Impact of Opioid Prescribing Guidelines on Postoperative Opioid Prescriptions Following Elective Spine Surgery: Results From an Institutional Quality Improvement Initiative

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BACKGROUND: With a dramatic rise in prescription opioid use, it is imperative to review postsurgical prescribing patterns given their contributions to the opioid epidemic.
OBJECTIVE: To evaluate the impact of departmental postoperative prescribing guidelines on opioid prescriptions following elective spine surgery.
METHODS: Patients undergoing elective cervical or lumbar spine surgery between 2017 and 2018 were identified. Procedure-specific opioid prescribing guidelines to limit postoperative prescribing following neurosurgical procedures were developed in 2017 and implemented in January 2018. Preguideline data were available from July to December 2017, and postguideline data from July to December 2018. Discharge prescriptions in morphine milliequivalents (MMEs), the proportion of patients (i) discharged with an opioid prescription, (ii) needing refills within 30 d, (iii) with guideline compliant prescriptions were compared in the 2 groups. Multivariable (MV) analyses were performed to assess the impact of guideline implementation on refill prescriptions within 30 d.
RESULTS: A total of 1193 patients were identified (cervical: 308; lumbar: 885) with 569 (47.7%) patients from the preguideline period. Following guideline implementation, fewer patients were discharged with a postoperative opioid prescription (92.5% vs 81.7%, $P < .001$) and median postoperative opioid prescription decreased significantly (300 MMEs vs 225 MMEs, $P < .001$). The 30-d refill prescription rate was not significantly different between preguideline and postguideline cohorts (pre: 24.4% vs post: 20.2%, $P = .079$). MV analyses did not demonstrate any impact of guideline implementation on need for 30-d refill prescriptions for both cervical (odds ratio [OR] = 0.68, confidence interval [CI] = 0.37-1.26, $P = .22$) and lumbar cohorts (OR = 0.95, CI = 0.66-1.36, $P = .78$).
CONCLUSION: Provider-aimed interventions such as implementation of procedure-specific prescribing guidelines can significantly reduce postoperative opioid prescriptions following spine surgery without increasing the need for refill prescriptions for pain control.

KEY WORDS: Opioids, Postsurgical, Spine surgery, Lumbar spine, Cervical spine, Lumbar fusion, Degenerative spine disease, Lumbar decompression, Lumbar laminectomy, Anterior cervical discectomy and fusion, Posterior cervical fusion, Prescription use

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The opioid epidemic continues to represent a significant public health crisis in the United States. Between 1999 and 2017, opioid overdoses claimed nearly 700 000 lives while almost 130 people still continue to die each day.[1] More than 5 million Americans currently suffer from opioid use disorder while 10.3 million have abused them at some point in their lifetime.[2,3] Since 2001, this epidemic has posed an economic burden in excess of $1 trillion to the US economy.[4] Prescription opioid use has been recognized as a key contributor to this epidemic,

ABBREVIATIONS: ACDF, anterior cervical discectomy and fusion; **CPT,** current procedural terminology; **ERAS,** enhanced recovery after surgery; **IQR,** interquartile range; **MIS,** minimally invasive spine; **MME,** morphine milliequivalent; **MSQC,** Michigan Surgical Quality Collaborative; **MV,** multivariable; **OME,** oral morphine equivalent; **PCF,** posterior cervical fusion; **PLF,** posterior lumbar fusion

TABLE 1. Opioid Prescribing Guidelines Implemented by the Department of Neurologic Surgery

Tier 1 Max OME 100 (eg, 13 tabs 5 mg oxycodone)	Tier 2 Max OME 200 (eg, 26 tabs 5 mg oxycodone)	Tier 3 Max OME 300 (eg, 40 tabs 5 mg oxycodone)	Tier 4 Max OME 400 (eg, 53 tabs 5 mg oxycodone)
Peripheral nerve: neuroplasty	Cranial: craniotomy	Spinal: simple cervical or simple lumbar, without fusion	Spinal: simple cervical or simple lumbar with fusion
Peripheral nerve: excision	Cranial: craniectomy	Spinal: thoracic or thoracolumbar without fusion	Spinal: thoracic or thoracolumbar with fusion
Cranial: other*		Spinal: other without fusion	Spinal: other with fusion

OME, oral morphine equivalent.
*Cranial: other procedures include secondary dural repair for skull base cerebrospinal fluid leak; insertion or replacement of cranial neurostimulator pulse generator or receiver; creation or removal of shunts, venriculo-peritoneal, pleural or other terminus; endovascular procedures; burr-holes (s) for evacuation of extradural or subdural hematoma; ventriculostomies.

due to a dramatic surge in opioid prescribing since 1999, driven in part by initiatives such as the "fifth vital sign" introduced in 2001 by the American Pain Society.[5] The United States accounts for 80% of the world's prescription opioid consumption.[6] It was estimated that in 2012, nearly 82.5 prescriptions were written everyday for every 100 persons, a number nearly 4 times higher compared to 1999.[7,8] It is reported that >70% of prescription opioid users obtain the drug through diversion and in 55% of these cases, the drug is obtained through a family member or a friend with excess leftover pills from a legitimate prescription.[2,9]

Surgeons play an important role in this epidemic, being only second to pain medicine physicians in the rate of opioid prescribing.[10] It is estimated that 60% to 90% of outpatient opioids prescribed at discharge following surgery go unused[11] while 1 out of every 3 postsurgical prescriptions is abused.[12] Postdischarge opioids prescribed after surgery are also associated with a well-documented risk of chronic opioid dependence, especially in opioid-naive patients for whom these prescriptions often serve as the inaugural exposure.[9,13]

Postoperative opioid prescribing practices are often limited by lack of evidence-based guidelines, frequently resulting in wide variation and overprescription due to arbitrary doses prescribed as per surgeon discretion.[5,14] Institution and procedure-specific guidelines may have the potential to limit postdischarge opioid prescriptions after elective surgery.[15,16] In the current study, we aimed to determine the impact of opioid prescribing guidelines implemented internally within our neurosurgery department on postoperative discharge prescription practices and 30-d refill prescriptions following elective cervical and lumbar spine surgery. We also aimed to determine the factors associated with guideline compliance and need for 30-d refill prescriptions.

