Association Between a Statewide Medicaid Opioid Policy and Postoperative Opioid Prescribing among Surgeons at a Large Safety-Net Hospital

Irene Y. Zhang

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Joshua M. Liao

Edwin S. Wong

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Abstract

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Chair of the Supervisory Committee:

Joshua M. Liao

Department of Health Systems and Population Health

Background: Restrictive state and payer policies may be effective in reducing opioid prescribing by surgeons, but their impact has not been well studied. In 2017, Washington Medicaid implemented an opioid prescribing limit of 42 pills, prompting a large regional safety-net hospital to implement a decision support intervention in response. We aimed to evaluate the effects on surgeons' prescribing.

Study Design: We retrospectively studied postoperative opioid prescribing (quantity of pills prescribed at discharge) to opioid-naïve surgical patients at a regional safety-net hospital from 2016 to 2020. We investigated associations between the policy and opioid prescribing using interrupted time series analysis (ITSA), adjusting for clinical and sociodemographic factors.

Results: 12,799 surgical encounters involving opioid-naïve patients (59% male, mean age 52) were analyzed. Opioids were prescribed for 75%. From 2016 to 2020, the mean prescribed opioid quantity decreased from 36 pills to 17 pills. In ITSA, the Medicaid policy implementation was associated with an immediate change of -8.4 pills (95% CI -12 to -4.7, $p<0.001$) per prescription and a subsequent rate of decrease similar to that pre-policy. Comparing changes between patients insured through Medicaid versus Medicare, Medicaid patients had an immediate change of -9.8 pills (95% CI -19 to -0.76, $p=0.03$) after policy implementation and continued decreases similar to those pre-policy. No immediate or subsequent policy-related changes were observed among Medicare patients.

Conclusion: In a large regional safety-net institution, postoperative opioid prescriptions decreased in size over time, with immediate changes associated with a state Medicaid policy and corresponding decision support intervention. These findings pose implications for surgeons, hospital leaders and payers seeking to address opioid use via judicious prescribing.

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Introduction

Surgeons represent an important group of prescribers for opioid medications. Prescribing by surgeons can account for 22% of all new opioid prescriptions, with high total and daily opioid amounts compared with clinicians in other specialties (1). Moreover, 6 to 10% of opioid-naïve surgical patients subsequently develop new persistent use, filling at least one opioid prescription between 90 and 180 days postoperatively (2, 3).

Together with the fact that larger opioid prescriptions can increase the risks of long-term use, overdose, and diversion, these findings underscore postoperative prescribing as a potential target area for addressing opioid use and outcomes (2–9). Accordingly, a number of states have enacted policies to restrict opioid prescribing, including in the postoperative setting (10). In 2017, the Washington Health Care Authority implemented a major statewide policy that sought to limit the quantity of pills allowed in new opioid prescriptions written in all settings for Medicaid beneficiaries (11, 12).

Despite early descriptions about how surgeons prescribe opioids, less is known about contemporary trends in prescribing among surgeons within the past five years – an important period over which the clinical and policy communities have evolved in their response to the opioid epidemic. Additionally, while prior work has assessed prescribing for Medicaid patients (13, 14), there is a dearth of knowledge about postoperative opioid prescribing in safety-net hospitals, settings that are critical for serving not only Medicaid patients, but also other historically marginalized and high-need groups. Both knowledge gaps – about contemporary trends and postoperative prescribing in safety-net settings – also limit insight about if and how state policies have influenced opioid prescribing by surgeons.

In this analysis, we aimed to address these gaps by describing contemporary trends in postoperative opioid prescribing at one of the largest safety-net hospitals in the western United States, and evaluating changes in postoperative opioid prescribing as a result of practice changes implemented in response to the 2017 Washington Medicaid policy.

Methods

Study Design

We conducted a retrospective analysis of postoperative opioid prescribing at a large, regional safety-net hospital in Washington. This study was approved by the University of Washington Institutional Review Board.

Changes in Opioid Prescribing Policy and Implementation

On November 1, 2017, Washington State implemented a policy limiting new opioid prescriptions to 42 pills or equivalent liquid formulation doses for Medicaid patients age 21 and older, and 18 pills for those 20 years old and younger (11, 12). Patients exempt from this policy included those undergoing active cancer treatment, in hospice, palliative or end-of-life care, or other medically indicated diagnoses. Patients with chronic pain on opioids – defined as patients who had filled 90 days of opioids in the prior 120 days as of November 1, 2017 – were also exempted (11, 12).

