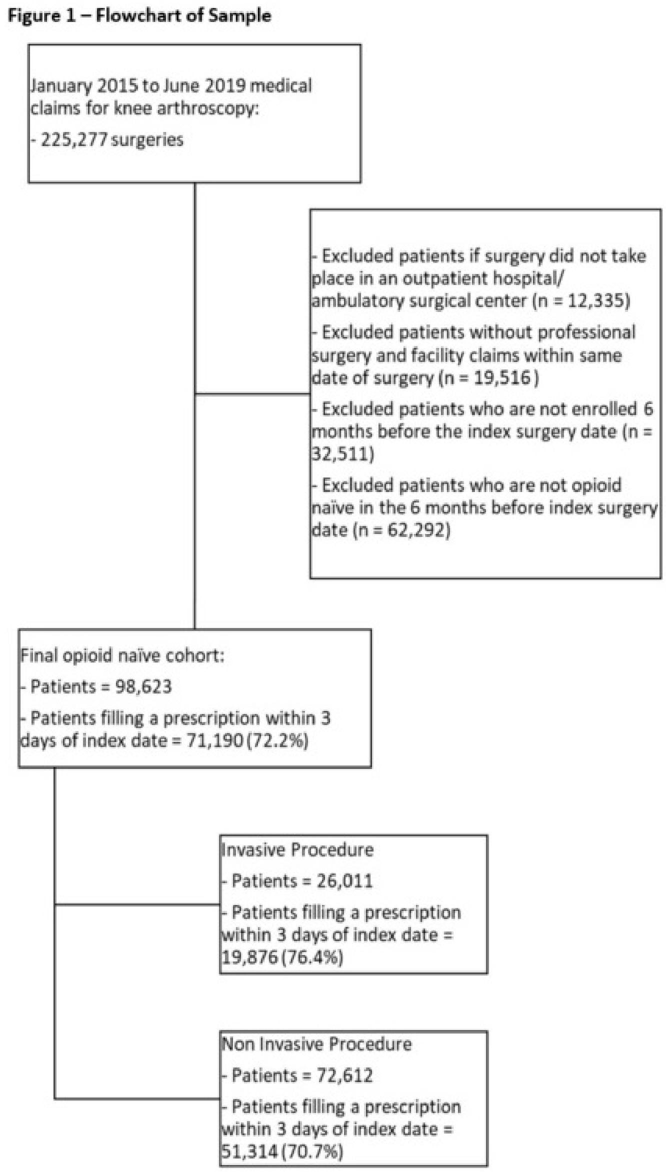

Figure 1

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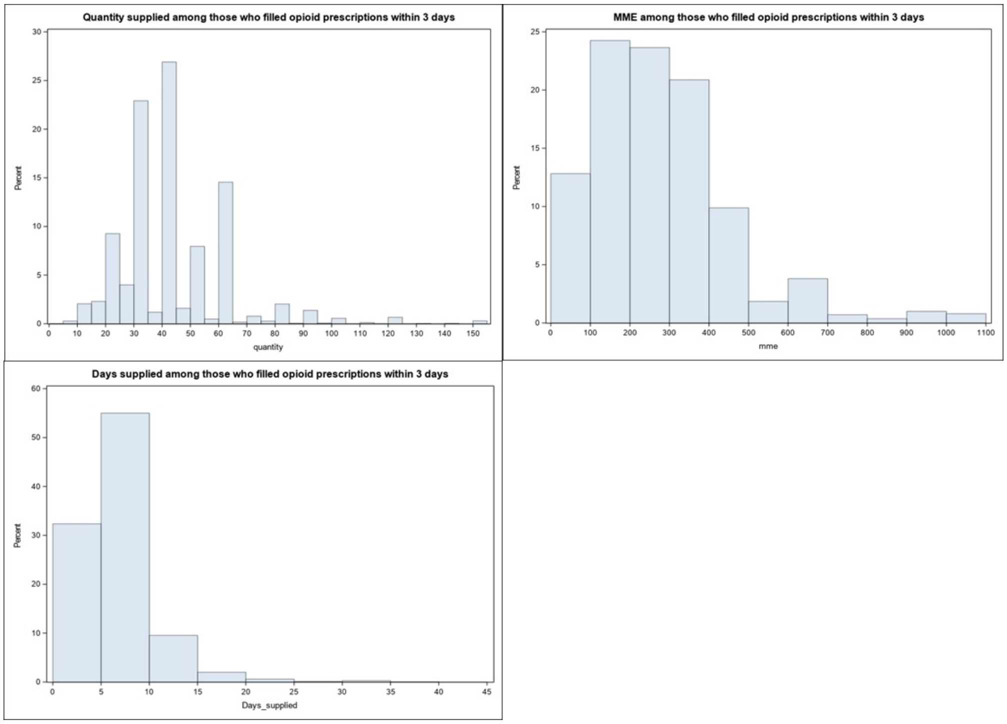

