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Postoperative opioid prescription and patient-reported outcomes after elective spine surgery: a Michigan Spine Surgery Improvement Collaborative study

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CLINICAL ARTICLE

Postoperative opioid prescription and patient-reported outcomes after elective spine surgery: a Michigan Spine Surgery Improvement Collaborative study

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OBJECTIVE This study was designed to assess how postoperative opioid prescription dosage could affect patient-reported outcomes after elective spine surgery.

METHODS Patients enrolled in the Michigan Spine Surgery Improvement Collaborative (MSSIC) from January 2020 to September 2021 were included in this study. Opioid prescriptions at discharge were converted to total morphine milligram equivalents (MME). A reference value of 225 MME per week was used as a cutoff. Patients were divided into two cohorts based on prescribed total MME: ≤ 225 MME and > 225 MME. Primary outcomes included patient satisfaction, return to work status after surgery, and whether improvement of the minimal clinically important difference (MCID) of the Patient-Reported Outcomes Measurement Information System 4-question short form for physical function (PROMIS PF) and EQ-5D was met. Generalized estimated equations were used for multivariate analysis.

RESULTS Regression analysis revealed that patients who had postoperative opioids prescribed with > 225 MME were less likely to be satisfied with surgery (adjusted OR [aOR] 0.81) and achieve PROMIS PF MCID (aOR 0.88). They were also more likely to be opioid dependent at 90 days after elective spine surgery (aOR 1.56).

CONCLUSIONS The opioid epidemic is a serious threat to national public health, and spine surgeons must practice conscientious postoperative opioid prescribing to achieve adequate pain control. The authors' analysis illustrates that a postoperative opioid prescription of 225 MME or less is associated with improved patient satisfaction, greater improvement in physical function, and decreased opioid dependence compared with those who had > 225 MME prescribed.

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KEYWORDS MSSIC; Michigan Spine Surgery Improvement Collaborative; opioid; patient-reported outcome; satisfaction; spine surgery; pain

Judicious postoperative opioid prescribing is essential in achieving sufficient pain control and avoiding complications from immobility because of pain. This is especially true in light of the current opioid epidemic that represents a significant public health crisis in the US. According to the Centers for Disease Control and Prevention, more than 16,000 individuals died of overdoses involving prescription opioids in 2020.[1] Studies have also revealed that greater than 70% of opioid-prescribed patients obtain medicine via diversion, and 55% of these cases are from excess medications from a legitimate prescription.[2,3]

Surgeons, unfortunately, significantly contribute to the opioid epidemic, with the second highest rate of opioid prescriptions after pain medicine physicians.[4] Spine surgery patients are particularly at risk of opioid-related complications, as one of the primary indications for spine surgery

ABBREVIATIONS aOR = adjusted OR; MCID = minimal clinically important difference; MME = morphine milligram equivalents; MSSIC = Michigan Spine Surgery Improvement Collaborative; PRO = patient-reported outcome; PROMIS PF = Patient-Reported Outcomes Measurement Information System 4-question short form for physical function.

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is pain, and many are on a long-term regimen of opioids prior to surgery. Opioid prescriptions for spinal conditions have increased by 660% in the last 10 years, and excessive opioid prescribing after spine surgery is common.[5–8] In response, many states have instituted new legislation limiting the amount of opioids prescribed for acute pain. In Michigan, a new law went into effect on June 1, 2018.[9] Among several tenets of the bill, prescriptions beyond a 3-day supply mandated that a provider consult the Michigan Automated Prescription System, an online registry of Schedule 2–5 drugs. In addition, prescriptions for acute pain were capped at a 7-day duration.