METHODS

Opioid Prescribing Guidelines

The Department of Neurologic Surgery at Mayo Clinic, Rochester, Minnesota, implemented procedure-specific guidelines for postoperative discharge opioid prescribing in January 2018 as a quality improvement initiative. The guideline development process primarily consisted of expert opinion guided by internal data on historical prescribing and refill patterns. Multidisciplinary input was sought from neurosurgeons, anesthesiologists (pain medicine), health services researchers, advanced practice providers, pharmacists, and nurses. A tiered approach was utilized with providers recommended to prescribe a maximum number of morphine milliequivalents (MMEs) based on the level of procedure: tier 1: 100 MMEs, tier 2: 200 MMEs, tier 3 = 300 MMEs, tier 4: 400 MMEs which translate to approximately 13, 26, 40, and 53 tablets respectively of 5 mg oxycodone (Table 1). Spine surgery procedures were included in tier 3 and tier 4; decompressions alone without arthrodesis or instrumentation were designated as tier 3 while tier 4 included all procedures involving arthrodesis or instrumentation.

Cohort

Following Institutional Review Board (IRB) approval, we queried all adult patients undergoing elective cervical or lumbar spine surgery within our department with available postdischarge opioid prescription information and research consent. The cohort was divided into 2 groups of patients: the preguideline group consisting of patients undergoing surgery between July to December 2017 and a postguideline group of patients who underwent surgery between July and December 2018. Due to early differences in guideline adoption and transition to a new electronic health record system in May 2018, the time period from January to June 2018 was excluded from analysis. Since this project was undertaken as a quality improvement initiative, our IRB deemed the study exempt from review.

Outcomes and Covariates of Interest

The primary outcomes of interest for comparison between the 2 groups included (i) the proportion of patients receiving a postoperative opioid prescription at discharge (index prescription) and (ii) the dose in MMEs prescribed at discharge. Due to our institutional prescribing practices, "discharge" opioid prescriptions were defined as prescriptions written in the 7 d before surgery, during the admission and on the day of discharge. Both liquid and tablet medications were included. Secondary outcomes of interest included (i) guideline compliance and (ii) the proportion of patients receiving another refill prescription following the index prescription within 30 d of hospital discharge.

Covariates of interest included demographics (age, sex, race, body mass index [BMI]), preoperative opioid use (defined as opioid-naive: yes vs no), and surgical factors such as level of procedure (cervical or lumbar), type of procedure (decompression alone vs fusion), and number of operative levels. Patients with no opioid prescription or history of opioid use in the 90 d before surgery were considered opioid-naive. The

number of operative levels was determined using Current Procedural Terminology (CPT) codes.

Statistical Analysis

Continuous variables were summarized as medians with interquartile ranges (IQRs) and compared using Wilcoxon rank-sum tests, while categorical variables were summarized as frequencies with proportions and compared using Chi-square and Fisher exact tests. Univariate comparisons were analyzed before and after guideline implementation. Box plots with medians and IQRs were constructed to compare the dose in MMEs prescribed at discharge for each procedure type. Separate multivariable logistic regression analyses fitted for guideline compliance and 30-d postdischarge refills were performed for cervical and lumbar spine surgery cohorts, with adjustment for demographics and procedural factors (approach, number of operative levels, type of procedure: decompression alone vs arthrodesis). At least 10 outcome events were needed for inclusion of 1 covariate in the model. All statistical analyses were performed using SAS Version 9.4 (SAS Institute Inc, Cary, NC, USA). *P*-values were 2 sided with alpha $\leq$0.05 considered statistically significant. Since this study was an assessment of the impact of an institutional quality improvement initiative, a priori sample size estimation was not performed.

RESULTS

Baseline Characteristics

A total of 1193 patients were included (n = 569, 47.7% from the preguideline group and the remaining (52.3%, n = 624) in the postguideline group) with the majority (64.1%, n = 764) being males. Median (IQR) age of the cohort was 62 (51-71) yr and the majority were opioid-naive (64.3%, n = 767). With the exception of race (P = .026), there were no significant differences in the 2 groups in terms of demographics or proportion of preoperative opioid-naive patients (all P > .05). The majority of patients underwent lumbar spine surgery (n = 885, 74.2%), while the remaining underwent cervical spine surgery. Table 2 summarizes demographics and procedure distribution within each group.

Impact of Guideline Implementation on Discharge Opioid Prescription Practices

Following guideline implementation, the proportion of patients discharged with an index opioid prescription decreased overall (92.6% vs 81.7%, P < .001) and for each procedure, although some comparisons were not statistically significant, perhaps affected by the limited sample size for some procedure types (Figure 1A). These findings were found to be consistent on subgroup analysis for opioid naive (Figure 1B) and nonopioid-naïve patients (Figure 1C).

