Limitations on Postoperative Opioid Prescriptions and Effects on Health Care Resource Use Following Elective Anterior Cervical Discectomy and Fusion

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■ OBJECTIVE: **To curb the misuse of postoperative prescription opioids, the state of North Carolina enacted the Strengthen Opioid Misuse Prevention (STOP) Act of 2017 limiting the duration of initial postoperative opioid prescriptions. The purpose of this study was to evaluate the STOP Act's effect on health care resource use by comparing patient outcomes and opioid prescribing practices following elective anterior cervical discectomy and fusion (ACDF).**

■ METHODS: **Outcomes and opioid prescribing data were retrospectively evaluated for Pre-Law (January 1, 2017, to December 31, 2017) and Post-Law (January 1, 2018, to December 31, 2018) elective 1- to 4-level anterior cervical discectomy and fusion patient cohorts. Outcome measures included hospital and clinic resource use in the form of emergency department visits, readmissions, major postoperative complications, number of clinic visits, or number of clinic phone calls by patients reporting uncontrolled pain or requesting new opioid prescriptions. Opioid-prescribing practices in the form of discharge prescription number of pills and total morphine milliequivalents also were recorded.**

■ RESULTS: **Surrounding the STOP Act's implementation, there was no significant difference ($P > 0.05$) in emergency department visits, readmissions, major complications, number of postoperative clinic visits, or number of clinic phone calls for uncontrolled pain or new prescription requests. There was a significant decline in mean discharge prescription number of pills (89.7 vs. 67.0, $P < 0.001$), and average morphine milliequivalents (683.4 vs. 509.6, $P < 0.001$).**

■ CONCLUSIONS: **This may reflect overprescribing in this population, where larger opioid prescriptions were likely not needed to manage pain that would otherwise require a return to care.**

INTRODUCTION

Inappropriate use of prescription opioids is a significant contributing factor to drug overdoses within the United States, resulting in 5.2 deaths per 100,000 population in 2017.[1] This same year, the opioid crisis was declared a public health emergency, with legislative action proposed to limit opioid prescribing practices in the United States.[2] Concurrently, many states enacted separate legislation aimed at postoperative opioid prescriptions as well as opioid prescriptions for acute pain.[3] While the exact restrictions imposed by these laws vary from state to state, a central feature is often a limitation placed on the duration or quantity of opioids following surgery or for episodes of acute pain.[4-6]

Previous work has shown a 5%—6% risk of long-term opioid use following an initial prescription in opioid-naive patients.[7-10] This risk also appears to be dose dependent, with both the number of prescriptions filled and the cumulative dose initially dispensed associated with long-term use.[7] Although overdoses related to elicit or synthetic opioid use are more common, approximately 40% of opioid-related overdose deaths involve prescription opioids within the United States.[1]

Between 2016 and 2017, the state of North Carolina had the largest relative increase in death rates from opioid-involved overdoses, with 39% of those deaths related to prescription opioid abuse.[1] In 2017, North Carolina enacted the Strengthen Opioid Misuse Prevention (STOP) Act into law.[10] Taking effect on

Key words
- ACDF
- Anterior cervical discectomy and fusion
- Opioids
- Postoperative pain

Abbreviations and Acronyms
ACDF: Anterior cervical discectomy and fusion
BMI: Body mass index
MME: Morphine milliequivalents
STOP: Strengthen Opioid Misuse Prevention

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January 1, 2018, the law limited the duration of postoperative opioid prescriptions to 7 days, with exceptions for patients receiving opioids for treatment of chronic pain or pain being treated as part of cancer care, hospice care, or palliative care.