In response to this policy, a large, regional safety-net hospital implemented an institution-wide clinical decision support intervention within its electronic health record (EHR). The intervention (a) alerted clinicians whenever an opioid prescription for any patient was larger than the policy limits (42 pills for age 21 and older, or 18 pills for ages 18-20), (b) informed them about the opioid policy including that it was directed at Medicaid patients, and (c) required clinicians to either cancel, modify, or provide justification for the prescription (eFigure 1). This alert was the only way in which this policy was implemented in the hospital system.

Data Source and Sample

Data were obtained from the institutional enterprise data warehouse, a repository of demographic, clinical, and administrative data drawn from the electronic health record. The study sample consisted of hospital encounters involving adult patients (age 18 years or older) undergoing any surgical procedure between September 1, 2016 and September 31, 2020.

A set of inclusion and exclusion criteria were used to identify the study sample. As the intent was to analyze the prescribing behavior of surgeons relating to new opioid prescriptions for acute, postoperative pain, the sample was limited to encounters involving opioid-naïve patients – defined by no recorded prescription or documented home medication containing an opioid class medication (15, 16) (eTable 1) in the 365 days prior to and including the date of surgery. Additionally, atypical encounters involving re-operations with multiple surgical dates within a single hospital encounter, preoperative or postoperative hospital length of stay greater than 30 days, or discharge by a non-surgical service were excluded. Encounters involving patients with missing payer information and uninsured patients were excluded. Patients who had opted out of all research at the time of their clinical care were also excluded per institutional policy. The final sample included 12,799 surgical encounters among 12,025 patients over the 4-year period.

Descriptive Characteristics

Encounter-level characteristics were described using mean and standard deviation (SD) or median and interquartile range (IQR) for continuous variables, and frequencies and percentages for categorical variables. Information on sex, race, and ethnicity including the classifications reported were obtained from the EHR. In addition to the primary outcome for opioids detailed below, we also described the prescription of any opioid medication (15, 16) (eTable 1) at discharge and the prescription of any non-opioid adjunct pain medications – acetaminophen, non-steroidal anti-inflammatory drugs (NSAIDs), and gabapentin (eTable 1).

Study Outcome and Variables

The primary outcome was the quantity of opioids prescribed at discharge for the index surgical encounter, defined as the number of pills or 5mL volume amounts, consistent with the definition in the 2017 Washington Medicaid opioid prescribing policy (12). The analysis included all opioid class medications with indications for use in acute pain management (eTable 1) (15, 16).

Covariates were specified *a priori* and included factors that have been linked to opioid prescribing decisions in other contexts – patient age, sex, race, ethnicity, chronic pain (17–23). In addition, we adjusted for factors plausibly associated with postoperative opioid prescribing – Elixhauser comorbidity index, cancer diagnosis, surgery division/department, and postoperative length of stay in the hospital. Consistent with prior work, all *International Classification of Diseases, Ninth Revision* and *Tenth Revision* (ICD-9 and ICD-10) diagnosis codes from the 365 days prior to and including the date of surgery were used to define preoperative clinical variables corresponding to the patient in each encounter, including a history of chronic pain (eTable 2) (2, 3, 13, 24), cancer (eTable 2) (6), and Elixhauser comorbidity index (25).

Study Periods

Descriptive summaries of the data spanned September 1, 2016 to September 31, 2020. The study period for the statistical analysis spanned 28 months from September 1, 2016 through December 31, 2018. We defined a 14-month pre-policy period (September 1, 2016 to October 31, 2017) and 14-month post-policy period (November 1, 2017 to December 31, 2018).

Statistical Analysis

Given linear trends in opioid prescribing and similar numbers of monthly surgical encounters over our study period (eFigure 2), we used interrupted time series analysis (ITSA) to estimate changes in prescribed opioid quantity associated with the policy and ensuing clinical decision support intervention (26–28). The ITSA was implemented using a series of multivariable linear regressions with heteroskedastic robust standard errors and the above covariates (specifications in Supplementary Materials). The goal of the ITSA was to estimate changes in opioid quantity immediately following policy implementation, as well as differences in the subsequent rate of change in opioid quantity over time relative to the pre-policy period; either or both of which could represent policy effects.

