The Impact of State Level Public Policy, Prescriber Education, and Patient Factors on Opioid Prescribing in Elective Orthopedic Surgery: Findings From a Tertiary, Academic Setting

Daniel J. Cunningham, MD, MHSc; Steven Z. George, PT, PhD; and Brian D. Lewis, MD

Abstract

Background: The United States is in the midst of an opioid misuse epidemic. There have been recent changes to North Carolina's public policy leading to institutional education attempting to reduce high-risk opioid prescribing. This study investigated whether state-level and institutional efforts were associated with provider-level changes in opioid prescriptions after common orthopedic surgeries.

Patients and Methods: Six-week post-operative opioid prescribing in patients 18 years or older undergoing high-volume elective surgeries were reviewed retrospectively. Three patient cohorts from equivalent calendar year periods were included in this analysis; preceding policy implementation (January 1, 2017, to March 31, 2017), immediately after policy implementation (January 1, 2018, to March 31, 2018), and 1 year after policy implementation (January 1, 2019, to March 31, 2019). Multivariable models were constructed to evaluate the effects of public policy and institutional education on postoperative opioid prescribing.

Results: The mean (standard deviation) amount of oxycodone 5-mg equivalents prescribed at discharge decreased from 75.6 (53.2) in 2017 to 55.7 (36.2) in 2018 and then 45.6 (32.6) in 2019 ($P < .05$). Similarly, 6-week postoperative cumulative oxycodone 5-mg equivalents prescribed also significantly decreased from 123.3 (145.8) in 2017 to 84.1 (90.3) in 2018 and to 80.2 (150.1) in 2019. Other outcomes including prescription duration and rates of outlier prescribing showed similar trends.

Conclusion: In a North Carolina tertiary academic hospital, opioid prescribing decreased after public policy implementation and an institutional response of education for prescribers within a national context of changing practices in opioid prescribing. State-level public policy and prescriber education could be important avenues for decreasing postoperative opioid prescription in orthopedic settings.

 ■ Mayo Clin Proc Inn Qual Out 2021;5(1):23-34

Prescription opioid abuse and opioid-related deaths have reached a level deemed a public health crisis by the Centers for Disease Control and Prevention (CDC).[1-3] The risk of continued opioid usage at 1 year for patients receiving at least 1 day of opioid therapy for any reason has been reported at 6%.[4] In a meta-analysis of patients undergoing a wide range of general and subspecialty surgical procedures, 7% of patients continued to fill opioid prescriptions up to 3 months after surgery.[5] Following the 50 most common orthopedic procedures, 5.3% of opioid-naive patients have been estimated to go on to chronic opioid use,[6] and up to 35% of patients taking opioids before total knee arthroplasty developed chronic opioid use, defined as continuing opioid use for greater than 1 year.[7] There is an increased risk of development of chronic opioid use if a patient's initial prescription exceeds 10 days,[8] or 3-5 days in some reports[4]; this risk is increased in

From the Department of Orthopaedic Surgery, Duke University Medical Center, Durham, NC (D.J.C., S.Z.G., B.D.L.); and Duke Clinical Research Institute, Durham, NC (S.Z.G.).

patients with psychiatric distress and increased pain.[9,10] A short-duration, high total-day opioid prescribing pattern was associated with higher health care utilization and costs for patients receiving hip surgery, suggesting other consequences associated with opioid use.[7] Unfortunately, there is little available evidence to guide postoperative opioid prescriptions and even less consensus to define appropriate postoperative opioid dosages in orthopedic surgery.[11] However, it has been shown that high-risk opioid prescribing is common, and it can lead to overuse by the patient or diversion to others[12-16]; therefore, effective methods to limit extremes in opioid prescription are warranted.

The rising opioid epidemic in North Carolina led the state's legislature to draft and enact a bill targeting opioid prescribing entitled the "Strengthen Opioid Misuse Prevention (STOP) Act," which became active on January 1, 2018. Part of this legislation limited opioid prescriptions after all surgeries to a 7-day supply, and it required prescribers to check the North Carolina Controlled Substance Reporting System when prescribing opioid medications to ensure that their patients were not receiving opioid prescriptions from other providers. Importantly, this legislation did not dictate restrictions on quantities prescribed and allows individual providers to prescribe according to anticipated patient need. Other states have enacted similar laws with significant positive results on opioid prescribing.[17-19]

Because provider education has demonstrated significant results in reducing opioid prescriptions, the orthopedic surgery department at our institution undertook a project to reduce the amount of high-risk opioid prescribing within the department.[11,20,21] A committee within the department evaluated information regarding opioid prescribing after orthopedic procedures and identified a lack of education regarding opioids for both our providers and our patients. In response, educational materials regarding responsible opioid prescribing, opioid use, and North Carolina law were generated and distributed to practitioners and patients. However, no specific absolute limits on opioid prescribing were enacted.

The purpose of this study was to evaluate opioid prescribing patterns for common orthopedic surgeries before and after the implementation of the STOP Act to evaluate the effects of this legislation and departmental policies that arose to address the new law. The study hypothesis was that the implementation of these policies would be associated with an immediate decrease in the number of opioids prescribed from 2017 to 2018 and that the decrease would be sustained from 2018 to 2019. In addition, we hypothesized that patient factors would be associated with opioid prescribing patterns.

PATIENTS AND METHODS

Study Design

This study is a retrospective, observational study of opioid prescribing patterns before, during, and after the implementation of department-level and state-wide changes in opioid prescribing practice and policy. Information was obtained through data extraction by our institution's Analytics Center for Excellence of patients undergoing elective procedures across the divisions of the orthopedic surgery department. Procedure selection was based on each departments' highest-volume procedures through input of the division chiefs. The procedures included in this analysis reflected high-volume operations for which patients routinely received opioid medications. This study was designed and reported in accordance with the STROBE (Strengthen the Reporting of Observational Studies in Epidemiology) statement for cohort studies, which provides guidance for strengthening observational studies.[22]

Variables and Data Sources

Procedures included anterior cervical discectomy and fusion (ACDF), anterior cruciate ligament reconstruction (ACLR), carpal tunnel release (CTR), hallux valgus correction, lumbar microdiscectomy, rotator cuff repair (RCR), total ankle arthroplasty (TAA), total hip arthroplasty (THA), total knee arthroplasty (TKA), and trapeziectomy with suspensionplasty. Medical records for all patients undergoing the procedures listed above during January 1, 2017, to March 31, 2017, were reviewed through our institution's Analytics

Center of Excellence to establish a baseline cohort of the opioid quantity, type, and refills prescribed for these common procedures (2017 cohort). We believed that this timeframe was temporally isolated from institutional and public policy initiatives in our state. Similarly, two additional cohorts were derived from patients undergoing the previously mentioned procedures from January 1, 2018, to March 31, 2018, and January 1, 2019, to March 31, 2019. The dates in 2018 were selected to align with institutional education (completed by January 1, 2018) and legislation enactment (enacted on January 1, 2018), whereas the dates in 2019 were selected to evaluate the longitudinal effects of opioid-prescribing legislation and institutional efforts in a seasonally similar cohort.