A significant reduction in median (IQR) dose of MMEs prescribed was also observed overall (300 (187.5-450) vs 225 (112.5-300) MMEs, P < .001) and for all procedures along with a decrease in variability as given by the IQR (Figure 2A) with the exception of single-level anterior cervical discectomy and fusion (ACDF) which showed an increase in median MMEs prescribed postguideline implementation that did not reach statistical significance (225 (150-450) vs 290(187.5-375) MMEs, P = .63). Similar findings were observed for opioid-naive (Figure 2B) and nonopioid naïve patients (Figure 2C).

Guideline Compliance and 30-day Postdischarge Refills

Guideline compliance was high in the postguideline cohort (93.4%). Had there been guidelines prior to guideline implementation, only 57.1% of discharge prescriptions would have qualified as "compliant." Multivariable logistic regression showed that guideline implementation was the strongest factor in predicting postdischarge prescription within guideline limits for both cervical (odds ratio [OR] = 10.80, confidence interval [CI] = 4.93-23.64, P < .001) and lumbar (OR = 12.50, CI = 7.77-20.11, P < .001) procedures. Among patients undergoing cervical procedures, anterior approaches (OR = 4.42, CI = 1.64-11.85, P = .003, ref = posterior) and decompression only procedures (OR = 2.62, CI = 1.02-6.72, P = .045, ref = arthrodesis) were associated with higher guideline compliance. For lumbar procedures, decompression alone was associated with higher guideline compliance (OR = 3.02, CI = 1.97-4.64, P < .001, ref = arthrodesis). Other factors such as age, sex, and number of operative levels were not found to be statistically significant (all P > .05) (Figure 3).

On univariate comparison, it was found that 30-d refill prescription rates decreased overall (24.4% vs 20.2%, P = .079) and also for most procedures following guideline implementation (Figure 4A). These findings were also observed following subgroup comparisons in opioid-naive (Figure 4B) and nonopioid-naïve patients (Figure 4C). On adjusted analysis, it was found that guideline implementation did not significantly impact the odds of refill prescription, for both cervical (OR = 0.68, CI = 0.37-1.26, P = .22, ref = preguideline) and lumbar cohorts (OR = 0.95, CI = 0.66-1.36, P = .78, ref = preguideline). Within the cervical spine surgery cohort, patients undergoing anterior approaches were less likely to receive a 30-d refill (OR = 0.26, CI = 0.11-0.60, P = .002, ref = posterior) (Figure 5A). Among those undergoing lumbar spine surgery, patients who were opioid-naive (OR = 0.63, CI = 0.45-0.89, P = .008, ref = preoperative opioid users) or who underwent decompression alone (OR = 0.38, CI = 0.26-0.56, P < .001, ref = arthrodesis) were less likely to require a refill prescription within 30 d of discharge. Age, sex, number of operative levels, and BMI did not impact the odds of 30-d refills (all P > .05) (Figure 5B).

DISCUSSION

Following implementation of evidence-based postoperative opioid prescribing guidelines within our department, we observed a significant decrease in proportion of patients discharged with opioid prescriptions following spine surgery. The median MMEs prescribed overall decreased by 25% (75 MMEs), which was the equivalent of 10 fewer pills of 5 mg oxycodone. Further, a

TABLE 2. Cohort Characteristics and Outcomes

	Preguideline (n = 569)	Postguideline (n = 624)	Total (n = 1193)	*P* value
Age				.1098
Median (IQR)	62.0 (50.0, 70.0)	62.0 (52.0, 73.0)	62.0 (51.0, 71.0)	
Last BMI before discharge				.3227
Median (IQR)	29.7 (26.0, 33.4)	29.3 (25.6, 33.3)	29.5 (25.8, 33.4)	
Gender				.1591
Male	376 (66.2%)	388 (62.3%)	764 (64.1%)	
Female	192 (33.8%)	235 (37.7%)	427 (35.9%)	
Race				.0256
White	525 (92.3%)	554 (88.8%)	1079 (90.4%)	
Black	6 (1.1%)	10 (1.6%)	16 (1.3%)	
Other	21 (3.7%)	19 (3.0%)	40 (3.4%)	
Unknown	17 (3.0%)	41 (6.6%)	58 (4.9%)	
Opioid-naïve				.8865
No	202 (35.5%)	224 (35.9%)	426 (35.7%)	
Yes	367 (64.5%)	400 (64.1%)	767 (64.3%)	
Any opioids prescribed at discharge				**< .0001**
No	42 (7.4%)	114 (18.3%)	156 (13.1%)	
Yes	527 (92.6%)	510 (81.7%)	1037 (86.9%)	
30-d refill				.0787
No	430 (75.6%)	498 (79.8%)	928 (77.8%)	
Yes	139 (24.4%)	126 (20.2%)	265 (22.2%)	
Oral morphine equivalents (OME), median (IQR)	300.0 (187.5, 450.0)	225.0 (112.5, 300.0)	240.0 (150.0, 375.0)	**< .0001**
Within guideline limits				**< .0001**
No	244 (42.9%)	41 (6.6%)	285 (23.9%)	
Yes	325 (57.1%)	583 (93.4%)	908 (76.1%)	
Procedure groups				**< .0001**
PCF: 1-4 levels	45 (7.9%)	55 (8.8%)	100 (8.4%)	
ACDF: single- level	26 (4.6%)	10 (1.6%)	36 (3.0%)	
ACDF: multi-level	11 (1.9%)	42 (6.8%)	52 (4.4%)	
Circumferential lumbar fusion: 3 level	3 (0.5%)	0 (0.0%)	3 (0.3%)	
ALF: single-level	1 (0.2%)	0 (0.0%)	1 (0.1%)	
ALF: multi-level	0 (0.0%)	7 (1.1%)	7 (0.4%)	
PLF: single-level	47 (8.3%)	19 (3.0%)	66 (5.5%)	
PLF: multi-level	41 (7.2%)	83 (13.3%)	124 (10.4%)	
2-Level	37 (6.5%)	60 (9.6%)	97 (8.1%)	
3-Level	3 (0.5%)	0 (0.0%)	3 (0.3%)	
4-Level	0 (0.0%)	23 (3.7%)	23 (1.9%)	
5-Level	1 (0.2%)	0 (0.0%)	1 (0.1%)	
Lumbar disc arthroplasty: 1 level	0 (0.0%)	3 (0.5%)	3 (0.3%)	
Lumbar disc arthroplasty: 2 level	0 (0.0%)	5 (0.8%)	5 (0.4%)	
Cervical decompression: 1-3 levels	69 (12.1%)	43 (6.9%)	112 (9.4%)	
Cervical decompression: 4 levels	0 (0.0%)	6 (1.0%)	6 (0.5%)	
Lumbar decompression: single-level	214 (37.6%)	119 (19.1%)	333 (27.9%)	
Lumbar decompression: multi-level	111 (19.5%)	232 (37.2%)	343 (28.8%)	