Figure 1

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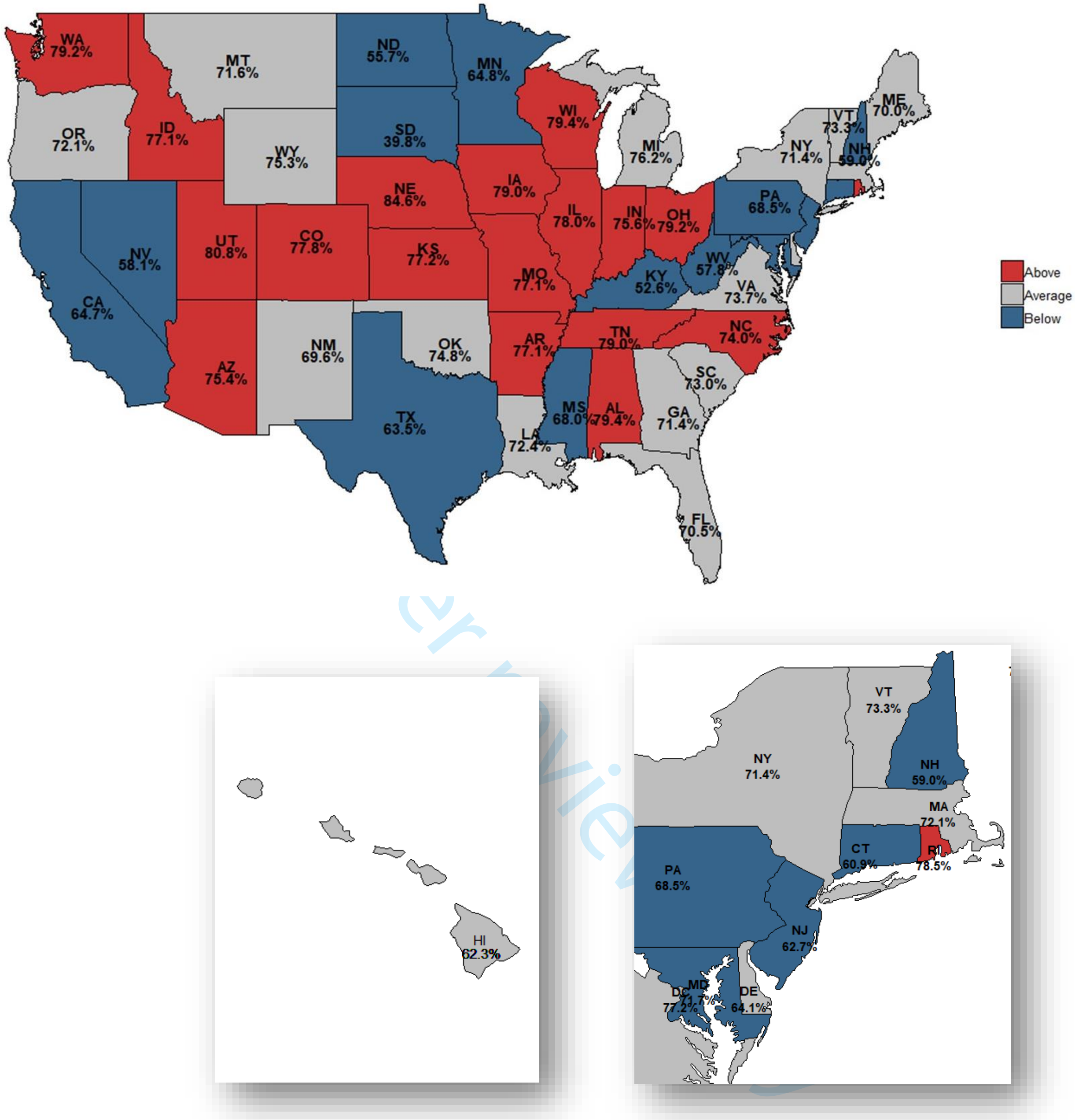