The primary study outcomes were oxycodone 5-mg equivalents prescribed per patient at discharge through 6 weeks postoperative, initial discharge oxycodone 5-mg equivalents, opioid refills within 6 weeks postoperative, and initial discharge and 6-week cumulative minimum and maximum opioid days prescribed. Oxycodone 5-mg equivalents were calculated on the basis of opioid conversion factors made available through the CDC via initial conversion to oral morphine equivalents followed by conversion to oxycodone 5-mg equivalents for ease of interpretation.[23] Prescription day minimums and maximums were calculated (1) using the maximal allowable volume at the shortest interval duration and (2) using the minimum allowable volume at the longest interval duration. For example, a patient might have been prescribed 36 oxycodone pills at 1-3 oxycodone 5-mg pills every 4-6 hours as needed for pain. The minimum days prescribed would be calculated using a daily rate of 3 pills every 4 hours (18 pills per day), while the maximum days prescribed would be calculated using a daily rate of 1 pill every 6 hours (4 pills per day). The minimum days prescribed would be 2 days, whereas the maximum days prescribed would be 9 days.

Some surgeons prefer to provide their patients a prescription for opioid pain medications shortly before surgery so that patients do not have to visit the pharmacy on the day of their discharge from the hospital. To reflect this practice, prescriptions given within 30 days of an upcoming surgery without a discharge opioid prescription within 5 days after surgery were considered as prescriptions intended for postoperative use. In the absence of an accepted definition of outlier postoperative opioid prescribing, outlier prescriptions in this study were defined as 1.5 times the interquartile range (Q3-Q1) above the third quartile for the 2017 cohort. Procedure-specific outliers were also defined in the same statistical manner and analyzed in the Appendix (available online at http://mcpiqojournal.org). Preoperative opioid usage was defined as any opioid prescription within 90 days preoperatively, with the exception of prescriptions intended for postoperative usage.

Intervention

The STOP Act legislation dictated the following in regard to perioperative opioid prescriptions: "Practitioners cannot prescribe more than a five-day supply of any Schedule II or Schedule III opioid or narcotic upon the initial consultation and treatment of a patient for acute pain unless the prescription is for post-operative acute pain relief for immediate use following a surgical procedure, in which case the prescription cannot exceed a seven-day supply." In addition, prescribers were mandated to check their state's Controlled Substances Reporting System (CSRS) before prescribing opioid medications to evaluate for patients receiving opioid prescriptions from multiple providers. This legislation went into effect on January 1, 2018. Prescribers received training and education on this intervention approximately 3 months before legislation enactment from the study institution. Specifically, prescribers were provided a pamphlet on safe opioid prescribing, which included reiteration of the legislative mandates surrounding prescriber review of the North Carolina CSRS before initiating opioid therapy and 7-day supply maximum along with encouragement for prescribing daily doses less than 20 morphine milliequivalents per day. Institutional guidelines (but not mandates) were developed before January 1, 2018, for general categories of procedures based on best practices in specific surgeries, with a review of the literature where available and consensus building in regard to prescribing for individual procedures where no literature existed as follows: (1) small procedures

TABLE 1. Baseline Patient and Operative Factors for the 2017, 2018, and 2019 Cohorts[a,b]

Factor	2017 cohort (N = 1498)	2018 cohort (N = 1584)	2019 cohort (N = 1510)	*P* value
Age	60.5 (13.51)	60.5 (12.87)	61.2 (13.28)	.2
Female sex	861 / 1498 (57.5%)	879 / 1584 (55.5%)	890 / 1510 (58.9%)	.41
White ethnicity	1148 / 1498 (76.6%)	1251 / 1584 (79%)	1203 / 1510 (79.7%)	.043
Current smoking	129 / 1498 (8.6%)	139 / 1584 (8.8%)	109 / 1510 (7.2%)	.163
Body mass index (kg/m^2)	30.3 (6.39)	30.2 (5.92)	30.3 (6.37)	.94
Resident prescribed initial opioid	275 / 1498 (18.4%)	269 / 1584 (17%)	331 / 1510 (21.9%)	.013
Preoperative opioid prescription OMEs	145.1 (652.41)	90.9 (454.2)	111.3 (888.61)	.179
Any preoperative opioid prescription	405 / 1498 (27%)	349 / 1584 (22%)	317 / 1510 (21%)	<.001
Anterior cervical discectomy and fusion	256 / 1498 (17.1%)	293 / 1584 (18.5%)	265 / 1510 (17.5%)	.74
Anterior cruciate ligament reconstruction	38 / 1498 (2.5%)	57 / 1584 (3.6%)	49 / 1510 (3.2%)	.27
Carpal tunnel release	148 / 1498 (9.9%)	142 / 1584 (9%)	155 / 1510 (10.3%)	.72
Hallux valgus correction	86 / 1498 (5.7%)	97 / 1584 (6.1%)	84 / 1510 (5.6%)	.83
Lumbar microdiscectomy	83 / 1498 (5.5%)	90 / 1584 (5.7%)	94 / 1510 (6.2%)	.42
Rotator cuff repair	96 / 1498 (6.4%)	106 / 1584 (6.7%)	83 / 1510 (5.5%)	.3
Total ankle arthroplasty	70 / 1498 (4.7%)	77 / 1584 (4.9%)	76 / 1510 (5%)	.65
Total hip arthroplasty	308 / 1498 (20.6%)	306 / 1584 (19.3%)	289 / 1510 (19.1%)	.33
Total knee arthroplasty	379 / 1498 (25.3%)	372 / 1584 (23.5%)	372 / 1510 (24.6%)	.67
Trapeziectomy with suspensionplasty	34 / 1498 (2.3%)	44 / 1584 (2.8%)	43 / 1510 (2.8%)	.32
Postoperative aspirin	369 / 1498 (24.6%)	216 / 1584 (13.6%)	310 / 1510 (20.5%)	.005
Postoperative NSAID	276 / 1498 (18.4%)	361 / 1584 (22.8%)	324 / 1510 (21.5%)	.042
Postoperative acetaminophen	543 / 1498 (36.2%)	558 / 1584 (35.2%)	622 / 1510 (41.2%)	.005

[a]NSAID = nonsteroidal anti-inflammatory drug; OME = oral morphine equivalent.
[b]Overall *P* values shown. $P < .05$ indicates statistical significance.

(carpal tunnel release, trigger finger release), 10 pills of 5-mg hydrocodone/325-mg acetaminophen with no refills; (2) moderate procedures (shoulder arthroscopy, extremity fracture surgery), 20 pills of 5-mg hydrocodone/325-mg acetaminophen with 1 possible refill if needed; and (3) large procedures (spinal fusion), 90 pills of 5-mg hydrocodone/325-mg acetaminophen with up to two refills if needed (see Appendix for complete educational materials). In addition, educational materials were also distributed to patients (see Appendix available online at http://mcpiqojournal.org). Of note, there were no absolute limits on the volume of opioid prescriptions given the heterogeneity of surgical procedures.