The adverse consequences of postoperative opioid usage have been documented in the literature. Reported complications include wound-related problems, readmission, elevated costs, and chronic opioid dependence.[10–12] Prescription opioids often serve as a common gateway for addiction, especially in opioid-naive patients, and approximately 10% of spine surgery patients are reported to become opioid dependent after their surgeries.[13–18] Also, prescription opioids are often unused, which increases the risk abuse and diversion.[19]

However, even within the context of new legislation and a heightened awareness among prescribers about the dangers of prescription opioid abuse, there continues to exist considerable variability in prescribing patterns for elective surgical procedures.[20] This issue is further exacerbated in spine surgery, as many patients have chronic pain, and a significant number of patients are already on a regimen of daily opiates prior to surgery.[21]

The goal of this study was to investigate how variations in postoperative opioid prescription dosage after elective spine surgery can influence outcomes. We hypothesized that increased opioid prescription is associated with poor patient-reported outcomes (PROs) after adjusting for other covariates. Despite the demonstrated benefits of judicious opioid use to avoid unwanted consequences, there exists some resistance among providers because curtailing access to opioids may lead to patient dissatisfaction. We also hypothesized that higher opioid prescribing does not equate to greater patient satisfaction.

Methods

Study Design, Setting, and Participants

The institutional review board of Henry Ford Health approved this study. Because of the retrospective nature of the study, patient consent was not required. The details of the Michigan Spine Surgery Improvement Collaborative (MSSIC) have been provided previously.[22] Briefly, the MSSIC is a statewide quality improvement initiative including 29 hospitals with 200 orthopedic surgeons and neurosurgeons from various settings. Member hospitals are required to perform a minimum of 200 annual spine surgeries with active participation from both neurosurgeons and orthopedic surgeons. The MSSIC is funded by Blue Cross Blue Shield of Michigan. The MSSIC reviews elective spine surgeries for degenerative disease; cases outside the scope of the MSSIC include surgery for nondegenerative disease and complex pathology (e.g., spinal cord injury, traumatic fracture, preexisting infection, grade 3 or 4 spondylolisthesis, scoliosis > 25°, congenital anomalies, and ≥ 4-level fusion). Using the MSSIC database, 20,239 patients who underwent elective cervical and lumbar spine surgery from January 2020 to September 2021 were included in this study.

Variables, Data Sources, and Measurements

The MSSIC maintains a prospectively collected data registry that includes patient demographics, clinical presentation, medical history, surgical procedure, details of hospital stay, postsurgical adverse events within 90 days of surgery, and PROs after surgery. Opioid prescriptions at discharge were recorded in the electronic health record and abstracted by trained chart abstractors. This information included the type of opioid prescribed, dosing schedule, and quantity. Total morphine milligram equivalents (MME) per week were calculated based on this information. The primary outcomes of this study were patient satisfaction, return to work after surgery, the Patient-Reported Outcomes Measurement Information System 4-question short form for measuring physical function (PROMIS PF), and EQ-5D at 90 days after the index procedure.

The North American Spine Society patient satisfaction index, which is scaled from 1 to 4, was used to measure patient satisfaction at 90 days after the surgery.[23] Patients with scores of 1 (“The treatment met my expectations”) and 2 (“I did not improve as much as I hoped, but I would undergo the same treatment for the same outcome”) were considered to be satisfied, and patients with scores of 3 (“I did not improve as much as I had hoped, and I would not undergo the same treatment for the same outcome”) and 4 (“I am the same or worse than before treatment”) were categorized as unsatisfied. For return to work, only patients who intended to return to work were included in the analysis. For PROs, improvements reaching the minimal clinically important difference (MCID) were used. Increases ≥ 4.5 points for lumbar cases and ≥ 3 points for cervical cases were used as the MCID thresholds for PROMIS PF.[24–27] The MCID threshold for EQ-5D was 0.15 points.[26,28,29]

Statistical Analysis

Pearson’s chi-square test or Fisher’s exact test was used for categorical variables. For continuous variables, the Student t-test or Mann-Whitney U-test was used. Univariate analysis was performed for comparison across the three cohorts. Multivariate generalized estimating equation models with a logit link were performed to investigate the association between postoperative opioid prescription MME and PROs. The analysis also accounted for baseline differences (demographics, comorbidities, baseline PROMIS PF and EQ-5D scores, and surgical characteristics) and hospital-to-hospital variations from which data were collected. All analyses were performed using SAS version 9.4 (SAS Institute, Inc.).