WA 79.2%
MT 71.6%
ND 55.7%
MN 64.8%
OR 72.1%
ID 77.1%
WY 75.3%
SD 39.8%
WI 79.4%
MI 76.2%
ME 70.0%
VT 73.3%
NY 71.4%
NH 59.0%
IA 79.0%
NE 84.6%
IL 78.0%
IN 75.6%
OH 79.2%
PA 68.5%
NV 58.1%
UT 80.8%
CO 77.8%
KS 77.2%
MO 77.1%
KY 52.6%
WV 57.8%
VA 73.7%
CA 64.7%
NM 69.6%
OK 74.8%
AR 77.1%
TN 79.0%
NC 74.0%
AZ 75.4%
SC 73.0%
TX 63.5%
MS 68.0%
AL 79.4%
GA 71.4%
LA 72.4%
FL 70.5%
Above
Average
Below
HI 62.3%
VT 73.3%
NY 71.4%
NH 59.0%
MA 72.1%
CT 60.9%
RI 78.5%
PA 68.5%
NJ 62.7%
DE 64.1%

APPENDIX

Definition of new Arthroscopy by CPT code:

Arthroscopic procedures with significant bony work or expected increased pain (i.e. total synovectomy) involved: 29876, 29885, 29886, 29887, 29888, 29889

Arthroscopic procedures that do not involve significant bony work:

29870, 29871, 29873, 29874, 29875, 29877, 29879, 29880, 29881, 29882, 29883, 29884

Opioid classes identified in pharmacy claims and included: Codeine, Dihydrocodeine, Fentanyl, Hydrocodone, Hydromorphone, Meperidine, Morphine, Oxcyodone, Oxymorphone, Tapentadol, Tramadol

Appendix Table 1 – Opioid Prescribing Information for filled Prescription within 3 days of Surgery Date (N=63,439)

Quantity	Mean	Min	10%	Median	90%	95%	Max
Total	41.79	1	10	40 (IQR 30-50)	60	80	1298
Non-Invasive	42.96	1	10	40 (IQR 30-45)	60	60	1000
Invasive	52.16	1	12	40 (IQR 30-60)	70	90	1298

MME	Mean	Min	10%	Median	90%	95%	Max
Total	292.47	7.5	60	250 (IQR 150-375)	465	600	9734
Non-Invasive	264.47	7.5	50	225 (IQR 150-450)	450	600	7500
Invasive	363.88	7.5	75	300 (IQR 225-450)	600	750	9734

Days Supply	Mean	Min	10%	Median	90%	95%	Max
Total	6.03	1	2	5 (IQR 4-7)	10	12	120
Non-Invasive	5.74	1	2	5 (IQR 4-7)	10	10	120
Invasive	6.76	1	2	6 (IQR 5-8)	10	14	90

Notes: Mean opioid prescribing information for quantity, MME, and days supply are displayed for those members who filled an opioid within 3 days. Information on the minimum, medium, maximum, and the 10, 90, and 95 percentile are also reported.

Appendix Table 2 – Average Observed Prescribing Rates, Quantity, and MME by State