Missing Data

All patients who underwent one of the selected procedures between the timeframes were evaluated. One outlier patient in the 2018 cohort with exceptionally high perioperative opioid utilization (14 opioid prescriptions within 6 weeks postoperatively totaling 14,866 oxycodone 5-mg equivalents) was excluded because of considerable effects on adjusted analyses. However, overall study inference was not altered when this patient was included in analysis. Otherwise, there were 17 of 4593 patients (0.37%) with incomplete data regarding smoking status or body mass index. This analysis included 4 of 1502 patients (0.27%) in the 2017 cohort, 6 of 1591 patients (0.38%) in the 2018 cohort, and 7 of 1517 patients (0.46%) in the 2019 cohort. Analyses of the primary study outcomes were performed with and without these patients and were found to be similar; therefore, these patients were excluded from final analyses to perform analyses on a complete-case basis.

Statistical Analysis

Descriptive statistics including means and standard deviations, medians, ranges, rates, and percentages were calculated. The primary study

TABLE 2. Opioid Prescribing Outcomes[a]

Factor	2017 cohort (N = 1498)	2018 cohort (N = 1584)	2019 cohort (N = 1510)	Overall test *P* value
Cumulative 6-week 5-mg oxycodone prescribed	123.3 (145.8)	84.1 (90.3)	80.2 (150.1)	<.001*,†
Initial prescription 5-mg oxycodone	75.6 (53.2)	55.7 (36.2)	45.6 (32.6)	<.001*,†,‡
Number of postoperative opioid prescriptions	1.6 (1.2)	1.5 (1.1)	1.6 (1.3)	.0414*,‡
More than one postoperative opioid prescription	557 / 1498 (37.2%)	483 / 1584 (30.5%)	478 / 1510 (31.7%)	<.001*,†
Cumulative prescription outlier (>260 oxycodone pills)	129 / 1507 (8.6%)	65 / 1593 (4.1%)	52 / 1492 (3.5%)	<.001*,†
Initial prescription outlier (>190 oxycodone pills)	21 / 1507 (1.4%)	7 / 1593 (0.4%)	3 / 1492 (0.2%)	<.001*,†
Initial prescription shortest duration (days)	6.2 (4.3)	5.2 (5.9)	4.7 (2.8)	<.001*,†,‡
Initial prescription longest duration (days)	12.4 (6.6)	10.1 (10.5)	8.2 (4.5)	<.001*,†,‡
6-week cumulative prescriptions shortest duration (days)	12.7 (15.6)	9.9 (13.9)	9.6 (13.6)	<.001*,†
6-week cumulative prescriptions longest duration (days)	22.6 (22.6)	16.9 (20.1)	14.9 (18.5)	<.001*,†,‡
Initial prescription shortest duration 7 days or shorter	1067 / 1498 (71.2%)	1389 / 1584 (87.7%)	1348 / 1510 (89.3%)	<.001*,†

*,†, and ‡ indicate significant differences ($P < .05$) in post hoc comparisons between 2017 and 2018, 2017 and 2019, and 2018 and 2019 groups, respectively. $P < .05$ indicates statistical significance.
[a]Cumulative 6-week prescription outliers were defined as greater than 260 pills, whereas initial prescription outliers were defined as greater than 190 pills.

outcomes were total oxycodone 5-mg equivalents prescribed per patient up to 6 weeks postoperatively, initial discharge oxycodone 5-mg equivalents prescribed, opioid refills up to 6 weeks postoperatively, outlier initial and 6-week cumulative prescriptions, and initial discharge and 6-week postoperative minimum and maximum days prescribed. The primary study predictor was whether the patient was part of the 2017, 2018, or 2019 cohorts. Analysis of variance and chi-squares analysis with 2 × 3 contingency tables were used as appropriate to assess the unadjusted associations of cohort year with continuous and categorical opioid outcomes. Student *t* tests and chi-squared analysis with 2 × 2 contingency tables were used to assess post hoc differences in continuous and categorical outcomes between the 2017 and 2018, 2018 and 2019, and 2017 and 2019 groups as appropriate. Multivariable linear and logistic regression main effects models were then constructed to provide adjustment for baseline covariates. Statistical analyses were performed in JMP Pro version 14.0 (SAS Institute, Cary, NC). Type I error rate was set at 0.05 to aid in interpreting results of the statistical analyses.

RESULTS

Table 1 displays the baseline patient and operative factors for the 2017, 2018, and 2019 cohorts. Patient characteristics for the cohorts were similar, with the exception of increased white ethnicity in the 2018 and 2019 cohorts compared with the 2017 cohort, increased resident involvement in initial prescriptions in the 2019 cohort, decreased number of preoperative opioid prescriptions and any preoperative opioid prescriptions in the 2018 and 2019 cohorts, decreased utilization of postoperative aspirin in the 2018 and 2019 cohorts, increased utilization of postoperative nonsteroidal anti-inflammatory drug (NSAID) in the 2018 and 2019 cohorts, and increased utilization of acetaminophen in the 2019 cohort.

Table 2 shows the study outcomes for the 2017, 2018, and 2019 cohorts. Compared with 2017, all opioid outcomes (initial and cumulative 6-week oxycodone, days prescribed, rates of more than one opioid prescription, rates of outlier prescriptions, and rates of initial prescription exceeding the 7-day threshold) were significantly lower in 2018. With exception of the number of postoperative opioid prescriptions, all opioid outcomes were also significantly lower in 2019 compared with 2017 (all $P < .05$). The initial prescription volume, initial prescription shortest and longest duration, and 6-week cumulative prescription longest duration were significantly lower in 2019 compared with 2018. The number of postoperative opioid prescriptions increased significantly in 2019 compared with 2018.

TABLE 3. Regression Coefficients for Cumulative Oxycodone 5-mg Equivalents Prescribed, Initial Oxycodone 5-mg Equivalents Prescribed, Binary Opioid Refill Prescriptions, Number of Opioid Refill Prescriptions, and Outlier Prescription[a,b]