Average marginal effects were used to aide in the interpretation of ITSA estimates. We calculated average marginal effects and 95% confidence intervals (95% CI) to understand how much greater or smaller the outcome was in the presence of the policy, during the post-policy period, compared to what it would be predicted to be in the absence of the policy (29, 30). Thus, average marginal effects yield the difference in the quantity of opioids prescribed as a result of the policy, conditional on the policy being implemented versus not implemented. We calculated average marginal effects for each month post-policy separately.

We conducted a single group ITSA to analyze overall changes in opioid quantity associated with the policy and corresponding decision support intervention for all types of patients (Supplementary Materials). This allowed us to estimate changes in opioid quantity immediately following the policy, as well as subsequent differences in the rate of change of opioid quantity over time in the post-policy period compared to the pre-policy period. For this model, the average marginal effects can be interpreted as how much greater or smaller the mean prescribed opioid quantity was in each month post-policy for patients overall, compared to what it would have been in the absence of the policy.

In addition, because the policy was directed towards Medicaid beneficiaries, we conducted a multi-group ITSA to compare changes in prescribed opioid quantity associated with the policy by insurance subgroups, i.e. to assess for differential changes for Medicaid versus other groups. When conducting a multi-group ITSA, a key assumption is non-divergent (or parallel) trends in the pre-policy period between groups, which signals that in the absence of the policy the two groups are on similar trajectories with respect to the outcome, and which allows for the interpretation of any differential changes in the post-policy period as potential policy effects. Our data showed divergent trends in the pre-policy period for Medicaid versus all non-Medicaid patients, as well as Medicaid versus commercially insured patients, which precluded these direct comparisons in a multi-group ITSA construct. Based on evidence for non-divergent trends in the outcome before the policy, we compared Medicaid versus Medicare patients in this analysis (Supplementary Materials). This allowed us to directly estimate changes in opioid quantity immediately after the policy and subsequent differences in the rate of change of opioid quantity over time post-policy relative to pre-policy, for the Medicaid group compared to the Medicare group. Here the average marginal effects can be interpreted separately for each group as how much greater or smaller the mean prescribed opioid quantity was in each month post-policy, compared to what it would have been for that group in the absence of the policy.

We additionally conducted a multi-group ITSA to explore differential changes in prescribed opioid quantity associated with the policy across different surgical specialties. The three highest volume specialties that had non-divergent trends in the pre-policy period (Orthopedics, General Surgery, and Neurosurgery) were compared in this analysis.

Sensitivity analyses were conducted by repeating both ITSA models with the exclusion of encounters involving patients with a pre-operative diagnosis of chronic pain (2, 3, 13, 24) (eTable 2), or cancer (6) (eTable 2), as they could have been considered exempt from the Washington Medicaid policy (12).

Statistical tests were two-sided with alpha = 0.05. Analyses were conducted in R, version 4.1.0 (31).

Results

Descriptive Statistics

The sample included 12,799 surgical encounters involving opioid-naïve patients undergoing procedures from a range of surgical specialties (Table 1). Characteristics included that 59% were male, 77% were White, and the mean age was 52 years (SD: 18). A minority had a history of chronic pain (11%) or cancer (9.8%), and the mean Elixhauser score was 2 (SD: 2). In terms of insurance, 33% had commercial, 28% had Medicaid only, and 23% had Medicare only. Smaller proportions were dually-eligible for Medicare and Medicaid (9%) or covered under other insurance (7%), which included military or other government institutional payers.

Overall, for 75% of the surgical encounters, an opioid was prescribed at discharge. Smaller proportions were prescribed adjunct pain medications at discharge: 69% acetaminophen, 23% NSAIDs, and 12% gabapentin (Table 1).

Unadjusted Trends

From 2016 to 2020, surgeons generally prescribed fewer opioids postoperatively (Figure 1). This general trend was observed for both Medicaid and non-Medicaid patients (eFigure 3). The mean quantity of opioids per prescription decreased from 36 pills (SD: 34) in 2016 to 17 pills (SD: 17) in 2020. The median quantity of opioids similarly decreased from 30 pills (IQR: 40) to 12 pills (IQR: 30). Across all patient types, the proportion of opioid prescriptions exceeding the limits in the Medicaid policy (42 pills for patients age 21 and older, or 18 pills for ages 18-20) decreased from 34% in 2016 to 4% in 2020. The proportions of different types of opioids prescribed appeared similar from year to year, with oxycodone being the most common (eTable 3).