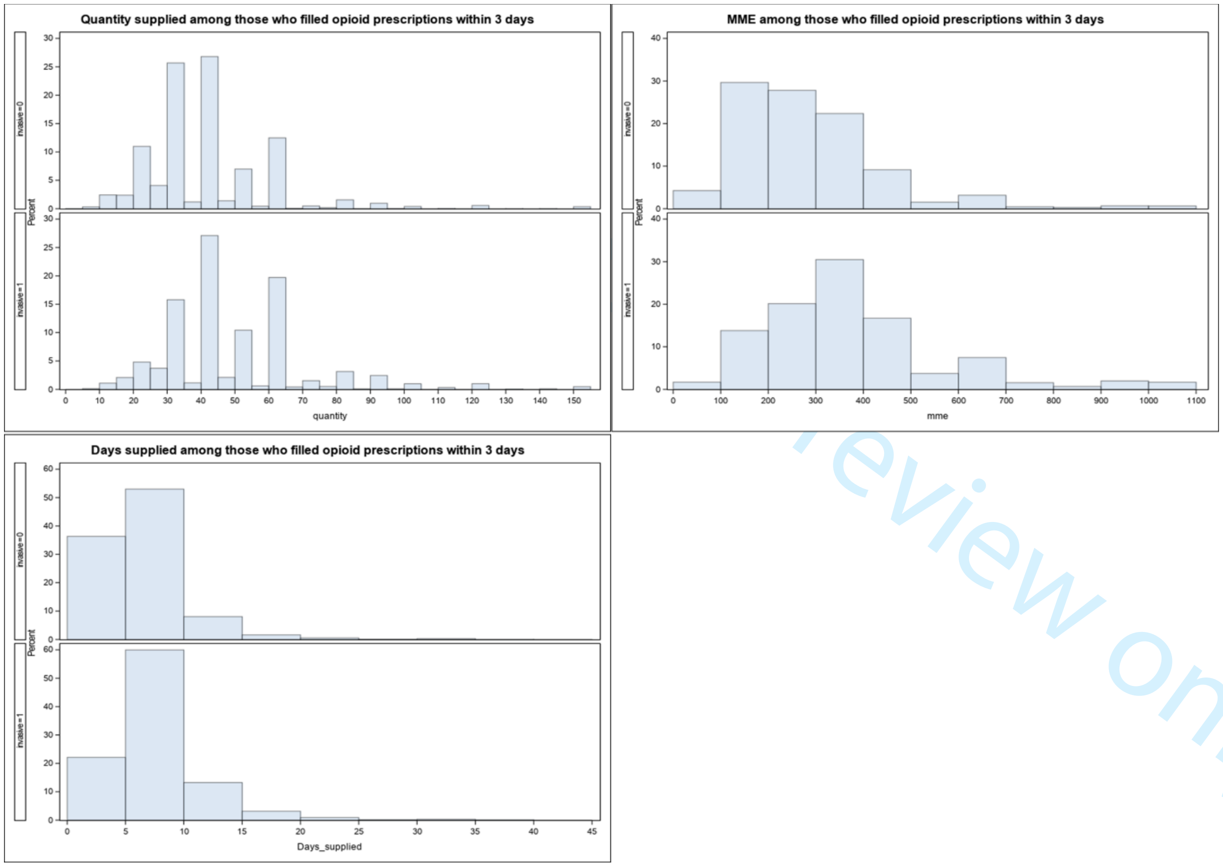
State	Prescribing Rate	Tablets	MME
Alaska	0.42	49.09	447.73
Alabama	0.79	37.00	298.37
Arkansas	0.77	39.48	316.19
Arizona	0.75	38.49	265.74
California	0.65	40.34	302.36
Colorado	0.78	38.10	263.56
Connecticut	0.61	28.71	200.65
D.C.	0.77	44.54	335.89
Delaware	0.64	37.64	241.81
Florida	0.71	39.19	275.07
Georgia	0.71	39.03	293.63
Hawaii	0.62	33.85	216.76
Iowa	0.79	42.20	289.02
Idaho	0.77	43.32	360.37
Illinois	0.78	41.56	273.43
Indiana	0.76	43.38	288.30
Kansas	0.77	43.18	301.81
Kentucky	0.53	42.50	334.85
Louisiana	0.72	39.45	333.97
Massachusetts	0.72	35.10	243.07
Maryland	0.72	36.45	251.97
Maine	0.70	34.04	239.30
Michigan	0.76	42.97	290.01
Minnesota	0.65	35.51	225.56
Missouri	0.77	43.45	282.13
Mississippi	0.68	36.94	297.58
Montana	0.72	40.17	277.99
North Carolina	0.74	40.83	286.43
North Dakota	0.56	34.22	243.85
Nebraska	0.85	41.62	274.06
New Hampshire	0.59	28.68	189.35
New Jersey	0.63	33.54	244.84
New Mexico	0.70	35.70	236.55
Nevada	0.58	41.53	328.32
New York	0.71	36.88	256.48
Ohio	0.79	41.66	274.22
Oklahoma	0.75	44.87	370.50
Oregon	0.72	39.47	271.92
Pennsylvania	0.68	35.69	234.77
Rhode Island	0.79	29.59	201.37

South Carolina	0.73	41.60	310.22
South Dakota	0.40	40.96	247.53
Tennessee	0.79	36.32	282.58
Texas	0.64	44.66	322.67
Utah	0.73	43.80	323.29
Virginia	0.81	37.10	291.04
Vermont	0.74	41.53	292.94
Washington	0.73	24.13	156.88
Wisconsin	0.79	39.77	277.17
West Virginia	0.79	39.08	245.44
Wyoming	0.58	38.28	242.95