Factor	Cumulative additional 6-week 5-mg oxycodone prescribed	Initial additional 5-mg oxycodone prescribed	Number of additional post-operative opioid prescriptions	More than one post-operative opioid prescription odds ratio	Cumulative prescription outlier odds ratio (>260 oxycodone pills)	Initial prescription outlier odds ratio (>190 oxycodone pills)	Initial prescription shortest duration additional days	Initial prescription longest duration additional days	6-week cumulative prescriptions shortest duration additional days	6-week cumulative prescriptions longest duration additional days	Initial prescription shortest duration 7-days or shorter odds ratio
2018 cohort	−9.7 (−14.6, −4.8; *P*≤.001)	−3.1 (−4.7, −1.6; *P*≤.001)	−0.04 (−0.09, 0.01; *P*=.086)	0.77 (0.65, 0.9; *P*=.001)	0.43 (0.3, 0.6; *P*≤.001)	0.28 (0.11, 0.7; *P*=.007)	−0.17 (−0.35, 0.02; *P*=.075)	−0.18 (−0.48, 0.12; *P*=.24)	−0.63 (−1.18, −0.07; *P*=.028)	−1.0 (−1.78, −0.22; *P*=.012)	3.03 (2.49, 3.68; *P*≤.001)
2019 cohort	−14.6 (−19.5, −9.7; *P*≤.001)	−13.4 (−14.9, −11.8; *P*≤.001)	0.04 (−0.01, 0.08; *P*=.131)	0.8 (0.68, 0.94; *P*=.008)	0.35 (0.25, 0.5; *P*≤.001)	0.12 (0.03, 0.41; *P*≤.001)	−0.67 (−0.86, −0.49; *P*≤.001)	−2.02 (−2.32, −1.71; *P*≤.001)	−0.98 (−1.55, −0.42; *P*≤.001)	−3.0 (−3.79, −2.22; *P*≤.001)	3.54 (2.89, 4.34; *P*≤.001)
Age	−1.2 (−1.5, −0.9; *P*≤.001)	−0.2 (−0.3, −0.1; *P*≤.001)	−0.01 (−0.01, −0.01; *P*≤.001)	0.99 (0.98, 0.99; *P*≤.001)	0.95 (0.94, 0.97; *P*≤.001)	0.96 (0.93, 0.99; *P*=.018)	0.02 (0.01, 0.03; *P*=.002)	0 (−0.02, 0.02; *P*=.67)	−0.08 (−0.12, −0.05; *P*≤.001)	−0.16 (−0.21, −0.11; *P*≤.001)	1.01 (1.01, 1.02; *P*≤.001)
Female sex	−2.7 (−6.2, 0.9; *P*=.14)	−2.1 (−3.2, −1; *P*≤.001)	0.01 (−0.02, 0.05; *P*=.4)	1.15 (1.01, 1.32; *P*=.041)	0.95 (0.72, 1.26; *P*=.72)	0.36 (0.16, 0.8; *P*=.013)	−0.04 (−0.18, 0.09; *P*=.53)	−0.14 (−0.36, 0.08; *P*=.22)	0.25 (−0.15, 0.66; *P*=.22)	0.14 (−0.43, 0.7; *P*=.64)	0.99 (0.84, 1.17; *P*=.93)
White ethnicity	−3.8 (−8.1, 0.5; *P*=.087)	0.4 (−0.9, 1.8; *P*=.53)	−0.05 (−0.09, −0.01; *P*=.015)	0.73 (0.62, 0.85; *P*≤.001)	0.87 (0.63, 1.2; *P*=.39)	1.56 (0.57, 4.25; *P*=.39)	0.03 (−0.13, 0.19; *P*=.72)	0.02 (−0.25, 0.29; *P*=.88)	−0.44 (−0.93, 0.05; *P*=.08)	−0.56 (−1.25, 0.13; *P*=.109)	0.92 (0.75, 1.13; *P*=.45)
Current smoking	8.9 (2.5, 15.3; *P*=.006)	1 (−1, 3; *P*=.32)	0.12 (0.06, 0.18; *P*≤.001)	1.49 (1.17, 1.88; *P*=.001)	1.99 (1.3, 3.03; *P*=.001)	2.39 (0.93, 6.15; *P*=.071)	−0.02 (−0.26, 0.23; *P*=.9)	−0.09 (−0.49, 0.3; *P*=.64)	1.05 (0.32, 1.78; *P*=.005)	1.23 (0.21, 2.26; *P*=.018)	0.99 (0.74, 1.32; *P*=.94)
Body mass index (kg/m^2)	0 (−0.6, 0.6; *P*=.93)	0 (−0.2, 0.2; *P*=.98)	0 (−0.01, 0; *P*=.57)	1.01 (1, 1.02; *P*=.075)	0.99 (0.97, 1.02; *P*=.52)	0.97 (0.91, 1.04; *P*=.35)	−0.01 (0.04, 0.01; *P*=.19)	−0.01 (−0.05, 0.02; *P*=.47)	−0.02 (−0.09, 0.04; *P*=.52)	−0.01 (−0.1, 0.09; *P*=.88)	0.99 (0.98, 1.01; *P*=.28)
Resident prescribed initial opioid	2.7 (−2.4, 7.8; *P*=.3)	0.6 (−1, 2.2; *P*=.5)	0.15 (0.1, 0.2; *P*≤.001)	1.7 (1.4, 2.07; *P*≤.001)	0.76 (0.47, 1.21; *P*=.25)	0.3 (0.06, 1.43; *P*=.13)	−0.03 (−0.22, 0.17; *P*=.79)	−0.3 (−0.62, 0.01; *P*=.06)	0.36 (−0.22, 0.94; *P*=.23)	−0.07 (−0.88, 0.74; *P*=.87)	1.02 (0.8, 1.3; *P*=.87)
Preoperative opioid prescription OMEs	0.1 (0, 0.1; *P*≤.001)	0 (0, 0; *P*≤.001)	0 (0, 0; *P*≤.001)	1 (1, 1; *P*=.004)	1 (1, 1; *P*≤.001)	1 (1, 1; *P*≤.001)	0 (0, 0; *P*≤.001)	0 (0, 0; *P*=.067)	0 (0, 0; *P*≤.001)	0 (0, 0; *P*≤.001)	1 (1, 1; *P*=.035)
Any preoperative opioid prescription	13.9 (9.5, 18.2; *P*≤.001)	0.8 (−0.6, 2.2; *P*=.24)	0.24 (0.2, 0.28; *P*≤.001)	2.25 (1.91, 2.65; *P*≤.001)	3 (2.21, 4.07; *P*≤.001)	3.26 (1.41, 7.56; *P*=.006)	0.12 (−0.04, 0.29; *P*=.152)	−0.02 (−0.29, 0.25; *P*-0.9)	2.44 (1.94, 2.94; *P*≤.001)	3.07 (2.36, 3.77; *P*≤.001)	0.93 (0.68, 1; *P*=.053)
Postoperative aspirin	−2.6 (−7.4, 2.3; *P*=.3)	−1.5 (−3.1, 0; *P*=.05)	0 (−0.05, 0.04; *P*=.89)	0.87 (0.72, 1.04; *P*=.119)	0.82 (0.56, 1.18; *P*=.28)	0.58 (0.19, 1.81; *P*=.35)	−0.06 (−0.25, 0.12; *P*=.5)	−0.46 (−0.76, −0.16; *P*=.003)	−0.11 (−0.67, 0.44; *P*=.69)	−0.08 (−0.86, 0.69; *P*=.83)	1 (0.79, 1.25; *P*=.99)
Postoperative NSAID	3.8 (−0.8, 8.5; *P*=.105)	2 (0.5, 3.5; *P*=.007)	0.02 (−0.03, 0.06; *P*=.49)	1.1 (0.92, 1.3; *P*=.3)	1.13 (0.81, 1.58; *P*=.46)	1.07 (0.42, 2.77; *P*=.89)	−0.02 (−0.19, 0.16; *P*=.83)	0.1 (−0.18, 0.39; *P*=.48)	0.46 (−0.07, 0.99, *P*=.089)	0.9 (0.16, 1.64; *P*=.018)	0.97 (0.77, 1.22; *P*=.79)