Such legislation is of great interest for providers who frequently prescribe opioids for patient care in their surgical practice. Neurosurgeons and orthopedic surgeons are among the top prescribers of opioids,[11,12] with anterior cervical discectomy and fusion (ACDF) being one of the most common procedures performed by spine surgeons in both specialties.[13,14] Although indications for an ACDF may vary, patients undergoing elective ACDF for degenerative changes or disc herniations often present with painful radicular symptoms and may be receiving opioids prior to surgery. In addition, the role of opioids in postoperative pain control following spine surgery is standard, though the average appropriate dosage and duration of opioid prescriptions following ACDF is unclear. It is reasonable to be concerned that too little pain control would result in uncontrolled pain and return to care (i.e., readmission, emergency department visits, additional clinic visits, and phone calls), while too much would result in misuse or chronic use. In this study we examined clinical outcomes and prescribing practices surrounding the enactment of the North Carolina STOP Act in 2018 in our medical center. By comparing patients undergoing elective 1- to 4-level ACDF between January 1, 2017, to December 31, 2017 (pre-law) and between January 1, 2018, to December 31, 2018 (post-law) as pseudo-experimental cohorts, this study examined the effects of opioid prescription limiting legislation on clinic and hospital resource use.

METHODS

We performed a retrospective chart review of all patients older than 18 years old undergoing elective 1- to 4-level ACDF between January 1, 2017, to December 31, 2017 (pre-law) and between January 1, 2018, to December 31, 2018 (post-law). Patients were identified by querying for the Current Procedural Terminology code 22551. Patients undergoing combined anterior and posterior cervical surgery or extended cervicothoracic fusions were excluded. Basic demographic information was obtained including age at time of surgery, sex, body mass index (BMI), and type of insurance. Operative data included number of ACDF levels performed, surgeon specialty (neurosurgeon or orthopedic surgeon), length of stay, discharge disposition, emergency department visits within 90 days after surgery, readmission within 90 days, major postoperative complications, number of clinic visits within 90 days, and number of clinic phone calls related to pain control or request for opioid prescription refill within 90 days. Overlapping patients, or patients undergoing elective ACDF in both the pre-law and post-law period, were excluded. Opioid-prescribing data were obtained solely from the patient's electronic medical record, as access to a state-wide reporting database was not available for the entire length of the study. Patients receiving opioids at the time of surgery for management of chronic pain, defined as long-term pain management by a pain specialist, were excluded. Opioid-prescribing data included number of pills within and total morphine milliequivalents (MME) of discharge prescriptions, new prescriptions within 30 days, refill new prescriptions from 30 to 90 days postoperative, and prescriptions within 30 days before surgery. A post-hoc power analysis was performed with an alpha of 0.05 for the discharge prescription number of pills. Long-term postoperative was defined as receiving a new opioid prescription in the 30- to 90-day postoperative period. Opioid-naive patients were defined as those who did not receive any opioid prescriptions within 30 days before surgery. As the law limited the number of pills in a discharge prescription to 7 days, after the law's implementation a prescription could be written as 1 or 1–2 pills per dose for 7 days based on the provider's discretion, limiting duration but not quantity. Post-law prescribing variability was examined by evaluating the proportion of patients who received 42 pills or less (a maximum of 1 pill dosed every 4 hours for 7 days) in both cohorts, and outcomes of those patients who received 42 pills or less versus those who received greater than 42 pills in the post-law cohort.

Continuous variables were compared using Student t tests, and categorical variables were compared with χ^2 analysis or Fisher exact test (when greater than 20% of cells had a value less than 5). Backwards stepwise multiple logistic regression modeling was performed to determine factors independently associated with receiving a new opioid prescription at 30 days postoperative, as well as receiving an opioid prescription in the 30- to 90-day postoperative period after adjusting for confounding variables. All statistics and figure modeling were performed using JMP Pro 14 (JMP, Version 14; SAS Institute Inc., Cary, North Carolina, USA). Our project was reviewed and approved by our institutional review board before chart review.

RESULTS

A total of 122 patients were identified in the pre-law cohort, and 107 patients were identified in the post-law cohort. Five patients with chronic pain were identified/excluded in the pre-law group, and 4 were identified/excluded in the post-law group, leaving 117 and 103 patients for the pre-law and post-law cohort analysis, respectively. **Table 1** shows the pre-law and post-law patient characteristics. There were no significant differences between the groups ($P > 0.05$) in terms of age, sex, BMI, surgeon specialty, insurance, or number of levels fused.