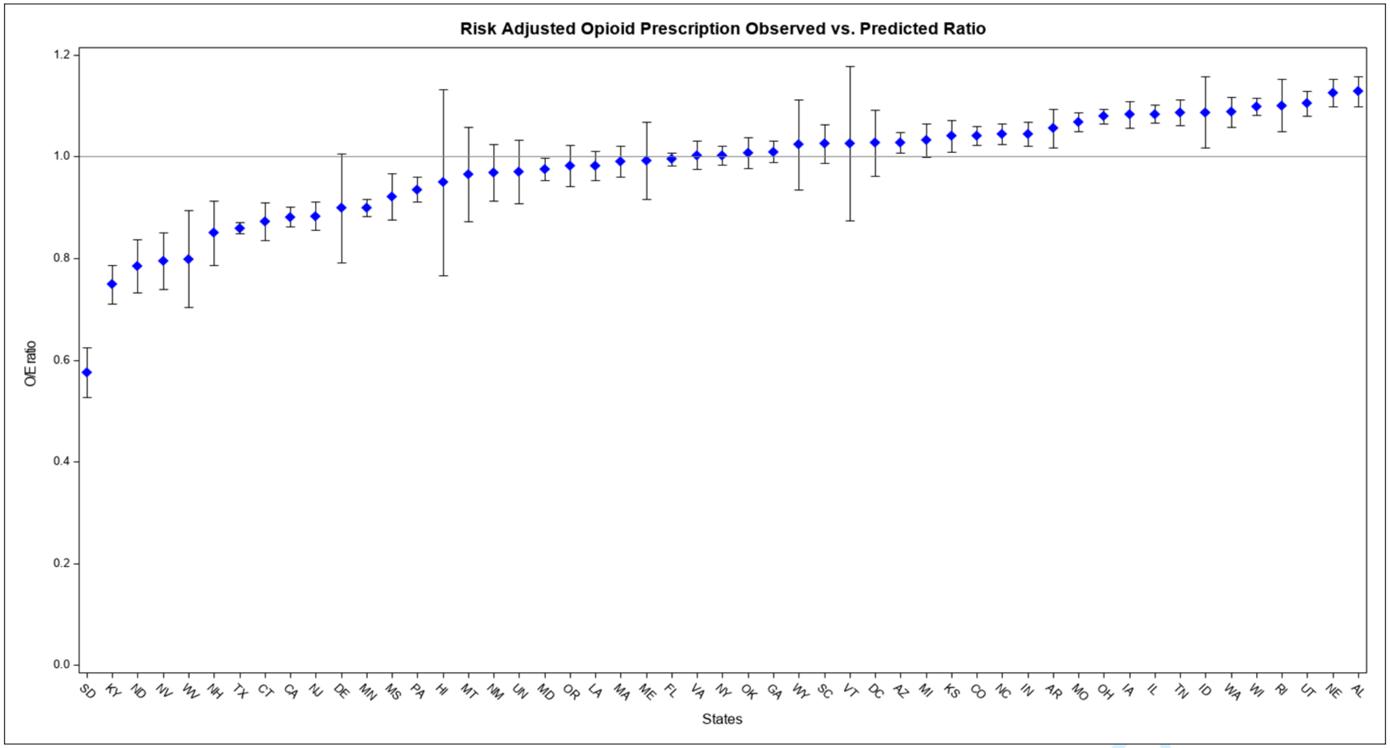
Appendix Table 3 –Total MME Saved if Dosage Would not Have Exceeded the Median Total MME Level

Year	Median MME	Patients	Total MME Saved
2015	300	5,572	1,303,848
2016	300	5,713	1,319,703
2017	300	5,474	1,187,858
2018	210	7,950	993,750
2019 (first two quarters)	180	3,886	423,574
All	250	28,595	5,230,577

Appendix Figure 1 – Distribution on the Filled Prescriptions within 3 Days of the Index Date by Invasive vs. Non-invasive Procedure