Results

Participants and Descriptive Data

A total of 20,239 patients were included in this study. The three most common opioids prescribed were hydro-

TABLE 1. Common opioids prescribed at discharge

Opioid	No. of Opioids
Hydrocodone	11,502
Oxycodone	8343
Tramadol	1159
Morphine	328
Codeine	267
Hydromorphone	108

codone, oxycodone, and tramadol (Table 1). Patients were divided into two cohorts based on postoperative prescription MME. A cutoff of 225 MME per week was chosen, which is equivalent to 30 pills of hydrocodone 7.5 mg each and would translate to 1 week's worth of Norco 7.5/325 (Allergan USA)–based dosing every 6 hours in compliance with the current Michigan law where providers are not allowed to prescribe more than a 7-day supply of narcotics for acute pain.[9] Also, our initial iterations of analysis revealed that the median dose being prescribed at our participating sites was 225 MME, which provided a helpful reference point for surgeons and practices that are familiar with this prescription dosing.

A total of 8739 patients had 225 MME or less prescribed at discharge and 11,500 patients were prescribed > 225 MME. Descriptive characteristics of the two cohorts are illustrated in Table 2. Patients with > 225 MME were more likely to be younger and have a higher BMI, lower level of educational completion, history of depression and anxiety, American Society of Anesthesiologists class > II, and daily preoperative opioid use. Patients with > 225 MME also had a higher proportion of multilevel surgery and fusion surgery, which was accounted for as one of the variables in the generalized estimating equation model.

Univariate Outcome Data

Patients with > 225 MME were less likely to achieve MCID using PROMIS PF and to return to work. They were also more likely to continue opioid use at 90 days after surgery (Table 3).

Main Results

Our multivariate analysis is summarized in Table 4. After accounting for differences in baseline characteristics, comorbidities, operative details, and hospital-to-hospital variations (Fig. 1), the patients receiving > 225 MME were significantly less likely to achieve satisfaction (adjusted OR [aOR] 0.81, 95% CI 0.73–0.89; $p < 0.0001$) and the MCID for PROMIS PF at 90 days after surgery (aOR 0.88, 95% CI 0.82–0.95; $p < 0.0013$), and more likely to be taking opioids at 90 days after index surgery (aOR 1.56, 95% CI 1.35–1.79; $p < 0.001$) (Fig. 2).

Discussion

Key Results

Using the MSSIC database, which accounted for 29 hospitals and 200 orthopedic surgeons and neurosur-

TABLE 2. Baseline characteristics by postoperative total MME prescribed at discharge

Variable	Total MME at Discharge: MME ≤225 (n = 8739)	Total MME at Discharge: MME >225 (n = 11,500)	p Value
Mean age, yrs	59.5 ± 14.7	58.6 ± 12.8	**<0.001**
Mean BMI	30.6 ± 6.6	31.4 ± 6.9	**<0.001**
Male sex	4605 (52.7)	5923 (51.5)	0.0940
White race*	4578 (88.4)	6371 (87.4)	0.1170
Education†			**<0.0001**
Less than high school	206 (4.3)	326 (4.7)	
High school	2130 (44.6)	3354 (48.6)	
At least some college	1756 (36.7)	2448 (35.5)	
Postcollege	688 (14.4)	772 (11.2)	
Depression	2725 (31.2)	4556 (39.6)	**<0.001**
Anxiety	2645 (30.3)	4475 (38.9)	**<0.001**
CAD at baseline	1227 (14.0)	1676 (14.6)	0.2836
Current smoker‡	725 (14.3)	1204 (16.6)	**0.0007**
Diabetes	2020 (23.1)	2758 (24.0)	0.1499
History of DVT	512 (5.9)	715 (6.2)	0.2897
Independent ambulation	7194 (82.3)	9450 (82.2)	0.7868
ASA class >II	4637 (53.1)	6621 (57.6)	**<0.001**
Preop opioid daily use§	1260 (25.7)	2723 (38.3)	**<0.001**
Surgical location			0.4576
Lumbar	6097 (69.8)	8074 (70.2)	
Cervical	2635 (30.2)	3410 (29.7)	
Multilevel op	4398 (50.3)	6859 (59.6)	**<0.001**
Fusion op	4584 (52.5)	8200 (71.3)	**<0.001**