Adjusted Results

In the adjusted single group ITSA, overall the 2017 Medicaid policy implementation was associated with a change of -8.4 opioid pills (95% CI -12 to -4.7, $p < 0.001$) per prescription immediately following the policy, and a subsequent rate of decrease similar to that in the pre-policy period (eTable 4). Interpreting these findings through average marginal effects, there was a reduction in the opioid quantity prescribed, compared to what would be predicted in the absence of the policy, in each of the first 7 months following the policy (Figure 2). The magnitude of this reduction ranged from -4.6 pills (95% CI -6.6 to -2.6, $p < 0.001$) in month 1 to -3.0 pills (95% CI -5.9 to -0.16, $p = 0.04$) in month 7 following policy implementation. There were similar immediate decreases associated with the policy across different high-volume surgical specialties – Orthopedics, General Surgery, and Neurosurgery – when directly compared in a multi-group ITSA (eTable 5).

In the adjusted multi-group ITSA comparing changes by insurance subgroups, Medicaid patients had a change of -9.8 opioid pills (95% CI -19 to -0.76, $p = 0.03$) per prescription relative to Medicare patients immediately following policy implementation and continued decreases at rates similar to those prior to the policy thereafter (eTable 6). No immediate (-0.12, 95% CI -7.2 to 6.9, $p = 0.98$) or subsequent policy-related changes were observed among Medicare patients (eTable 6). Interpreting these estimates through average marginal effects, in the first 10 months following the policy implementation, there were fewer opioids prescribed to Medicaid patients compared to what would be predicted in the absence of the policy, ranging from -7.2 pills (95% CI -10 to -4.2, $p < 0.001$) in month 1 to -5.7 pills (95% CI -11 to -0.43, $p = 0.03$) in month 10 post-policy (Figure 3). There were no significant differences for Medicare patients in the quantity of opioids prescribed in each month post-policy, compared to what would be predicted in the absence of the policy (Figure 3).

Findings from sensitivity analyses were consistent with those from main analyses. In the single group ITSA excluding patients with chronic pain or cancer diagnoses, overall the policy implementation was associated with a change of -7.3 opioid pills (95% CI -12 to -3.1, $p = 0.001$) per prescription immediately following the policy, and continued decreases at rates similar to those prior to the policy thereafter (eTable 7). In the multi-group ITSA, the Medicaid group had an estimated immediate change of -12 opioid pills (95% CI -22 to -1.3, p = 0.03) per prescription relative to Medicare patients following the policy, while the Medicare group did not have a significant immediate change (2.3 pills, 95% CI -5.8 to 10, p = 0.58). For both groups, the quantity of opioids subsequently decreased in the post-policy period at rates similar to those prior to the policy (eTable 8).

Discussion

In this analysis of over 12,000 surgical encounters at one of the largest safety-net hospitals in the western United States, the quantity of opioids prescribed postoperatively by surgeons decreased from 2016 to 2020. Within this contemporary trend, the Washington Medicaid opioid policy in 2017 was associated with an 8-10 pill immediate reduction in the opioid quantity prescribed. This substantial 25% relative change likely represents a clinically meaningful decrease, considering that many patients use fewer than 10 total pills of opioids after discharge after common operations (32, 33). Notably, this decrease was particularly pronounced among Medicaid patients, suggesting that though the decision support intervention was implemented hospital-wide, surgeons may have responded in their prescribing decisions to a comparatively greater extent to the payer-based opioid policy than to simply the presence of an EHR alert.

In considering temporal trends in postoperative opioid prescribing, prior studies suggest that surgeons were prescribing high and increasing amounts of opioids for postoperative pain as recently as 2017 (1, 34, 35). Less is known about contemporary trends from 2017 to present. There is some evidence that opioid prescribing for selected types of surgery and at certain institutions has started to decrease (36–42). Our findings expand upon these studies and support that surgeons of varied subspecialties in a large regional safety-net setting prescribed opioids more judiciously from 2016 to 2020, an important period of learning about and responses to the opioid epidemic.