ACDF, anterior cervical discectomy and fusion, ALF, anterior lumbar fusion, PCF: posterior cervical fusion, PLF: posterior lumbar fusion.
Bold denotes statistical significance (P < =.05).

significantly smaller proportion of patients were discharged with an opioid prescription. It remains important to note that this decline in opioid prescribing was in tandem with preservation of 30-d refill rates, signaling patients were as likely postguideline implementation to take home a sufficient amount to control pain.

The present study represents the culmination of several quality improvement initiatives aimed at reducing postoperative opioid prescribing.[17] Prior to guideline development, a retrospective analysis of postoperative opioid prescriptions following the 25 most commonly performed elective surgical procedures was performed; 2 of which were relevant to spine surgery (lumbar

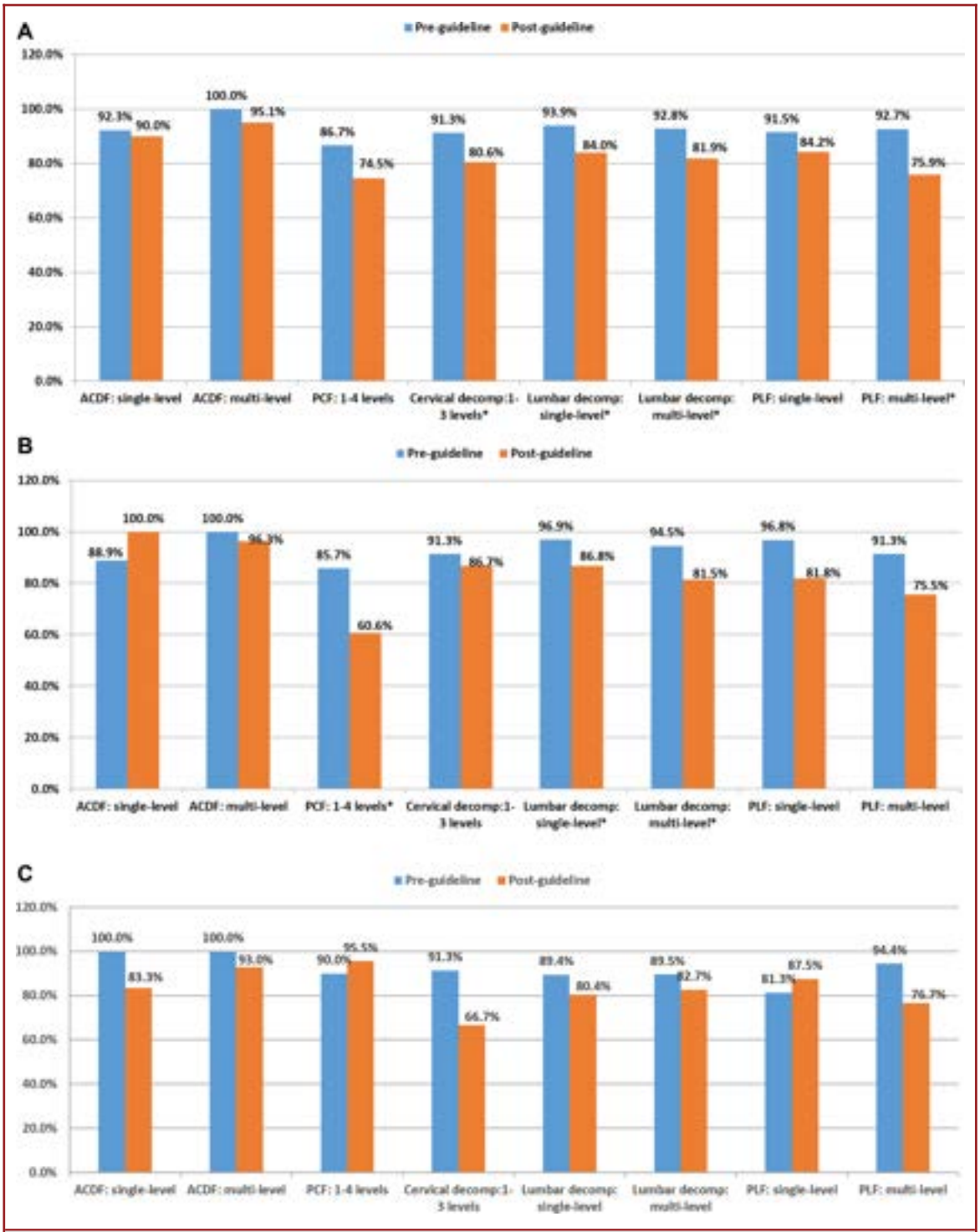

FIGURE 1. *Proportion of patients discharged with an opioid prescription in pre- and postguideline cohorts.* **A**, *All patients,* **B**, *opioid-naïve patients only, and* **C**, *nonopioid-naïve patients only. ACDF: anterior cervical discectomy and fusion, PLF: posterior lumbar fusion.∗ indicates* $P \leq .05$.

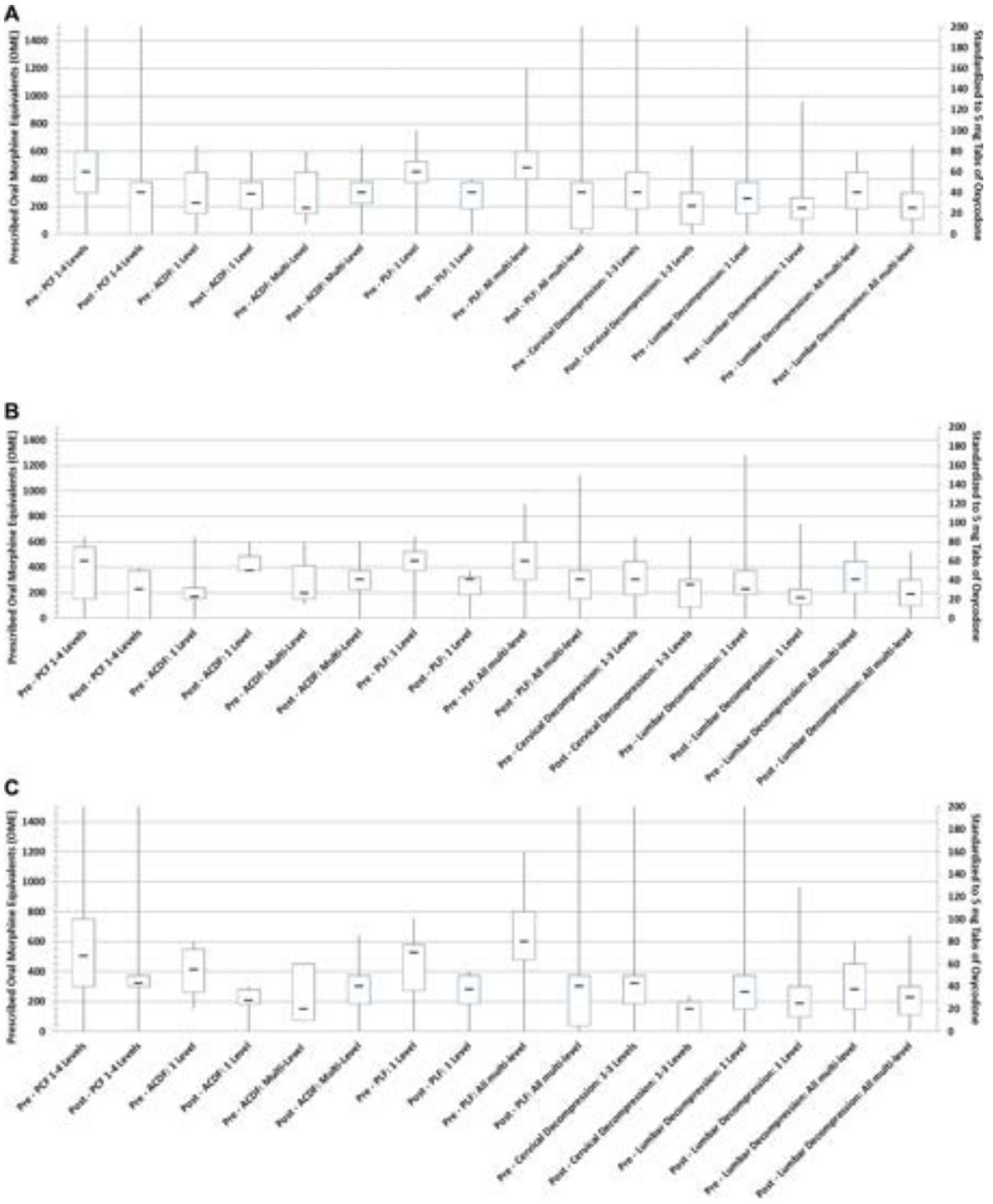

FIGURE 2. *Box plots comparing discharge opioid prescription practices between pre- and postguideline cohorts for* **A***, all patients,* **B***, opioid-naïve patients only, and* **C***, nonopioid-naïve patients only. ACDF: anterior cervical discectomy and fusion, PLF: posterior lumbar fusion.*