As summarized in **Table 2**, the groups did not differ in terms of length of stay (1.5 days for both pre-law and post-law, $P = 0.923$). Patients in both cohorts were most likely to be discharged home (92.3% and 86.4% pre-law and post-law) with no significant differences in disposition mix ($P = 0.352$). No patients in either group were discharged to a skilled nursing facility. There was also no significant difference in emergency department visits within 90 days (6.8% and 6.8% pre-law and post-law, $P = 0.990$), readmissions within 90 days (1.7% and 1.9% pre-law and post-law, $P = 0.898$), or average number of clinic follow-up appointments within 90 days (2.1 and 2.0 pre-law and post law, $P = 0.185$). The 2 major postoperative complications in the pre-law group were both postoperative hematomas requiring surgical evacuation. The single major post-operative complication in the post-law group was also a postoperative hematoma requiring surgical evacuation. Together, there was no difference in major postoperative complications between the groups (1.7% and 1.0% pre-law and post-law, $P = 0.633$). Finally, there were no differences in the average

Table 1. Pre-law and Post-law Patient Characteristics

	Pre-law (N = 117)	Post-law (N = 103)	All Patients (N = 220)	*P* Value
Age, years, mean (SD, 95% CI)	53.7 (11.6, 51.6—55.8)	56.2 (11.6, 53.9—58.5)	54.9 (11.6, 53.4—56.4)	0.108
Sex male, N (%)	67 (57.3%)	62 (60.2%)	129 (58.6%)	0.683
BMI, mean (SD, 95% CI)	29.8 (6.1, 28.6—30.9)	30.7 (6.4, 29.6—31.9)	30.2 (6.3, 29.4—31.1)	0.254
Surgeon specialty				0.993
Neurosurgeon, N (%)	58 (49.6%)	51 (49.5%)	109 (49.5%)	
Orthopedic surgeon, N (%)	59 (50.4%)	52 (50.5%)	111 (50.5%)	
Insurance, N (%)				0.272
Private	53 (45.3%)	40 (38.8%)	93 (42.3%)	
Medicare	20 (17.1%)	21 (20.4%)	41 (18.6%)	
Medicaid	20 (17.1%)	16 (15.5%)	36 (16.4%)	
DOC	7 (6.0%)	12 (11.7%)	19 (8.6%)	
Charity care/self-pay	17 (14.5%)	12 (11.6%)	29 (13.2%)	
VA	0 (0.0%)	2 (1.9%)	2 (0.9%)	
Number of levels fused, N (%)				0.399
1	41 (35.0%)	35 (34.0%)	76 (34.5%)	
2	51 (43.6%)	45 (43.7%)	96 (43.6%)	
3	23 (19.7%)	17 (16.5%)	40 (18.2%)	
4	2 (1.7%)	6 (5.8%)	8 (3.6%)	

SD, standard deviation; CI, confidence interval; BMI, body mass index; DOC, Department of Corrections; VA, Veteran Affairs.

number of clinic phone calls (0.4 and 0.5 pre-law and post-law, $P = 0.569$) or number of patients making clinic phone calls regarding uncontrolled pain or requesting a refill prescription (24.8% and 24.3% pre-law and post-law).

After the law's implementation, there was a significant decline in number of pills prescribed with the discharge prescription (89.7 and 67.0 pre-law and post-law, $P < 0.001$) as well as the total MME of the discharge prescription (683.4 and 509.6, pre-law and

Table 2. Clinical Outcomes of Pre-law and Post-law Groups

	Pre-law (*N* = 117)	Post-law (*N* = 103)	All Patients (*N* = 220)	*P* Value
Length of stay, days, Mean (SD, 95% CI)	1.5 (1.1, 1.3—1.8)	1.5 (1.4, 1.3—1.7)	1.5 (1.3, 1.3—1.7)	0.923
Discharge disposition, *N* (%)				0.352
Home	108 (92.3%)	89 (86.4%)	197 (0.89%)	
DOC	8 (6.8%)	12 (11.6%)	20 (8.1%)	
Rehab	1 (0.9%)	2 (1.9%)	3 (1.4%)	
Emergency department visit within 90 days, N (%)	8 (6.8%)	7 (6.8%)	15 (6.8%)	0.99
Readmission within 90 days, N (%)	2 (1.7%)	2 (1.9%)	4 (1.8%)	0.898
Major postoperative complication, N (%)	2 (1.7%)	1 (1.0%)	3 (1.4%)	0.633
Number of clinic visits within 90 days, mean (SD, 95% CI)	2.1 (0.5, 2.0—2.2)	2.0 (0.7, 1.9—2.1)	2.1 (0.6, 1.9—2.1)	0.185
Number of clinic phone calls related to pain or new prescription request, mean (SD, 95% CI)	0.4 (0.8, 0.2—0.5)	0.5 (1.0, 0.2—0.7)	0.4 (0.9, 0.3—0.5)	0.569
Patient phone call related to pain or new prescription request, N (%)	29 (24.8%)	25 (24.3%)	54 (24.5%)	0.93