ASA = American Society of Anesthesiologists; CAD = coronary artery disease; DVT = deep venous thrombosis.
Values are presented as the number of patients (%) or mean ± SD unless specified otherwise. Boldface type indicates statistical significance.
* Denominators = 5181 for MME ≤ 225 and 7287 for MME > 225.
† Denominators = 4780 for MME ≤ 225 and 6900 for MME > 225.
‡ Denominators = 5064 for MME ≤ 225 and 7260 for MME > 225.
§ Denominators = 4909 for MME ≤ 225 and 7107 for MME > 225.

TABLE 3. PROs at 90 days by postoperative total MME prescribed at discharge

Outcome	Total MME at Discharge: MME ≤225	Total MME at Discharge: MME >225	p Value
Satisfaction*	3895 (86.0)	5185 (84.2)	**0.0078**
PROMIS MCID†	1687 (60.3)	2225 (54.5)	**<0.0001**
EQ-5D MCID‡	1536 (54.3)	2244 (53.4)	0.4685
Return to work§	1323 (34.1)	1569 (30.3)	**0.0002**
Opioid use at 90 days¶	623 (14.3)	1503 (26.0)	**<0.0001**

Values are presented as the number of patients (%) unless specified otherwise. Boldface type indicates statistical significance.
* Denominators = 4528 for MME ≤ 225 and 6161 for MME > 225.
† Denominators = 2799 for MME ≤ 225 and 4084 for MME > 225.
‡ Denominators = 2829 for MME ≤ 225 and 4201 for MME > 225.
§ Denominators = 3884 for MME ≤ 225 and 5175 for MME > 225.
¶ Denominators = 4367 for MME ≤ 225 and 5771 for MME > 225.

TABLE 4. Multivariate analysis of PROs at 90 days by postoperative total weekly MME prescribed at discharge

Outcome	aOR (95% CI)*	p Value
Satisfaction	0.81 (0.73–0.89)	**<0.0001**
PROMIS MCID†	0.88 (0.82–0.95)	**0.0013**
EQ-5D MCID	1.01 (0.92–1.10)	0.8528
Return to work	0.91 (0.67–1.22)	0.5194
Opioid use at 90 days	1.56 (1.35–1.79)	**<0.0001**

Boldface type indicates statistical significance.
* Adjusted for all variables listed in Table 2.
† PROMIS score at baseline was adjusted.

geons, we reviewed 20,239 elective cervical and lumbar spine surgery cases from January 2020 to September 2021. Patients were divided into two cohorts based on their postoperative opioid prescription, with 225 MME as a cutoff value.[9]

Our regression analysis revealed that patients who had postoperative opioids prescribed with MME of 225 or less were more likely to be satisfied with surgery and achieve PROMIS PF MCID, and less likely to be opioid dependent at 90 days after elective spine surgery. No correlations were observed for achieving MCID using EQ-5D and return-to-work status.

Interpretation

Spine surgery patients are particularly vulnerable to opioid-related complications with high postoperative pre-