Continued on next page

TABLE 3. Continued

Factor	Cumulative additional 6-week 5-mg oxycodone prescribed	Initial additional 5-mg oxycodone prescribed	Number of additional post-operative opioid prescriptions	More than one post-operative opioid prescription odds ratio	Cumulative prescription outlier odds ratio (>260 oxycodone pills)	Initial prescription outlier odds ratio (>190 oxycodone pills)	Initial prescription shortest duration additional days	Initial prescription longest duration additional days	6-week cumulative prescriptions shortest duration additional days	6-week cumulative prescriptions longest duration additional days	Initial prescription shortest duration 7-days or shorter odds ratio
Postoperative acetaminophen	12.6 (8.3, 16.9; *P*≤.001)	6.5 (5.1, 7.8; *P*≤.001)	0.09 (0.05, 0.14; *P*≤.001)	1.4 (1.19, 1.64; *P*≤.001)	2.09 (1.51, 2.9; *P*≤.001)	1.55 (0.67, 3.61; *P*=.31)	−0.05 (−0.21, 0.11; *P*=.54)	0.65 (0.39, 0.92; *P*≤.001)	0.39 (−0.09, 0.88; *P*=.113)	1.78 (1.09, 2.46; *P*<0.001)	1.41 (1.16, 1.72; *P*≤.001)
Anterior cervical discectomy and fusion	14.9 (6, 23.9; *P*=.001)	13.6 (10.8, 16.5; *P*≤.001)	−0.03 (−0.12, 0.06; *P*=.5)	0.27 (0.21, 0.34; *P*≤.001)	0.23 (0.14, 0.37; *P*≤.001)	0.55 (0.15, 1.99; *P*=.37)	1.05 (0.71, 1.39; *P*≤.001)	1.71 (1.15, 2.27; *P*≤.001)	1.2 (0.17, 2.23; *P*=.022)	1.4 (−0.04, 2.84; *P*=.056)	0.47 (0.36, 0.62; *P*≤.001)
Anterior cruciate ligament reconstruction	−41.7 (−61.5, −21.9; *P*≤.001)	−9.8 (−16.1, −3.5; *P*=.002)	−0.38 (−0.57, −0.19; *P*≤.001)	0.18 (0.11, 0.29; *P*≤.001)	0.04 (0.01, 0.17; *P*≤.001)	n/c	−0.27 (−1.02, 0.48; *P*=.48)	−0.45 (−1.67, 0.78; *P*=.48)	−3.92 (−6.19, −1.65; *P*≤.001)	−5.07 (−8.25, −1.9; *P*=.002)	1.23 (0.64, 2.36; *P*=.6)
Carpal tunnel release	−36.3 (−47.9, −24.7; *P*≤.001)	−26.1 (−29.7, −22.4; *P*≤.001)	−0.28 (−0.39, −0.16; *P*≤.001)	0.13 (0.1, 0.18; *P*≤.001)	0.13 (0.06, 0.29; *P*≤.001)	0.32 (0.03, 3.36; *P*=.34)	−0.67 (−1.11, −0.23; *P*=.003)	−3.61 (−4.33, −2.89; *P*≤.001)	−1.86 (−3.19, −0.52; *P*=.006)	−5.85 (−7.71, −3.98; *P*≤.001)	1.64 (1.11, 2.43; *P*=.006)
Hallux valgus correction	−5.4 (−19.2, 8.4; *P*=.44)	−8.8 (−13.2, −4.4; *P*≤.001)	0.02 (−0.11, 0.16; *P*=.71)	0.29 (0.2, 0.4; *P*≤.001)	0.09 (0.03, 0.25; *P*≤.001)	n/c	−0.82 (−1.34, −0.3; *P*=.002)	−1.41 (−2.26, −0.55; *P*=.001)	−0.93 (−2.52, 0.65; *P*=.25)	−1.37 (−3.59, 0.84; *P*=.22)	1.11 (0.74, 1.68; *P*=.78)
Lumbar microdiscectomy	0.1 (−13.7, 13.8; *P*=.99)	3 (−1.4, 7.4; *P*=.177)	−0.07 (−0.2, 0.06; *P*=.28)	0.26 (0.19, 0.36; *P*≤.001)	0.16 (0.08, 0.32; *P*≤.001)	0.84 (0.18, 3.85; *P*=.83)	1.2 (0.68, 1.72; *P*≤.001)	0.67 (−0.18, 1.53; *P*=.123)	1.05 (−0.53, 2.63; *P*=.193)	−0.36 (−2.57, 1.85; *P*=.75)	0.48 (0.33, 0.69; *P*≤.001)
Rotator cuff repair	2.9 (−10.6, 16.3; *P*=.68)	5.8 (1.5, 10; *P*=.008)	0.08 (−0.05, 0.21; *P*=.24)	0.47 (0.35, 0.64; *P*≤.001)	0.09 (0.03, 0.26; *P*≤.001)	n/c	0.17 (−0.34, 0.68; *P*=.52)	3.21 (2.37, 4.04; *P*≤.001)	0.37 (−1.18, 1.91; *P*=.64)	4.04 (1.88, 6.2; *P*≤.001)	3.22 (1.91, 5.43; *P*≤.001)
Total ankle arthroplasty	5 (−10.4, 20.4; *P*=.52)	3.5 (−1.4, 8.4; *P*=.163)	0.01 (−0.14, 0.16; *P*=.88)	0.28 (0.19, 0.4; *P*≤.001)	0.25 (0.11, 0.61; *P*=.002)	0.85 (0.09, 8; *P*=.89)	−0.38 (−0.96, 0.21; *P*=.21)	−0.29 (−1.25, 0.67; *P*=.55)	−1.06 (−2.83, 0.71; *P*=.24)	−0.99 (−3.46, 1.48; *P*=.43)	0.97 (0.63, 1.5; *P*=.64)
Total hip arthroplasty	20.3 (10.9, 29.6; *P*≤.001)	13.1 (10.1, 16; *P*≤.001)	0.02 (−0.07, 0.11; *P*=.69)	0.3 (0.25, 0.37; *P*≤.001)	0.27 (0.18, 0.4; *P*≤.001)	1.25 (0.43, 3.59; *P*=.69)	−0.13 (−0.48, 0.23; *P*=.48)	0.92 (0.34, 1.5; *P*=.002)	−0.28 (−1.35, 0.79; *P*=.61)	0.49 (−1.01, 1.99; *P*=.52)	1.14 (0.88, 1.48; *P*=.53)
Trapeziectomy with suspensionplasty	−24.9 (−45.1, −4.7; *P*=.016)	−12.2 (−18.6, −5.8; *P*≤.001)	−0.05 (−0.25, 0.14; *P*=.59)	0.25 (0.16, 0.41; *P*≤.001)	0.1 (0.02, 0.54; *P*=.007)	n/c	−0.32 (−1.09, 0.44; *P*=.41)	−2.52 (−3.77, −1.27; *P*≤.001)	0.11 (−2.2, 2.42; *P*=.92)	−2.91 (−6.15, 0.33; *P*=.078)	0.99 (0.57, 1.73; *P*=.78)

[a]NSAID = nonsteroidal anti-inflammatory drug; OME = oral morphine equivalent.