SD, standard deviation; CI, confidence interval; DOC, Department of Corrections.

post-law, P < 0.001) (Table 3). A post-hoc power analysis with an alpha of 0.05 and our sample size and prescribing pill standard deviation demonstrated that we were well powered (power >0.9) to detect any difference greater than 10 pills. All patients except for 1 in the post-law cohort received opioid prescriptions at discharge. The variability in the number of pills prescribed at discharge increased in the post-law cohort (standard deviation 18.3 vs. 22.8, pre-law and post law) as did the variability in total MME of the discharge prescription (standard deviation 167.4 vs. 172.1 pre-law and post-law). The number of patients receiving a new prescription within 30 days of discharge significantly declined after the law's implementation (37.6% and 25.2% pre-law and post-law, P = 0.048). The number of new prescriptions within 30 days of discharge did not differ between the groups (0.5 and 0.3 pre-law and post-law). However, the total number of new pills prescribed within 30 days did decline (34.4 and 19.8 pre-law and post-law, P = 0.026) as did the total MME for new scripts written within 30 days (229.0 and 133.8 pre-law and post-law, P = 0.035). The number of patient receiving new prescriptions in the 30- to 90-day postoperative period did not significantly differ (25% and 19% pre-law and post-law, P = 0.588), nor did the average number of prescriptions written in the time period (0.3 and 0.3 pre-law and post law, P = 0.866), the average number of pills prescribed (16.9 and 16.9 pre-law and post law, P = 0.992), or the average MME for these prescriptions (114.7 and 100.9 pre-law and post-law, P = 0.718). Significantly fewer patients received an opioid prescription within 30 days before surgery in the post-law group (17.1% and 7.8% pre-law and post-law, P = 0.035). Post-law prescriptions received 30 days before surgery were significantly fewer in average total number (0.2 and 0.1 pre-law and post-law, P = 0.024) and number of pills (10.1 and 3.6 pre-law and post-law, P = 0.027), although there was no significant difference in total MME (71.8 vs. 37.9 pre-law and post-law, P = 0.206).

There was a continuous decline in the average total number of pills and MME for discharge prescriptions over the 2-year period (Figure 1). These declines began before the law's January 1, 2018, implementation date and continued into the subsequent year.

Variables that were found to be significant independent predictors of receiving a new prescription within 30 days and between 30 and 90 days' postoperatively by backwards stepwise logistic regression are listed in Table 4. Undergoing a 4-level ACDF was an independent predictor of receiving a new prescription within 30 days (odds ratio 9.59), as was receiving an opioid prescription 30 days before surgery (odds ratio 3.02). The only independent predictor of new prescriptions in the 30- to 90-day postoperative period (long-term use) was receiving an opioid prescription within 30 days before surgery (odds ratio 4.50).