Our findings align with prior studies analyzing the effects of state-level policies placing limits on opioid prescribing in some states (43–45), but not others (40, 43). Reasons for discrepant findings may include differences in the state policies themselves (e.g., specific quantities or durations specified), the settings in which the policies were evaluated, and varying methods of policy implementation. Nevertheless, our analysis and the magnitude of our findings – a decrease of 8-10 opioid pills or 25% from pre-policy levels – corroborate evidence about the potential impact of combining a policymaker-driven prescribing policy with a clinician-driven EHR alert (46, 47). Clinical decision support via the EHR presents one potentially promising way in which policy and practice leaders can drive practice change and better outcomes in this space.

Additionally, our findings raise important questions. On the one hand, it suggests that the Washington Medicaid policy reached its intended recipients. This occurred even as the clinical decision support in the EHR at this institution "alerted" clinicians for all patients, regardless of insurance, of the policy details and required surgeons to determine whether the policy applied to a given patient and/or was clinically appropriate to follow. On the other hand, it highlighted insurance type as a factor that needed to be considered in surgeons' prescribing decisions at a safety-net hospital, in the face of potential disparities that may already exist for opioid prescribing towards patients with Medicaid insurance (13). It bears considering whether these types of payer-based policies are the most appropriate and equitable strategies in addressing the opioid epidemic.

Limitations of this study include the analysis of surgical encounters from a single institution. However, findings about how a regional safety-net organization implemented changes in response to a sweeping Medicaid policy are nonetheless relevant. Future work should assess associations in other safety-net settings. Additionally, in non-safety net settings, there may be larger or smaller effect sizes of this and similar policies placing limits on opioid prescribing for reasons that include organizational capacity, resources, processes and programs, and this should be investigated in future work. As with all retrospective analyses, another limitation is the inability to definitively separate the effects from the opioid policy from other contemporaneous changes in opioid prescribing rules or practice. While there were other changes occurring during our study period (48–52), none prompted implementation efforts at the safety-net hospital. Like all observational analyses, there is the risk of residual confounding and inability to account for all differences between patient populations. Among other factors, we were not able to account for the specific surgeries performed due to data limitations. We were not able to directly compare Medicaid patients to other payer groups such as commercially insured patients because of the requisite assumptions for ITSA methodology and divergent trends in our data in the pre-policy period. We were also not able to perform subgroup analyses of the two different age groups (age < 21 and age >= 21) with different quantity limits specified in the policy, because of our focus on adult patients and very few encounters involving patients ages 18 to 20 in the sample. Finally, while this analysis focused on evaluating the association between policy and surgeon prescribing, future work is needed to assess patient use and other outcomes, such as subsequent opioid-related adverse events.

Conclusions

Ultimately, our findings suggest that surgeons practicing in a safety-net setting moved towards smaller opioid prescriptions – a contemporary trend associated with a state Medicaid policy. These findings pose implications for hospital leaders, payers, and other groups seeking to address opioid use via judicious clinician prescribing.

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References

1. Larach DB, Waljee JF, Hu HM, et al. Patterns of initial opioid prescribing to opioid-naive patients. Ann Surg 2020;271:290–295.

2. Brummett CM, Waljee JF, Goesling J, et al. New persistent opioid use after minor and major surgical procedures in us adults. JAMA Surg 2017;152.

3. Santosa KB, Hu HM, Brummett CM, et al. New persistent opioid use among older patients following surgery: A Medicare claims analysis. Surgery 2020;167:732–742.

4. Xu Y, Cuthbert CA, Karim S, et al. Associations Between Physician Prescribing Behavior and Persistent Postoperative Opioid Use Among Cancer Patients Undergoing Curative-intent Surgery. Ann Surg 2020:1–6.

5. Brescia AA, Waljee JF, Hu HM, et al. Impact of Prescribing on New Persistent Opioid Use After Cardiothoracic Surgery. Ann Thorac Surg 2019;108:1107–1113.

6. Chua KP, Brummett CM, Conti RM, Bohnert A. Association of Opioid Prescribing Patterns with Prescription Opioid Overdose in Adolescents and Young Adults. JAMA Pediatr 2020;174:141–148.

7. Schirle L, Stone AL, Morris MC, et al. Leftover opioids following adult surgical procedures: a systematic review and meta-analysis. Syst Rev 2020;9:139.

8. Brat GA, Agniel D, Beam A, et al. Postsurgical prescriptions for opioid naive patients and association with overdose and misuse: Retrospective cohort study. BMJ 2018;360.