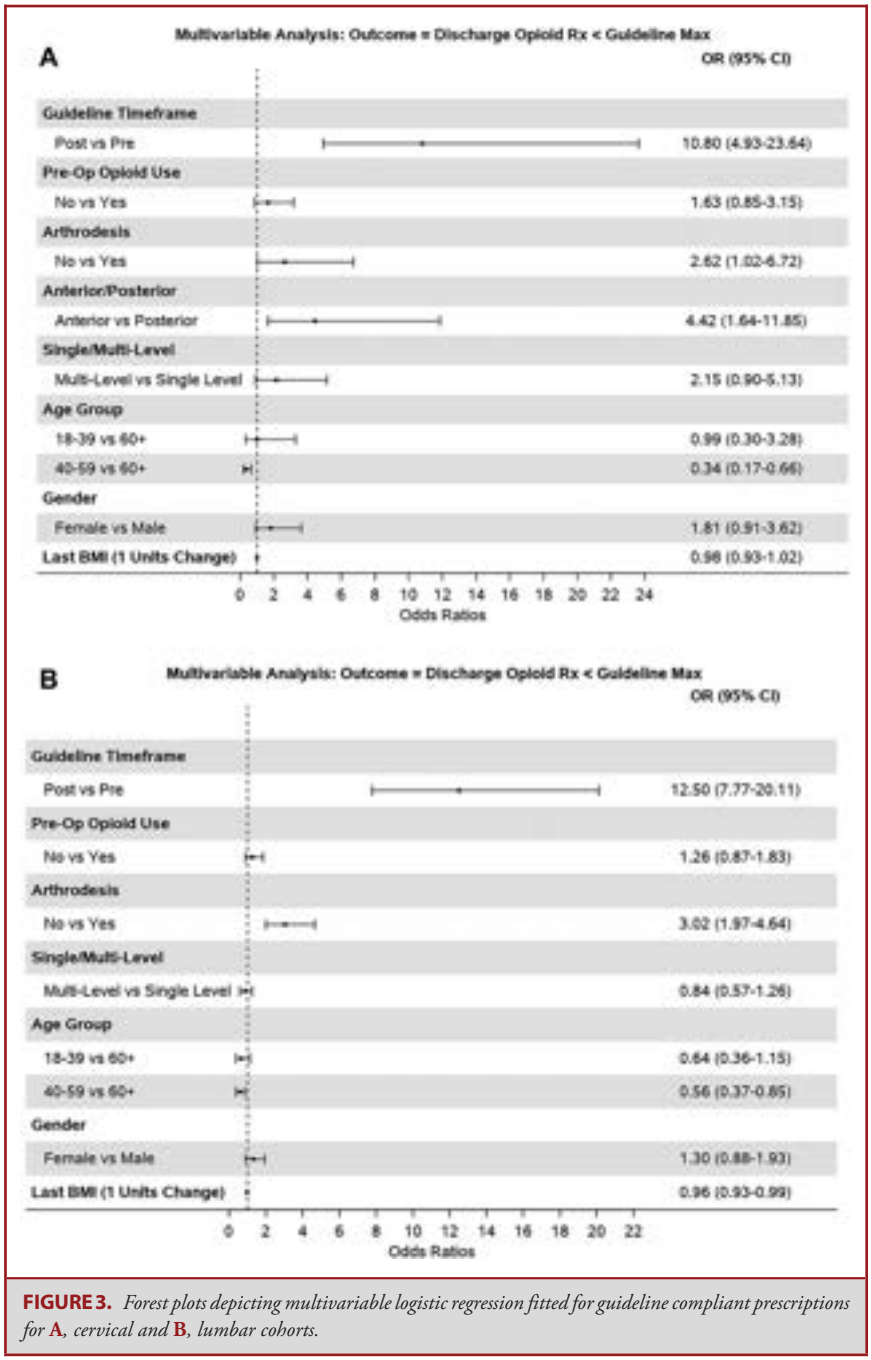

FIGURE 3. *Forest plots depicting multivariable logistic regression fitted for guideline compliant prescriptions for* **A**, *cervical and* **B**, *lumbar cohorts.*

laminotomy and lumbar laminectomy).[14] A wide variation in prescription practices for both procedures was found with the majority of patients (>80%) receiving an opioid prescription in excess of 200 MMEs. This was combined with another prospective study surveying patients undergoing the same procedures regarding their actual postoperative opioid consumption within 21 to 35 d following discharge.[18] The results indicated that a significant amount of opioids prescribed were unused following surgery. The findings from these analyses led to development and implementation of prescribing guidelines in other departments, including the general surgery practice[18] as well as cardiac surgery,[19] orthopedics,[20] urology,[21] and other surgical specialties, including neurosurgery as presented here.