The increased variability with regards to discharge MME and number of pills in the post-law cohort was analyzed by subgroup analysis of those who received 42 pills or fewer versus those who

Table 3. Pre- and Post-Law Opioid Prescription Data

	Pre-Law (*N* = 117)	Post-Law (*N* = 103)	*P* Value
Discharge prescription			
Number of pills, mean (SD, 95% CI)	89.7 (18.3, 86.3—93.0)	67.0 (22.8, 62.6—71.5)	**<0.001**
Total MME, mean (SD, 95% CI)	683.4 (167.4, 652.8—714.1)	499.9 (172.1, 466.2—533.5)	**<0.001**
Patients receiving 42 pills or fewer at discharge, *N* (%)	4 (3.4%)	27 (26.2%)	**<0.001**
New prescriptions within 30 days postoperative			
Number of patients receiving new prescriptions, *N* (%)	44 (37.6%)	26 (25.2%)	**0.048**
Number of new prescriptions, mean (SD, 95% CI)	0.5 (0.7, 0.3—0.6)	0.3 (0.6, 0.2—0.4)	0.096
Number of pills, mean (SD, 95% CI)	34.4 (54.2, 24.5—44.3)	19.8 (42.2, 11.5—28.0)	**0.026**
Total MME, Mean (SD, 95%CI)	229.0 (368.8, 161.4—296.5)	133.8 (297.9, 75.6—192.0)	**0.035**
New prescriptions from 30—90 days postoperative			
Number of patients receiving new prescriptions, *N* (%)	25 (21.37%)	19 (18.45%)	0.588
Number of new prescriptions, mean (SD, 95% CI)	0.3 (0.6, 0.2—0.4)	0.3 (0.8, 0.1—0.4)	0.866
Number of pills, mean (SD, 95% CI)	16.9 (41.9, 9.2—24.6)	16.9 (54.2, 6.3—27.5)	0.992
Total MME, mean (SD, 95% CI)	114.7 (281.3, 63.2—166.2)	100.9 (271.0, 47.9—153.9)	0.713
Preoperative prescriptions 30 days before surgery			
Number of patients with a preoperative prescription, *N* (%)	20 (17.1%)	8 (7.8%)	**0.035**
Number of prescriptions, Mean (SD, 95% CI)	0.2 (0.6, 0.1—0.4)	0.1 (0.3, 0.0—0.2)	**0.024**
Number of pills (SD, 95% CI)	10.1 (27.4, 5.1—15.1)	3.6 (14.9, 0.7—6.5)	**0.027**
Total MME, mean (SD, 95% CI)	71.8 (214.9, 32.5—111.2)	37.9 (181.4, 2.5—73.4)	0.206

Bold values are statistically significant.
SD, standard deviation; CI, confidence interval; MME, morphine milliequivalents.