9. Powell D, Pacula RL, Taylor E. How increasing medical access to opioids contributes to the opioid epidemic: Evidence from Medicare Part D. J Health Econ 2020;71:102286.

10. Ballotpedia. Opioid prescription limits and policies by state. Available at: https://ballotpedia.org/Opioid_prescription_limits_and_policies_by_state. Accessed February 23,

2021.

11. Office of Inspector General. Factsheet: Washington State's Oversight of Opioid Prescribing and Monitoring of Opioid Use. 2018. Available at: https://oig.hhs.gov/oas/reports/region9/91802001_Factsheet.pdf.

12. Washington State Health Care Authority. Analgesics: Opioid Agonists. 2020. Available at: https://www.hca.wa.gov/assets/billers-and-providers/opioid-policy.pdf.

13. Mikosz CA, Zhang K, Haegerich T, et al. Indication-Specific Opioid Prescribing for US Patients With Medicaid or Private Insurance, 2017. JAMA Netw Open 2020;3:e204514.

14. Roof MA, Mahure SA, Feng JE, et al. What Are the Effects of Patient Point of Entry and Medicaid Status on Postoperative Opioid Consumption and Pain Following Primary Total Knee Arthroplasty? J Arthroplasty 2020;35:2786–2790.

15. Dr. Robert Bree Collaborative. Opioid Prescribing Metrics. 2017.

16. Washington State Department of Health. Washington Prescription Monitoring Program Analytic Data File Documentation. 2020.

17. Soffin EM, Wilson LA, Liu J, et al. Association between sex and perioperative opioid prescribing for total joint arthroplasty: a retrospective population-based study. Br J Anaesth 2021;126:1217–1225.

18. Lawrence AE, Deans KJ, Chisolm DJ, et al. Racial Disparities in Receipt of Postoperative Opioids After Pediatric Cholecystectomy. J Surg Res 2020;245:309–314.

19. Peck CJ, Carney M, Chiu A, et al. Sex, Race, Insurance, and Pain: Do Patient Sociodemographics Influence Postoperative Opioid Prescriptions Among Hand Surgeons? Hand (N Y) United States 2021.

20. Sceats LA, Ayakta N, Merrell SB, Kin C. Drivers, Beliefs, and Barriers Surrounding Surgical

Opioid Prescribing: A Qualitative Study of Surgeons' Opioid Prescribing Habits. J Surg Res 2020;247:86–94.

21. Pletcher MJ, Kertesz SG, Kohn MA, Gonzales R. Trends in opioid prescribing by race/ethnicity for patients seeking care in US emergency departments. JAMA 2008;299:70–78.

22. Chou R, Gordon DB, De Leon-Casasola OA, et al. Management of postoperative pain: A clinical practice guideline from the American pain society, the American society of regional anesthesia and pain medicine, and the American society of anesthesiologists' committee on regional anesthesia, executive commi. J Pain 2016;17:131–157.

23. Thiels CA, Anderson SS, Ubl DS, et al. Wide Variation and Overprescription of Opioids after Elective Surgery. Ann Surg 2017;266:564–573.

24. Tian TY, Zlateva I, Anderson DR. Using electronic health records data to identify patients with chronic pain in a primary care setting. J Am Med Informatics Assoc 2013;20:275–280.

25. Gasparini A. comorbidity: An R package for computing comorbidity scores. J Open Source Softw 2018;3:648.

26. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. J Clin Pharm Ther 2002;27:299–309.

27. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: A tutorial. Int J Epidemiol 2017;46:348–355.

28. Linden A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. Stata J 2015;15:480–500.

29. Leeper TJ. margins: Marginal Effects for Model Objects. 2021.

30. Williams R. Using the margins command to estimate and interpret adjusted predictions and marginal effects. Stata J 2012;12:308–331.

31. R Core Team. R: A language and environment for statistical computing. 2021.

32. Hill M V., Mcmahon ML, Stucke RS, Barth RJ. Wide variation and excessive dosage of opioid prescriptions for common general surgical procedures. Ann Surg 2017;265:709–714.

33. Robinson KA, Thiels CA, Stokes S, et al. Comparing Clinician Consensus Recommendations to Patient-reported Opioid Use Across Multiple Hospital Systems. Ann Surg 2020;Publish Ah:1–5.