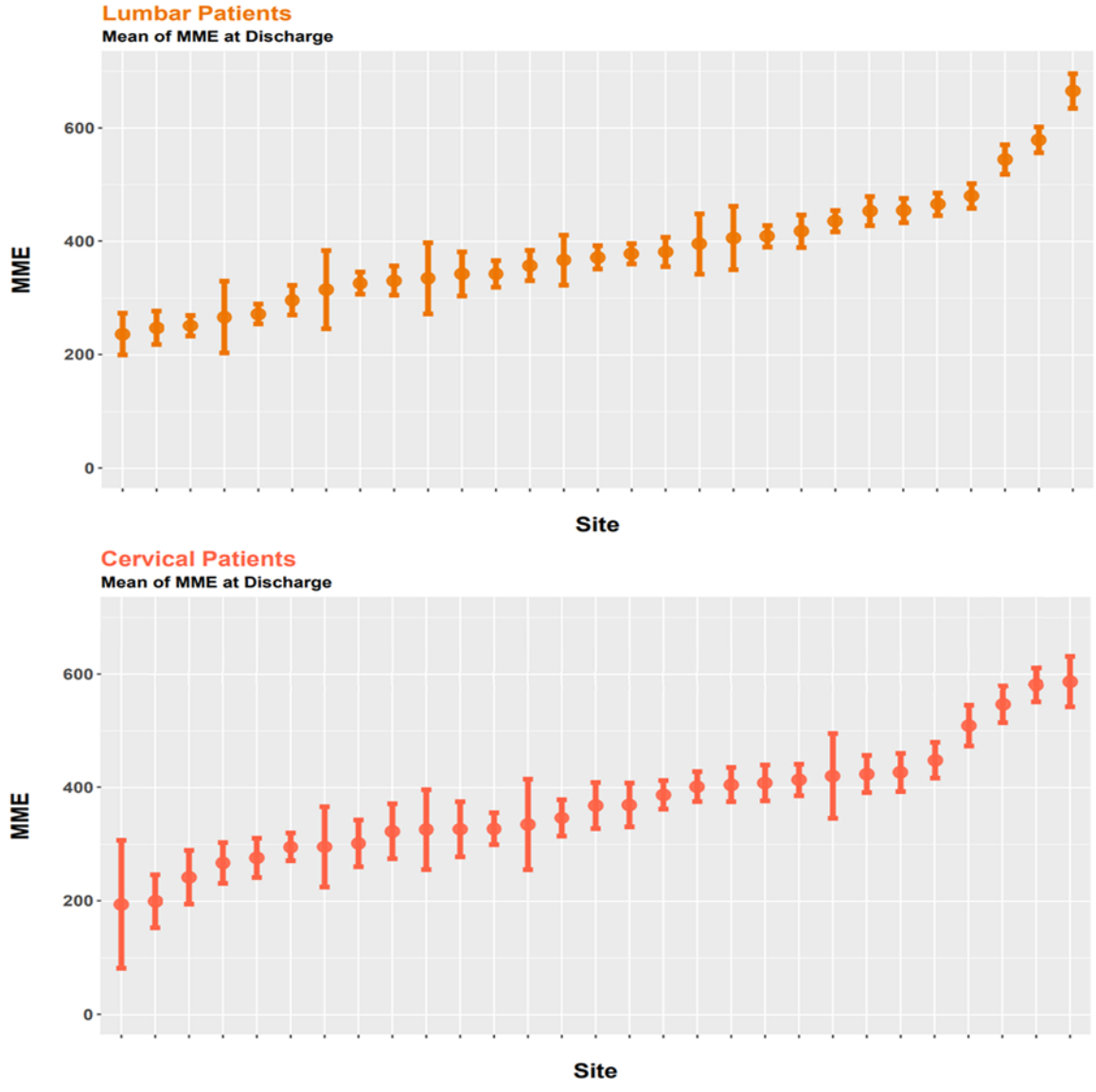

FIG. 1. Opioid prescription MME at discharge by participating hospital. Variations are adjusted for in the regression analysis to eliminate confounding effects. Values represent the mean ± SD. Figure is available in color online only.