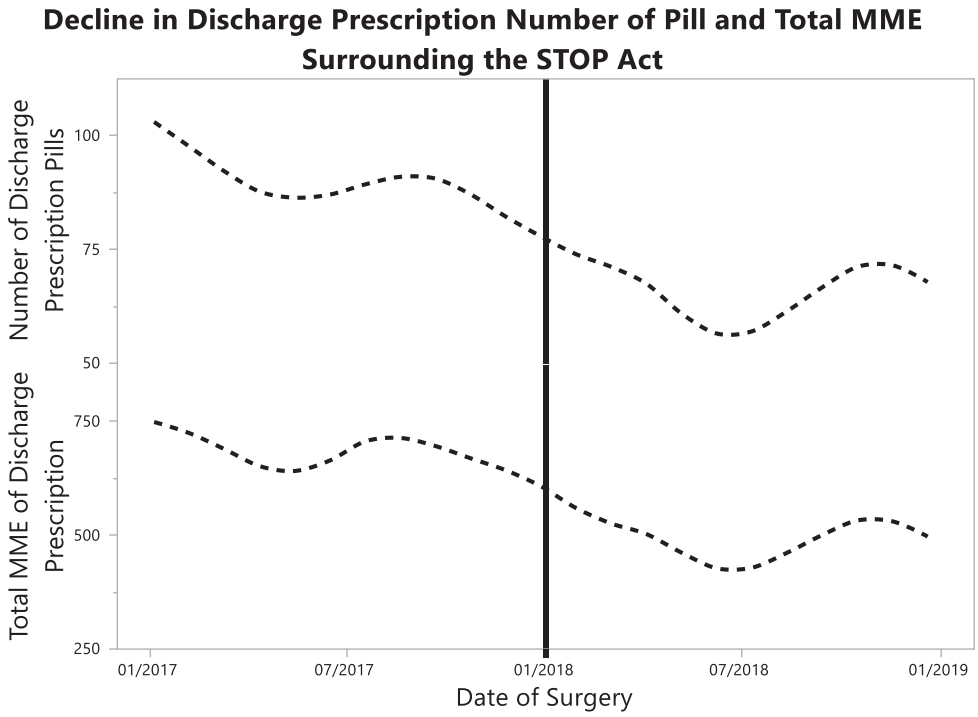

Figure 1. Decline in discharge prescription number of pill and total MME surrounding the STOP Act. The *vertical black line* marks the date of implementation for the STOP Act: January 1, 2018. MME, morphine milliequivalents; STOP Act, Strengthen Opioid Misuse Prevention Act.

received more than 42 pills at discharge. Within the pre-law cohort, 4 patients (3.4%) received 42 or fewer pills with their discharge prescription, compared with 27 patients (26.2%) in the post-law cohort ($P < 0.001$). Table 5 compares clinical characteristics of patients in the post-law cohort who received 42 pills or fewer versus those who received more than 42 pills at discharge. Patients who received 42 pills or fewer did not significantly differ in terms of age, BMI, or type. Patients receiving 42 pills or fewer tended to be male ($P = 0.005$) and were less likely to have undergone a 3- to 4-level fusion ($P < 0.001$). Outcomes of patients who received fewer than 42 pills compared with those who received more than 42 pills in the post-law cohort did not differ ($P > 0.05$) (Table 6).

DISCUSSION

Surrounding implementation of the STOP Act, discharge prescriptions following elective ACDF were reduced in terms of both

Table 4. Significant Independent Variables Associated with Receiving a New Opioid Prescription within 30 Days Postoperatively or within the 30 to 90 Days' Postoperative Period (Multiple Logistic Regression)

	Odds Ratio	*P* Value	95% CI
30 days' postoperative			
Received opioid prescription within 30 days before surgery	3.02	0.008	1.33—6.84
4-Level ACDF	9.59	0.004	1.74—53.00
Discharge to DOC	0.20	0.018	0.04—0.97
30—90 days' postoperatively			
Received opioid prescriptions within 30 days before surgery	4.50	<0.001	1.95—10.39

Nonsignificant variables included surgeon specialty, patient age, patient body mass index, patient gender, insurance type, length of stay, ACDF between 1 and 3 levels, and disposition other than DOC.

CI, confidence interval; ACDF, anterior cervical discectomy and fusion; DOC, Department of Corrections.

Table 5. Clinical Characteristics of Post-Law Patients Receiving 42 Pills or Fewer Versus More Than 42 Pills at Discharge

	Received 42 Pills or Fewer with Discharge Prescription (*N* = 27)	Received More than 42 Pills with Discharge Prescription (*N* = 76)	*P* Value
Age, mean (SD, 95% CI)	54.4 (11.1, 48.7—60.1)	56.9 (14.3, 54.5—59.2)	0.415
Sex male, *N* (%)	10 (37%)	52 (68%)	**0.005**
BMI, mean (SD, 95% CI)	30.1 (6.9, 27.3—32.9)	31.0 (6.2, 29.6—32.3)	0.604
Surgeon specialty			**0.037**
Neurosurgeon, *N* (%)	18 (66.7%)	33 (43.4%)	
Orthopedic surgeon, *N* (%)	9 (33.3%)	43 (56.6%)	
Insurance, *N* (%)			0.746
Private	13 (48.1%)	27 (35.5%)	
Medicare	5 (18.5%)	16 (21.1%)	
Medicaid	4 (14.8%)	12 (15.8%)	
DOC	2 (7.4%)	2 (13.2%)	
Charity care/self-pay	3 (11.1%)	9 (11.8%)	
VA	0 (0.0%)	2 (2.6%)	
Number of levels fused, *N* (%)			**<0.001**
1	17 (63.0%)	18 (23.7%)	
2	10 (37.0%)	35 (46.1%)	
3	0 (0.0%)	17 (22.4%)	
4	0 (0.0%)	6 (7.9%)	

Bold values are statistically significant.
SD, standard deviation; CI, confidence interval; BMI, body mass index; DOC, Department of Corrections; VA, Veteran Affairs.