[b]2018 and 2019 cohort outcomes reported compared to 2017 cohort. Procedures compared to total knee arthroplasty. "n/c" indicates odds ratio incalculable due to low event rate in target cohort (ie, no initial prescription outliers in anterior cruciate ligament reconstruction group). *P*<.05 indicates statistical significance.

As shown in Table 3, cumulative prescription volumes were increased in current smokers, patients with preoperative opioid usage, and patients with postoperative NSAID and acetaminophen prescriptions. It was decreased in the 2018 and 2019 cohorts and with increasing age. Initial prescription volumes were increased with pre-operative opioid usage and with post-operative NSAID and acetaminophen prescription but decreased with 2018 and 2019 cohorts, increased age, female sex, and aspirin prescription. The number of postoperative opioid prescriptions was increased with current smoking, resident prescription of initial opioid, preoperative opioid usage, and postoperative acetaminophen usage, but decreased with increasing age and white ethnicity. The odds of more than 1 postoperative prescription were significantly increased with female sex, current smoking, preoperative opioid usage, and postoperative acetaminophen prescription, but decreased with 2018 and 2019 cohorts, increased age, and white ethnicity. The odds of cumulative 6-week prescription outliers were increased with current smoking, preoperative opioid usage, and postoperative acetaminophen prescription, whereas it was significantly decreased in the 2018 and 2019 cohorts and with increased age. The odds of initial prescription outliers were increased with preoperative opioid usage but decreased with 2018 and 2019 cohorts, increased age, and female sex. In adjusted analyses, patients undergoing specific procedures—including ACLR, CTR, hallux valgus correction, and trapeziectomy with suspensionplasty—were prescribed fewer opioids compared with patients undergoing TKA. Conversely, patients undergoing ACDF, RCR, and THA were prescribed more opioids compared with patients undergoing TKA. Adjusted analyses also demonstrated decreased rates of additional opioid prescriptions and cumulative outlier prescribing in patients undergoing any non-TKA procedure. Initial prescription shortest duration was significantly increased with increasing age, preoperative opioid usage, and ACDF and lumbar microdiscectomy surgery, whereas it was significantly decreased in the 2019 cohort and in patients undergoing CTR and hallux valgus correction. Initial prescription longest duration was significantly increased in patients with postoperative acetaminophen and in patients undergoing ACDF, RCR, and THA, whereas it was significantly decreased in patients in the 2019 cohort, with postoperative aspirin, and in patients undergoing CTR, hallux valgus correction, or trapeziectomy with suspensionplasty. Six-week cumulative prescription shortest duration was significantly increased in current smokers, with preoperative opioid use, and in patients undergoing ACDF, whereas it was significantly decreased in patients in the 2018 and 2019 cohorts, with increased age, and in those undergoing ACL reconstruction and CTR. Six-week cumulative prescription longest duration was significantly increased in current smokers, with preoperative opioid use, in patients with postoperative NSAID or acetaminophen prescription, and in patients undergoing RCR, whereas it was significantly decreased in the 2018 and 2019 cohorts, with increasing age, and in patients undergoing ACL reconstruction and CTR. Finally, the odds of initial shortest prescription duration less than or equal to 7-days were significantly increased in the 2018 and 2019 cohorts, with increasing age, with postoperative acetaminophen, and in patients undergoing CTR or RCR, whereas it was significantly decreased (more likely to exceed 7-day supply) in patients with preoperative opioid prescriptions and in patients undergoing ACDF or lumbar microdiscectomy.

Appendix Table 1 (available online at http://mcpiqojournal.org) demonstrates reductions in cumulative 6-week opioid prescriptions in patients undergoing ACDF, ACLR, lumbar microdiscectomy, RCR, TAA, THA, and TKA. Initial prescription volumes were significantly reduced in all surgeries, with the exception of trapeziectomy with suspensionplasty. The number of opioid refills was significantly decreased in patients undergoing RCR, but it did not significantly differ for the other surgeries. Rates of at least one opioid refill were significantly reduced in patients undergoing ACDF, RCR, and TKA. Rates of procedure-specific outlier cumulative prescriptions were significantly decreased in patients undergoing ACDF, TAA, THA, and TKA. Rates of outlier initial prescriptions were significantly decreased in patients undergoing ACLR, CTR, THA, and TKA. See Appendix Table 1 (available online at http://mcpiqojournal.org) legend for procedure-specific outlier definitions.

DISCUSSION

This study identified reductions in perioperative opioid demand in patients undergoing common elective orthopedic surgeries after state-level public policy changes and prescriber education across multiple opioid prescribing dimensions: 6-week cumulative opioid prescription volume and duration, initial discharge opioid prescription volume and duration, opioid refills, and outlier prescriptions. These reductions were observed within a national context of increased attention on high-risk opioid prescribing and updates to practice guidelines for opioid prescribing.[24] Although we cannot infer causality given the design used in this study, the initial changes observed in 2018 were sustained, and there was even evidence to support they were enhanced 1 year after law enactment.

Preoperative opioid prescription and smoking status had notable effects on cumulative opioid usage and opioid refills. Although the effect of preoperative opioid use on postoperative opioid demand has been established in multiple orthopedic subspecialties,[10,13,25-29] the effect of smoking on opioid demand is less well documented. Smoking has biological and epidemiologic links to risk of chronic pain; therefore, the opioid usage and refills could be a proxy measure of inadequate pain relief. Specifically, several studies have demonstrated increased opioid utilization in smokers compared with nonsmokers[30,31] and higher pain levels and opioid requirements in smokers undergoing surgery compared with nonsmokers.[32,33] However, perioperative nicotine replacement was not associated with improvements in perioperative pain in smokers.[34]

In the present study, other factors such as age, sex, race, and body mass index had comparatively smaller effects on prescribing patterns. Despite their potential additive analgesic effect, postoperative acetaminophen and NSAID prescription was associated with increases in opioid prescription outcomes. It is possible that providers might have been prescribing these medications selectively to specific patients whom they perceived as high risk for elevated postoperative opioid demand or after procedures in which patients have been prescribed higher volumes of opioids, such as joint replacement or spinal fusion.