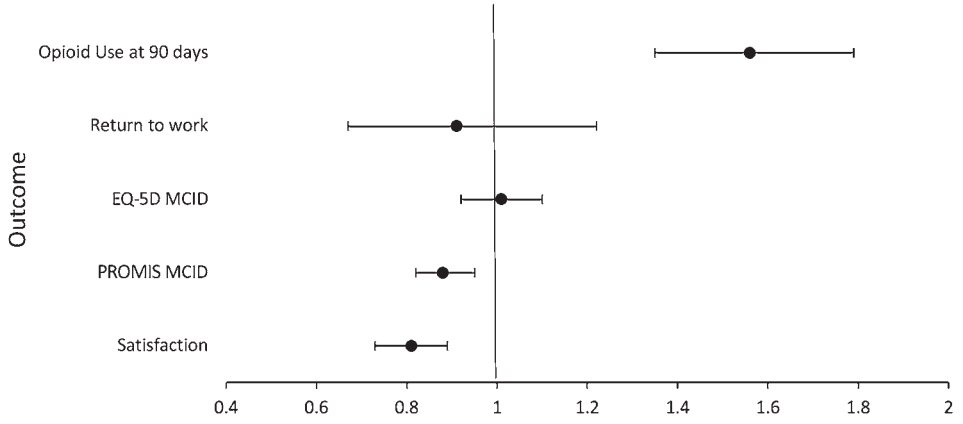

FIG. 2. Forest plot of aORs from multivariate analysis. All variables from Table 1 were incorporated into the model for each outcome. In addition, baseline EQ-5D and PROMIS PF were adjusted for within their respective models.

scription MME compared with other surgical procedures. For example, a review of 1546 vascular surgery patients' postoperative prescription MME demonstrated that most procedures required a postoperative MME well below 200.[30] Suprainguinal bypass, the procedure with the highest postoperative MME, had a median postoperative MME of 225. On the other hand, many of the cervical and lumbar spine surgeries had average postoperative MME in the 300s to 400s in 2016 according to reports from the Institute for Clinical Systems Improvement.[31] A study by Sanford et al. also demonstrated that 225 MME was a benchmark for the 1st quartile after lumbar decompression surgery.[32]

Nationwide recognition of the opioid epidemic has led to many collaborative efforts toward appropriate postoperative opioid use by healthcare providers and systems. A good example is the Minnesota Health Collaborative, led by the Institute for Clinical Systems Improvement, launching the Postoperative Opioid Prescribing Initiative. According to the organization, several hospitals targeted 25th percentile (1st quartile) postoperative MME as a benchmark for the following year, which was 225 MME for many cervical and lumbar spine surgeries in 2018.[31] Their efforts resulted in diminishing the average MME from 300s to 400s in 2016 to 200s in 2018, which is a remarkable accomplishment over only 2 years.[31] Their initiative is particularly commendable, as postoperative MME > 225 has been linked to increased overdose by patients' family members and prolonged narcotic use in opioid-naive patients.[33,34]

However, spine surgeons and other healthcare providers need more evidence-based recommendations for postoperative pain management, and there is a paucity of literature to appropriately guide spine surgeons. This is especially true when it comes to PROs. Therefore, we sought to assess if decreasing postoperative MME to 225 or lower would improve PROs.

In contrast to surgeon-centered outcome parameters such as complications, morbidity, and mortality, increasing emphasis is placed on PROs to measure patient quality of life following spine surgery.[35] Particularly, patient satisfaction is used more frequently, as it is patients' overall assessments of physical function, pain, expectations, personal experience, treatment efficacy, postoperative care, and other factors that cannot be easily quantified.[35] Patient satisfaction is also known to be strongly correlated with long-term outcomes, and satisfied patients are more likely to develop lasting and strong relationships with providers and be compliant with treatment and readily present with any new signs and symptoms.[36,37] Our analysis demonstrated that lower postoperative MME was associated with improved patient satisfaction, which is likely related to more patients reaching MCID using PROMIS PF scores. In addition, our regression analysis demonstrated that postoperatively, 225 MME or less was associated with decreased opioid use at 90 days, which is another important consideration given the widely known complications arising from opioid dependence.[10–19]