average number of pills prescribed and average total MME. In addition, the number of refills prescribed within 30 days of surgery declined, as did the total number of refill pills and average refill MME in this time period. Concurrently, there was no increase in hospital or clinic resource use in terms of emergency department visits, readmissions, major complications, number of follow-up clinic visits, and number of clinic phone calls by patients reporting uncontrolled pain or requesting new prescriptions. Taken together, this suggests that state legislation aimed at limiting postoperative opioid prescriptions may in part be successful in reducing the prescribed number of pills and total MME following elective ACDF without undue effects on patient outcomes or clinical resource usen by compliant health care systems from a health care system's perspective. In addition, this may reflect an area of overprescribing in this population, with the lack of change to post-operative resource use suggesting patient's postoperative pain was managed successfully with fewer opioids.

The number of patients receiving new opioid prescription within the 30-day postoperative period declined in the post-law cohort (37.6% and 25.2% pre-law and post-law, P = 0.048). Many providers feared that limitations on discharge opioid prescriptions would result in an increase in early refill requests given the smaller discharge prescriptions for the post-law cohort. It is possible that the decline in new prescriptions was the result of a greater awareness of opioid prescribing practices within the time period, given both the implementation of a state law and national coverage of the opioid crisis.[2] Indeed, the number of pills prescribed at discharge as well as discharge MME began to decline in 2017 prior to the law's implementation with a continued decline in 2018 as seen in Figure 1. This may have been in anticipation of the law or a reflection of a greater awareness of opioid prescribing practices, patient counseling, and expectation-setting aside from legislative restrictions. In addition, there was a decline in patients receiving opioid prescriptions within 30 days before surgery in the post-law group (17.1% and 7.8% pre-law and post-law, P = 0.035). Again, this could reflect a widespread change in overall prescribing practices at the hospital system, with opioids increasingly less likely to be prescribed across the 2-year study time period.

Significant independent predictors of receiving new prescriptions within 30 days postoperatively included receiving a 4-level ACDF (odds ratio 9.59, 8 patients total) and receiving an opioid prescription within 30 days before surgery (odds ratio 3.02, 28 patients total). As a 4-level ACDF is a more extensive procedure with likely a greater amount of soft tissue and muscle manipulation, it is reasonable that this would independently predict a new prescription in the early post-operative period. Furthermore, is it also probable that the patients likely suffered from more extensive

Table 6. Clinical Outcomes of Post-Law Patients Receiving 42 Pills or Fewer Versus More Than 42 Pills at Discharge

	Received 42 Pills or Fewer with Discharge Prescription (*N* = 27)	Received More than 42 Pills with Discharge Prescription (*N* = 76)	*P* Value
Length of stay, days, mean (SD, 95% CI)	1.7 (0.4, 0.3–1.0)	1.4 (0.3, 0.1–1.2)	0.372
Discharge disposition, *N* (%)			0.05
Home	23 (85.2%)	66 (86.8%)	
DOC	2 (7.4%)	10 (13.2%)	
Rehab	2 (7.4%)	0 (0%)	
Emergency department visit within 90 days, *N* (%)	2 (8.0%)	5 (6.5%)	0.884
Readmission within 90 days, *N* (%)	1 (4.0%)	1 (1.3%)	0.469
Major postoperative complication, *N* (%)	0 (0.0%)	1 (1.3%)	0.434
Number of clinic visits within 90 days, mean (SD, 95% CI)	1.9 (0.4, 1.6–2.2)	2.0 (0.5, 1.9–2.1)	0.323
Patient phone call related to pain or new prescription request, *N* (%)	6 (22.2%)	19 (25.0%)	0.771
New prescription within 30 days, *N* (%)	6 (22.2%)	20 (26.3%)	0.671
New prescription within 30–90 days, *N* (%)	6 (22.2%)	13 (17.1%)	0.562

SD, standard deviation; CI, confidence interval; DOC, Department of Corrections.

spinal pathology or deformity for these larger procedures. For patients discharged to the Department of Corrections, subsequent prescriptions were managed by the facility and would not have been captured by our study, explaining the significantly low odds ratio. Opioid use within 30 days before surgery was an independent predictor of both a new prescription within the 30-day postoperative period as well as long-term postoperative opioid use (odds ratio of 3.02 and 4.05, respectively). This finding confirms that of multiple studies looking at the effects of opioid prescription limits: 1) preoperative opioid use is associated with prolonged post-operative use; and 2) limiting opioid discharge prescriptions may have a limited effect on long-term use in the setting of pre-operative use.[4-6] However, given the smaller sample size of patients within the variable categories, our data are limited in their generalizability.