The United States is in the midst a growing epidemic of opioid misuse that has focused attention on opioid prescribers. Federal and state legislators have responded to these concerns by enacting various laws intended to reduce opioid waste. One example in North Carolina is the STOP Act, which became effective in January 1, 2018. This act targeted prescribing of controlled substances, such as opioids. The law limited first-time prescriptions of controlled substances for acute pain to a 5-day supply and postoperative prescriptions of controlled substances to a 7-day supply. Specific volumes of opioids equivalents were not legislated, which allowed prescribers freedom to modulate their postoperative and acute pain prescriptions toward anticipated patient need. Despite these freedoms, this study demonstrated sizeable reductions in perioperative opioid prescribing metrics, including the duration of opioid prescriptions, which was the target of the STOP Act.

These results add to a growing body of literature on the value of public policy and prescriber and patient education on reducing opioid consumption and unused opioids in the community. Other smaller studies have demonstrated reductions in opioid prescribing after outpatient hand surgery after prescriber education[11] and changes to prescriber order sets.[21] However, these results were limited to hand surgery patients. Reid et al described significant reductions in opioid prescriptions after TKA, rotator cuff repair, anterior cruciate ligament reconstruction, ankle fracture fixation, and lumbar discectomy after statewide legislation.[19] However, this study did not evaluate the longitudinal effect of this intervention, whereas our study reports continued and enhanced the effects of legislation and education on outcomes.

The orthopedic surgical literature is severely lacking in evidence- or consensus-based guidelines for opioid prescribing. Colleagues in general surgery have reported a consensus-driven limit on opioid prescribing after general surgical procedures, and even several orthopedic procedures, including arthroscopic partial meniscectomy, ACLR, RCR, and ankle fracture fixation (approximately 0-20 oxycodone 5-mg pills suggested).[35] We advocate for the development of evidence- or consensus-based recommendations targeted at clarifying appropriate postoperative prescribing for orthopedic surgical procedures.

The primary limitation of this study is related to its retrospective, uncontrolled design. Therefore, these findings cannot necessarily be used to support causal attributions for the effects of the state-level legislation or identification of any of the patient-level predictors for opioid prescriptions. Second, our study timeframes were pragmatically tailored to evaluate pre- and post-legislation and institutional response timeframes over 3 seasonally matched 3-month periods between 2017 and 2019. Although these timeframes were carefully selected to align with institutional and state-level legislation while addressing potential effects of seasonal differences in types of patients undergoing specific surgeries, it could have been helpful to include all possible patients over the 2017-2019 timeframe. However, our institution's review board requests focused samples sizes for retrospective studies, with limits set to approximately 5000 patients. Our time intervals complied with this request.

Other study limitations should be considered when interpreting these results. First, patients' opioid prescriptions could be evaluated only if they received their opioid prescription within our health care system. Although it is likely that patients received their discharge opioid prescriptions from their treating surgeon, it is possible that some patients received additional opioid medication from outside sources. We also do not have data on opioid consumption or patient-reported outcomes regarding pain control or patient satisfaction. To partially address this limitation, we have measured prescription refills as a surrogate for opioid usage that exceeded the initial prescription volume. Furthermore, we cannot be certain that patients were filling the opioid prescriptions that they were prescribed. The North Carolina Controlled Substances Reporting System maintains records of filled opioid prescriptions that can be checked by treating surgeons. However, because of the sensitive nature of this information the authors of this study could not obtain permission to use these records to compare opioid prescriptions to filled opioid prescriptions for the purposes of research despite multiple, thorough attempts through our institution and the North Carolina Department of Health and Human Services. Although these data have been reported in other studies, we were notified that collection and usage of this information for research would be illegal in North Carolina. Importantly, in this study it was difficult to separate out the individual effects of public policy and institutional responses in the broader national landscape of changing patient and prescriber perceptions of opioids. We did not have access to a suitable control group that could have helped to differentiate regional and national influences. Differentiation of influence from national and regional policies could be an important avenue for future research in opioid prescribing or other high-priority public health issues.

CONCLUSION

Our study highlights reductions in immediate and early postoperative opioid prescriptions, refills, outlier prescribing, and prescription durations after the initiation of prescriber education and state legislation within a broader national landscape of increased attention on opioid prescribing. Current smokers and patients with preoperative opioid usage had significant increases in perioperative opioid demand. This study highlights the potential influence of state-level legislation and prescriber education on reducing opioid prescribing. The nature of this study limits causal attribution, but our findings suggest that state legislation and prescriber and patient education could be important first steps to reduce the volume of opioid prescriptions that might go unused, even if specific upper boundaries for opioid prescribing are not legislated. These findings also indicate that more work is needed to establish appropriate guidelines regarding procedure-specific opioid prescription volumes.

SUPPLEMENTAL ONLINE MATERIAL

Supplemental material can be found online at http://mcpiqojournal.org. Supplemental material attached to journal articles has not been edited, and the authors take responsibility for the accuracy of all data.

Abbreviations and Acronyms: **ACDF** = anterior cervical discectomy and fusion; **ACLR** = anterior cruciate ligament reconstruction; **CDC** = Centers for Disease Control; **CSRS** = Controlled Substances Reporting System; **CTR** = carpal tunnel release; **NSAID** = nonsteroidal anti-inflammatory drug; **RCR** = rotator cuff repair; **STOP** = Strengthen Opioid Misuse and Prevention; **STROBE** = Strengthen the Reporting of Observational Studies in Epidemiology; **TAA** = total ankle arthroplasty; **THA** = total hip arthroplasty; **TKA** = total knee arthroplasty

Potential Competing Interests: There were no sources of funding for this study. While preparing this manuscript for publication, S.Z.G. received salary support from the Duke Endowment as part of the Duke School of Medicine Opioid Program portfolio.

Correspondence: Address to Daniel J. Cunningham, MD, MHSc, Duke University Medical Center, Department of Orthopaedic Surgery, 200 Trent Drive, Box 3000, Durham, NC 27710 (danieljocunningham@gmail.com).