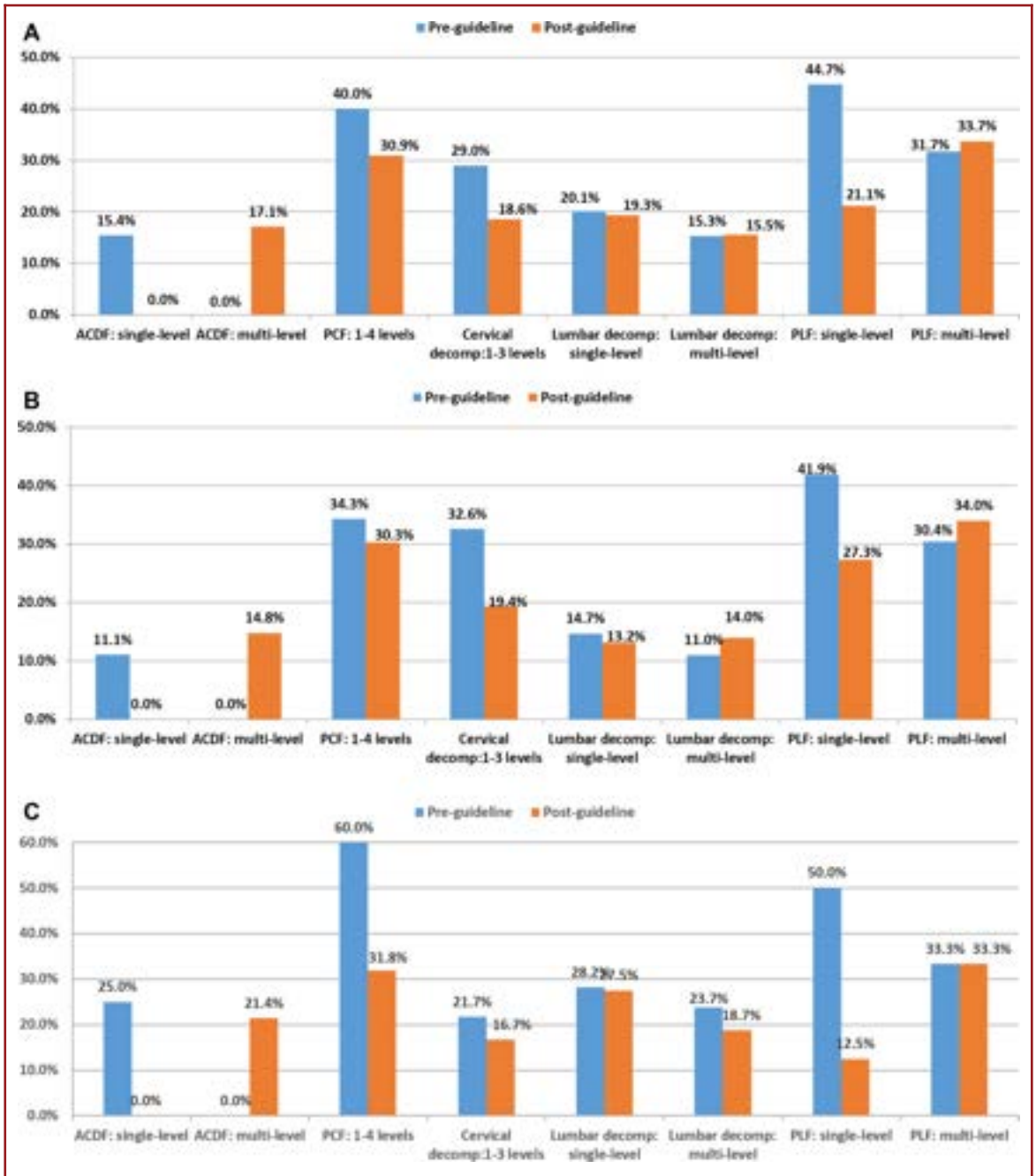

FIGURE 4. *Proportion of patients obtaining a refill prescription within 30 d of discharge for* **A**, *all patients,* **B**, *opioid-naïve patients only, and* **C**, *nonopioid-naïve patients only. ACDF: anterior cervical discectomy and fusion, PCF: posterior cervical fusion, PLF: posterior lumbar fusion.*

From orthopedic surgery, Wyles et al[20] assessed the impact of prescribing guidelines on postoperative discharge opioid prescriptions following total hip and total knee arthroplasty performed at our institution. Following guideline implementation, the authors found approximately a 50% decrease in median MMEs prescribed (750 vs 388 MMEs) with a preservation in 30-d refill rates (35% vs 35%). Howard et al[15] from the University of Michigan reported their experience with evidence-based opioid prescribing guidelines following laparoscopic cholecystectomy and reported a 70% reduction in median MMEs prescribed (200 vs 75 MMEs) after guideline implementation. In addition, following guideline implementation, there was a decline in 30-d refill