It is also worth noting significant differences in opioid prescription across participating sites (Fig. 1). Our multivariate model accounts for site-specific variability in addition to other information. We believe that the difference is likely based on practice patterns by individual surgeons, practices, or hospitals. This is one of our core tenets of quality improvement where significant variability in practice represents an opportunity for improvement. Our results reflect that appropriate reduction of postoperative prescription MME could result in improved postoperative outcome following elective spine surgery. Studies linking opioid use and functional outcome with spine surgery mostly focused on preoperative opioid use. Hills et al. reported that chronic opioid use prior to surgery was associated with not achieving meaningful improvements in function, quality of life, pain, and complications in their review of 2128 patients.[38] Similarly, Zakaria et al. also demonstrated that preoperative long-term opioid use (> 6 months) was associated with lower improvement in PROs, higher complications, and lower patient satisfaction.[21] However, it is difficult for spine surgeons to directly influence a patient's chronic opioid use because the opioids might be prescribed by multiple physicians, but the surgeons are often responsible for the management of postoperative pain in the acute phase. While appropriate postoperative pain management is important, our study results emphasize that spine surgeons should consciously seek to minimize post-

operative prescription MME, as the dose can negatively influence patient satisfaction and chronic opioid dependence.

Limitation and Generalizability

There are several limitations inherent to study design and data. Our study results were subject to unknown confounders that could not be addressed via multivariate analysis. It is also not possible to trace the actual opioid consumption by our patients. In addition, since MSSIC is a statewide registry, there may be certain features unique to Michigan hospital practice patterns, cultures, or patient demographic features that may not be universally applicable to locations or regions outside Michigan.

Specific to this study, we were only able to consider the amount of opioids prescribed at discharge, and we do not have data on whether these patients had subsequent refills and at what dose. Additionally, we do not have specifics on any nonopioid medications that are prescribed as part of multimodal analgesia. Therefore, our results are only based on the initial discharge pain regimen, and any interpretation should be considered in light of these limitations. In addition, preoperative MME was not recorded at the time of data collection and analysis using the MSSIC registry. While our regression analysis accounts for preoperative opioid use, it could not account for the specific preoperative MME of an individual patient. We also accounted for surgical details in the regression analysis, including site, level(s), and fusions. However, subgroup analysis for individual procedure types (e.g., transforaminal lumbar interbody fusion, anterior cervical discectomy and fusion, and posterior cervical fusion) was not feasible due to the sample size. Finally, we did not adjust for minimally invasive procedures as a separate covariate. However, given the heterogeneity of the patient population and broad observations that lower opiate prescribing is associated with better outcome, we do not believe that this would affect our overall observations. We did observe a wide variance in prescribing patterns among institutions within the MSSIC (Fig. 1) but were able to account for any site-to-site differences using our multivariate model.

In terms of generalizability, since MSSIC includes 29 hospitals from various practice settings (i.e., community hospitals to tertiary academic centers), we believe that our findings are widely generalizable to most spine surgery patients.

Conclusions

The opioid epidemic is a serious threat to national public health, and spine surgeons must practice conscientious postoperative opioid prescription to achieve adequate pain control. Our analysis illustrates that, compared with > 225 MME, a postoperative opioid prescription of 225 MME or less is associated with improved patient satisfaction and decreased opioid dependence.

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Conception and design: Chang, Schwalb, Abdulhak. Acquisition of data: Lim, Yeh, Macki, Haider, Hamilton, Mansour, Telemi, Nerenz, Park, Aleem, Easton, Khalil, Perez-Cruet. Analysis and interpretation of data: all authors. Drafting the article: Lim. Critically revising the article: Chang, Schultz, Nerenz, Abdulhak. Reviewed submitted version of manuscript: Lim, Yeh, Macki, Haider, Hamilton, Mansour, Telemi, Schultz, Nerenz, Schwalb, Abdulhak, Park, Aleem, Easton, Khalil, Perez-Cruet. Approved the final version of the manuscript on behalf of all authors: Chang. Statistical analysis: Schultz. Study supervision: Chang, Schwalb, Abdulhak, Park.

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