Within the 30- to 90-day postoperative period, we found no significant difference in the number of new prescriptions, average number of pills prescribed, and average MME. This is corroborated by similar studies that show no continued decline in prescription size and number beyond 30 days for common spine procedures.[5,6] As such, while opioid limiting legislation may be associated with a reduction in the number of unutilized opioids in the immediate postoperative period, it may have only a limited effect on reducing long-term postoperative opioid use.

Interestingly, variability in prescribing practices increased in the post-law period during the first 30 days. Before this, it was assumed that an additional effect of the law would be to make prescribing practices more consistent; however, this did not occur. Providers began to frequently prescribe either 1 pill every 4 hours for 7 days (42 pills) or 1–2 pills every 4 hours for 7 days (84 pills). In addition, while prescriptions of more than 84 pills were largely reduced in the post-law period, prescriptions with fewer than 42 pills became more frequent adding to the variability seen in that time period. By restricting duration but not dosing, the law had limited effect on reducing provider prescribing variability. Given the variable nature in which similar state laws are written nationwide, overall effects on prescriber practices may vary by state as well.[15,16]

There are limitations to this study limit the scope of the conclusions. First, there was no access to a state reporting system for narcotic prescriptions for the entirety of the time period studied. All the opioid prescriptions studied were written within the hospital system with data extracted from the patient's medical record. As such, durable conclusions regarding opioid naivety cannot be made, as patients may have been receiving chronic opioids prior to surgery from a provider outside of the hospital system. It was not possible to identify if a patient went on to receive narcotic prescriptions elsewhere after surgery, which limits our conclusions regarding long-term use. In addition, while practitioners prescribing narcotics in North Carolina are required to assess whether the patient is receiving similar medications from other sources using the state pharmacy database, enforcement of this rule at the time of the study was inconsistent. Irrespective of these limitations, the conclusions regarding postoperative resource use from the service line and hospital system perspective are sound. The population of this study was also largely patients undergoing 1- to 2-level ACDFs, and at baseline likely have a lower need for post-operative opioids. Further work is needed on patient populations that have more significant pain management requirements surrounding opioid prescribing limitations, such as deformity correction patients. Future work will use the state reporting system to capture a broader perspective of preoperative and postoperative opioid use, both within and outside a single hospital system. The study is limited to a single set of procedures performed within a single hospital system. Although it captured patients undergoing surgery from 6 different providers across 2

surgical specialties, the external validity and generalizability of these results to other procedures and clinical settings may be limited. Lastly, this study also takes only the perspective of the hospital system in terms of resource use, without inclusion of patient-reported outcomes that were not retrospectively available for the time period studies.

CONCLUSIONS

Surrounding the implementation of state legislation limiting postoperative opioid prescription duration, there was no associated increase in clinical resource use in the form of emergency department visits, readmissions, major postoperative complications, number of clinic visits, or number of clinic phone calls by patients reporting uncontrolled pain or requesting new prescriptions by patients undergoing elective ACDF. Hospital system prescription data revealed a significant decline in postoperative prescriptions, with preoperative prescriptions independently associated with refills and prolonged postoperative opioid use. Taken together, this reflects an area of overprescribing in this population, where opioid prescriptions were likely not needed to manage pain that would otherwise require a return to care.

CRediT AUTHORSHIP CONTRIBUTION STATEMENT

Brice A. Kessler: Conceptualization, Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Brainard Burrus:** Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Greeshma Somashekar:** Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Samuel P. Wurzelmann:** Methodology, Formal analysis, Data curation, Writing - original draft, Writing - review & editing. **Deb Bhowmick:** Conceptualization, Methodology, Supervision.

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