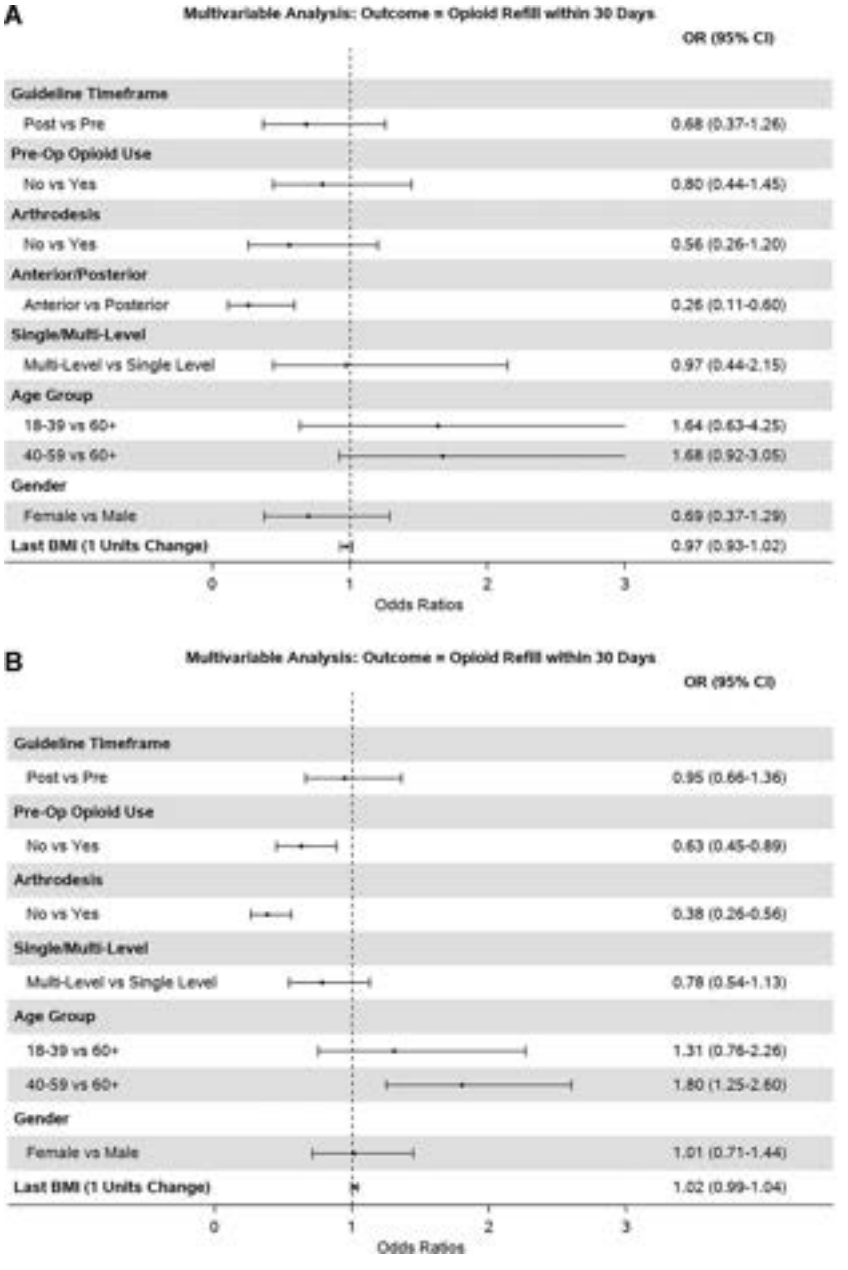

FIGURE 5. *Forest plots depicting multivariable logistic regression fitted for 30-d prescription refills for* **A**, *cervical and* **B**, *lumbar cohorts.*

rates (4.1% vs 2.5%) which was not statistically significant. The guideline development processes in both studies were similar to our initiative and were informed by patient reported postoperative opioid consumption and internal data on refill requests. Similar data from the Michigan Surgical Quality Collaborative (MSQC) showed a significant decrease in postoperative opioid prescribing following implementation of statewide procedure-specific prescribing guidelines for 9 elective general surgical procedures.[22] Another important finding from this analysis was that a decrease in postoperative discharge opioid prescribing was not associated with any clinically significant change in patient satisfaction or pain scores. Other results from spine surgery specific analyses include a recent report by Reid et al, which evaluated the impact of a statewide narcotic prescription limiting legislation

on postoperative opioid prescriptions following lumbar spine surgery.[23] The authors found a >50% decline in total number of pills and MMEs prescribed within 30 d postoperatively with no significant change in mean MMEs filled between 30 and 90 d. The Centers for Disease Control and other state legislatures have proposed mandatory guidelines to treat acute pain with opioid prescriptions < 7 d.[24,25] Although well-intentioned, a "one size fits all" approach would lack the procedure and practice specific granularity to provide optimum care. For instance, Park et al[26] observed a significant decline in postoperative opioid prescribing in patients undergoing spine surgery following enactment of opioid prescribing laws in the state of Michigan, but there was a slightly higher incidence for postoperative pain as a cause of readmission following surgery.

By contrast, to our knowledge, the present study is the first to evaluate a practice and procedure-specific initiative to reduce opioid prescribing following neurosurgery. An important element of the present initiative was a multidisciplinary approach to allow all possible unique perspectives and ensure buy in from all members of the care team.

It is important to be cognizant of the difference between inpatient opioid consumption and postdischarge opioid prescriptions, of which the latter formed the focus of our efforts. Practice initiatives such as enhanced recovery after surgery (ERAS) protocols and opioid sparing regimens for pain control do not address the problems with discharge opioid prescription practices, which are associated with unused leftover pills that may be diverted and misused as well as potential for new persistent opioid use.[27,28]

Limitations

There were limitations to our work. The present guidelines do not differentiate between opioid naive and preoperative opioid users. Further, the initiative undertaken by our department was aimed at the entire neurosurgical practice, including cranial and peripheral nerve surgery. The guidelines reported may therefore undergo change over time with accumulation of more longitudinal data to account for further procedure specificity and preoperative opioid use. For instance, consideration may be given in the future to re-organize some procedures such as single level ACDF, lumbar microdiscectomy, and Minimally invasive spine (MIS) laminectomy into tier 2 category. In addition, since we used CPT codes to identify procedures, we were unable to distinguish between MIS and open operations.

CONCLUSION

Findings from a single neurosurgical practice demonstrated that implementation of evidence-based, procedure-specific prescribing guidelines resulted in a decrease in opioid prescribing at discharge following common elective cervical and lumbar spine surgical procedures, without significant impact on 30-d prescription refills and with a high rate of guideline compliance. These data will be used to inform further guideline refinement and assess long-term compliance. The findings from this study may also help inform development and implementation of prescribing guidelines specific to other neurosurgical practices.

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