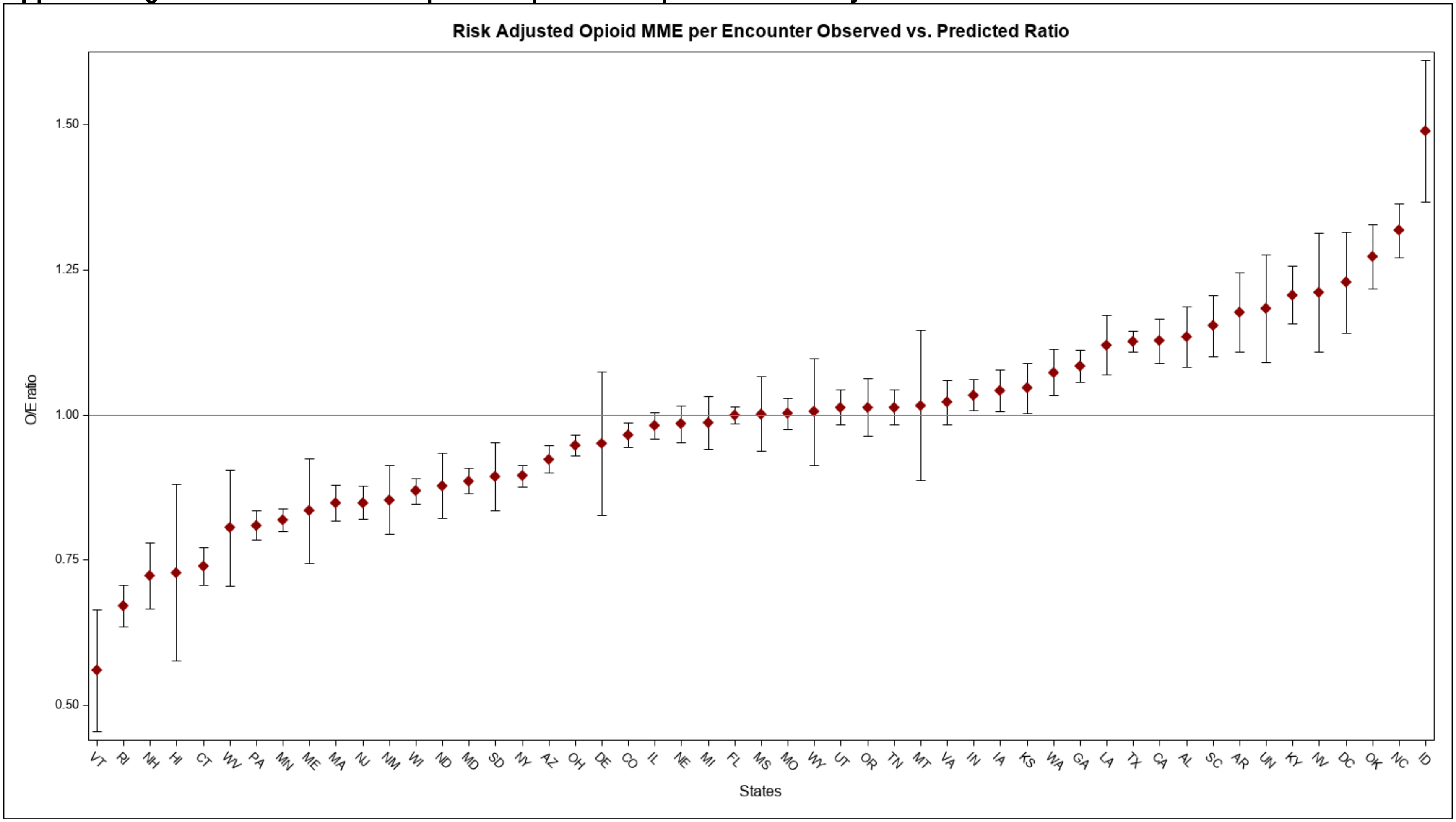


Appendix Figure 2 – Observed to Expected Opioid Prescribing Rate by State



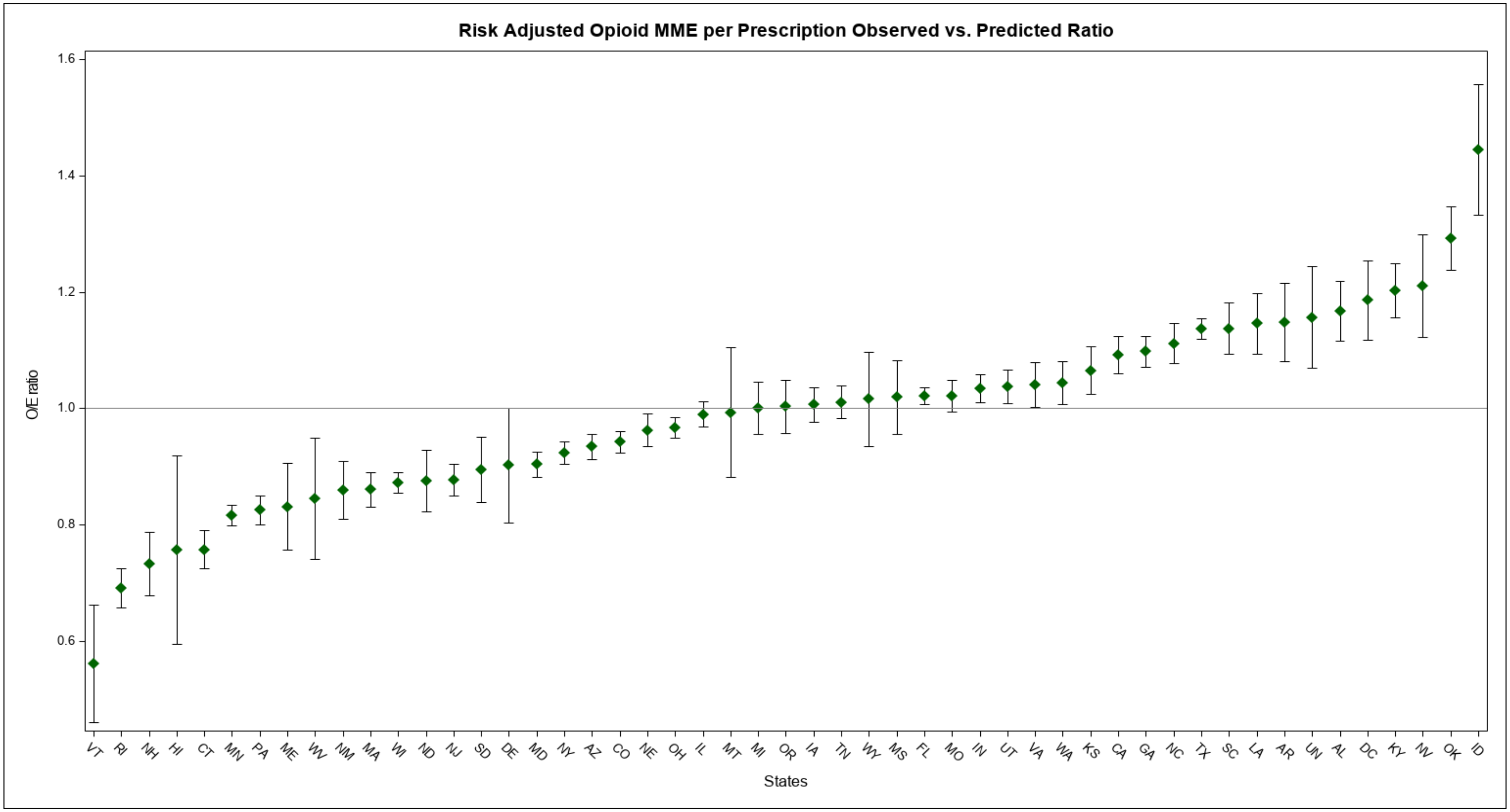
Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The median state-level prescribing rate during these years was 73%. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate logistic regression.

Appendix Figure 3 – Observed to Expected Opioid MME per Encounter by State



Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate linear regression.

Appendix Figure 4 – Observed to Expected Opioid MME per Prescription by State



Notes: State-level variation in the opioid prescribing rate for knee arthroscopies among patients who were opioid naive. The observed to expected prescribed rate is displayed for each state with a 95% confidence interval. States with higher-than-expected prescribing rates are displayed with an O/E rate larger than 1. Expected prescribing rate was adjusted for case mix with age, sex, procedure type, race, ethnicity, education, household income, comorbidities, and year, using multivariate linear regression.

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3-4
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	5-6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*5-6*
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	5-6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	5-6
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	16
		(c) Consider use of a flow diagram	16
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	6
		(b) Indicate number of participants with missing data for each variable of interest	16
Outcome data	15*	Report numbers of outcome events or summary measures	5
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7

		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	N/A
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	7-9
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	10
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11
Generalisability	21	Discuss the generalisability (external validity) of the study results	11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.