ORCID
Daniel J. Cunningham: https://orcid.org/0000-0003-4192-4202

REFERENCES

1. Frieden TR, Houry D. Reducing the risks of relief–The CDC opioid-prescribing guideline. *N Engl J Med*. 2016;374(16): 1501-1504.
2. Morris BJ, Mir HR. The opioid epidemic: Impact on orthopaedic surgery. *J Am Acad Orthop Surg*. 2015;23(5):267-271.
3. Rudd RA, Seth P, David F, Scholl L. Increases in drug and opioid-involved overdose deaths - United States, 2010-2015. *MMWR Morb Mortal Wkly Rep*. 2016;65(50-51):1445-1452.
4. Shah AHC, Martin BC. Characteristics of initial prescription episodes and likelihood of long-term opioid use - United States, 2006-2015. *MMWR Morb Mortal Wkly Rep*. 2017;66(10):265-269.
5. Lawal OD, Gold J, Murthy A, et al. Rate and risk factors associated with prolonged opioid use after surgery: Systematic review and meta-analysis. *JAMA Network Open*. 2020;3(6): e207367.
6. Orfield NJ, Gaddis A, Russell KB, Hartman DW, Apel PJ, Mierisch C. New long-term opioid prescription-filling behavior arising in the 15 months after orthopaedic surgery. *J Bone Joint Surg Am*. 2020;102(4):332-339.
7. Cook CE, Rhon DI, Lewis BD, George SZ. Post-operative opioid pain management patterns for patients who receive hip surgery. *Subst Abuse Treat Prev Policy*. 2017;12(1):14.
8. Jones CM, Paulozzi LJ, Mack KA. Sources of prescription opioid pain relievers by frequency of past-year nonmedical use United States, 2008-2011. *JAMA Intern Med*. 2014;174(5):802-803.
9. Helmerhorst GT, Vranceanu AM, Vrahas M, Smith M, Ring D. Risk factors for continued opioid use one to two months after surgery for musculoskeletal trauma. *J Bone Joint Surg Am*. 2014; 96(6):495-499.
10. Bot AG, Bekkers S, Arnstein PM, Smith RM, Ring D. Opioid use after fracture surgery correlates with pain intensity and satisfaction with pain relief. *Clin Orthop Relat Res*. 2014; 472(8):2542-2549.
11. Stepan JG, Sacks HA, Lovecchio FC, et al. Opioid prescriber education and guidelines for ambulatory upper-extremity surgery: Evaluation of an institutional protocol. *J Hand Surg Am*. 2019; 44(2):129-136.
12. Hall AJ, Logan JE, Toblin RL, et al. Patterns of abuse among unintentional pharmaceutical overdose fatalities. *JAMA*. 2008; 300(22):2613-2620.
13. Cunningham D, Lewis B, Hutyra C, Nho S, Olson S, Mather R. Prospective, observational study of opioid use after hip arthroscopy for femoroacetabular impingement syndrome. *Arthroscopy*. 2018;34(5):1488-1497.e6.
14. Kim N, Matzon JL, Abboudi J, et al. A prospective evaluation of opioid utilization after upper-extremity surgical procedures: Identifying consumption patterns and determining prescribing guidelines. *J Bone Joint Surg Am*. 2016;98(20): e89.
15. O'Neil JT, Wang ML, Kim N, Maltenfort M, Ilyas AM. Prospective evaluation of opioid consumption after distal radius fracture repair surgery. *Am J Orthop (Belle Mead NJ)*. 2017;46(1):E35-E40.
16. Sabatino MJ, Kunkel ST, Ramkumar DB, Keeney BJ, Jevsevar DS. Excess opioid medication and variation in prescribing patterns following common orthopaedic procedures. *J Bone Joint Surg Am*. 2018;100(3):180-188.
17. Reid DBC, Shah KN, Shapiro BH, Ruddell JH, Akelman E, Daniels AH. Mandatory prescription limits and opioid utilization following orthopaedic surgery. *J Bone Joint Surg Am*. 2019; 101(10):e43.
18. Potnuru P, Dudaryk R, Gebhard RE, et al. Opioid prescriptions for acute pain after outpatient surgery at a large public university-affiliated hospital: Impact of state legislation in Florida. *Surgery*. 2019;166(3):375-379.
19. Reid DBC, Shah KN, Ruddell JH, et al. Effect of narcotic prescription limiting legislation on opioid utilization following lumbar spine surgery. *Spine J*. 2019;19(4):717-725.
20. Dwyer CL, Soong M, Hunter A, Dashe J, Tolo E, Kasparyan NG. Prospective evaluation of an opioid reduction protocol in hand surgery. *J Hand Surg Am*. 2018;43(6):516-522.e1.
21. Stanek JJ, Renslow MA, Kalliainen LK. The effect of an educational program on opioid prescription patterns in hand surgery: A quality improvement program. *J Hand Surg Am*. 2015;40(2): 341-346.
22. von Elm E, Altman DG, Egger M, et al. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: Guidelines for reporting observational studies. *Int J Surg*. 2014;12(12):1495-1499.
23. Centers for Disease Control and Prevention. Available at: https://www.cdc.gov/drugoverdose/data-files/CDC_Oral_Morphine_Milligram_Equivalents_Sept_2018.xlsx. Accessed July 13, 2019.
24. Dowell D, Haegerich TM, Chou R. CDC guideline for prescribing opioids for chronic pain–United States, 2016. *JAMA*. 2016; 315(15):1624-1645.
25. Bedard NA, Pugely AJ, Dowdle SB, Duchman KR, Glass NA, Callaghan JJ. Opioid use following total hip arthroplasty: Trends and risk factors for prolonged use. *J Arthroplasty*. 2017;32(12):3675-3679.
26. Bedard NA, Pugely AJ, Westermann RW, Duchman KR, Glass NA, Callaghan JJ. Opioid use after total knee arthroplasty: Trends and risk factors for prolonged use. *J Arthroplasty*. 2017; 32(8):2390-2394.
27. Pugely AJ, Bedard NA, Kalakoti P, et al. Opioid use following cervical spine surgery: Trends and factors associated with long-term use. *Spine J*. 2018;18(11):1974-1981.
28. Kalakoti P, Hendrickson NR, Bedard NA, Pugely AJ. Opioid utilization following lumbar arthrodesis: Trends and factors associated with long-term use. *Spine (Phila Pa 1976)*. 2018;43(17):1208-1216.

29. Jain N, Brock JL, Phillips FM, Weaver T, Khan SN. Chronic preoperative opioid use is a risk factor for increased complications, resource use, and costs after cervical fusion. *Spine J*. 2018; 18(11):1989-1998.

30. Hooten WM, Townsend CO, Bruce BK, Warner DO. The effects of smoking status on opioid tapering among patients with chronic pain. *Anesth Analg*. 2009;108(1):308-315.

31. John U, Alte D, Hanke M, Meyer C, Volzke H, Schumann A. Tobacco smoking in relation to analgesic drug use in a national adult population sample. *Drug Alcohol Depend*. 2006; 85(1):49-55.

32. Warner DO, Patten CA, Ames SC, Offord K, Schroeder D. Smoking behavior and perceived stress in cigarette smokers undergoing elective surgery. *Anesthesiology*. 2004;100(5):1125-1137.

33. Creekmore FM, Lugo RA, Weiland KJ. Postoperative opiate analgesia requirements of smokers and nonsmokers. *Ann Pharmacother*. 2004;38(6):949-953.

34. Turan A, White PF, Koyuncu O, Karamanliodlu B, Kaya G, Apfel CC. Transdermal nicotine patch failed to improve postoperative pain management. *Anesth Analg*. 2008;107(3):1011-1017.

35. Overton HN, Hanna MN, Bruhn WE, et al. Opioid-prescribing guidelines for common surgical procedures: An expert panel consensus. *J Am Coll Surg*. 2018;227(4): 411-418.