34. Marrache M, Best MJ, Raad M, et al. Opioid Prescribing Trends and Geographic Variation After Anterior Cruciate Ligament Reconstruction. Sports Health 2020;12:528–533.

35. Chen CL, Jeffery MM, Krebs EE, et al. Long-Term Trends in Postoperative Opioid Prescribing, 1994 to 2014. JAAOS Glob Res Rev 2020;4:e1900171.

36. Keller DS, Kenney BC, Harbaugh CM, et al. A national evaluation of opioid prescribing and persistent use after ambulatory anorectal surgery. Surgery United States 2020.

37. Kuo JH, Huang Y, Kluger MD, et al. Use and Misuse of Opioids After Endocrine Surgery Operations. Ann Surg 2020:1–9.

38. Nobel TB, Zaveri S, Khetan P, Divino CM. Temporal trends in opioid prescribing for common general surgical procedures in the opioid crisis era. Am J Surg 2019;217:613–617.

39. Findlay BL, Britton CJ, Glasgow AE, et al. Long-term Success With Diminished Opioid Prescribing After Implementation of Standardized Postoperative Opioid Prescribing Guidelines: An Interrupted Time Series Analysis. Mayo Clin Proc Mayo Foundation for Medical Education and Research 2021;96:1135–1146.

40. Steven B. Porter M, Amy E. Glasgow M, Xiaoxi Yao, PhD M, Elizabeth B. Habermann P. Association of Florida House Bill 21 With Postoperative Opioid Prescribing for Acute Pain at a Single Institution. JAMA Surg 2020;155:263–264.

41. Kaafarani HMA, Eid AI, Antonelli DM, et al. Description and Impact of a Comprehensive Multispecialty Multidisciplinary Intervention to Decrease Opioid Prescribing in Surgery. Ann Surg 2019;270:452–462.

42. Howard R, Alameddine M, Klueh M, et al. Spillover Effect of Evidence-Based Postoperative Opioid Prescribing. J Am Coll Surg 2018;227:374–381.

43. Agarwal S, Bryan JD, Hu HM, et al. Association of State Opioid Duration Limits With Postoperative Opioid Prescribing. JAMA Netw Open 2019;2:e1918361.

44. Reid DBC, Shapiro B, Shah KN, et al. Has a Prescription-limiting Law in Rhode Island Helped to Reduce Opioid Use After Total Joint Arthroplasty? Clin Orthop Relat Res 2020;478:205–215.

45. Titan A, Doyle A, Pfaff K, et al. Impact of policy-based and institutional interventions on postoperative opioid prescribing practices. Am J Surg United States 2021.

46. Chua K-P, Kimmel L, Brummett CM. Disappointing Early Results From Opioid Prescribing Limits for Acute Pain. JAMA Surg United States 2020;155:375–376.

47. Lowenstein M, Hossain E, Yang W, et al. Impact of a State Opioid Prescribing Limit and Electronic Medical Record Alert on Opioid Prescriptions: a Difference-in-Differences Analysis. J Gen Intern Med 2020;35:662–671.

48. Premera Blue Cross. Premera's Opioid Safety Edits. 2019. Available at: https://www.premera.com/wa/provider/news/medicare-advantage/opioid-safety-edits/. Accessed February 15, 2022.

49. UnitedHealthcare. UnitedHealthcare makes a difference on the opioid front. 2018. Available at: https://www.uhc.com/broker-consultant/news-strategies/resources/unitedhealthcare-makes-a-difference-on-the-opioid-front. Accessed February 15, 2022.

50. United States House Ways and Means Committee. Statement of Dr. Hal Paz, M.D., M.S., Executive Vice President and Chief Medical Officer Aetna, Inc.: The Opioid Crisis: Removing Barriers to Prevent and Treat Opioid Abuse and Dependence in Medicare. 2018.

51. Centers for Medicare & Medicaid Services. 2019 Medicare Part D Opioid Policies: Information for Pharmacies. Available at: https://www.oplc.nh.gov/sites/g/files/ehbemt441/files/inline-documents/sonh/cms-opioid-tip-sheet-for-pharmacies.pdf. Accessed February 15, 2022.

52. Washington State Health Care Authority. Changes to the Washington Apple Health (Medicaid) Opioid Policy. 2019. Available at: https://www.hca.wa.gov/assets/billers-and-providers/support-act-clinical-slidedeck-oct2019.pdf. Accessed February 15, 2022.

Exhibits

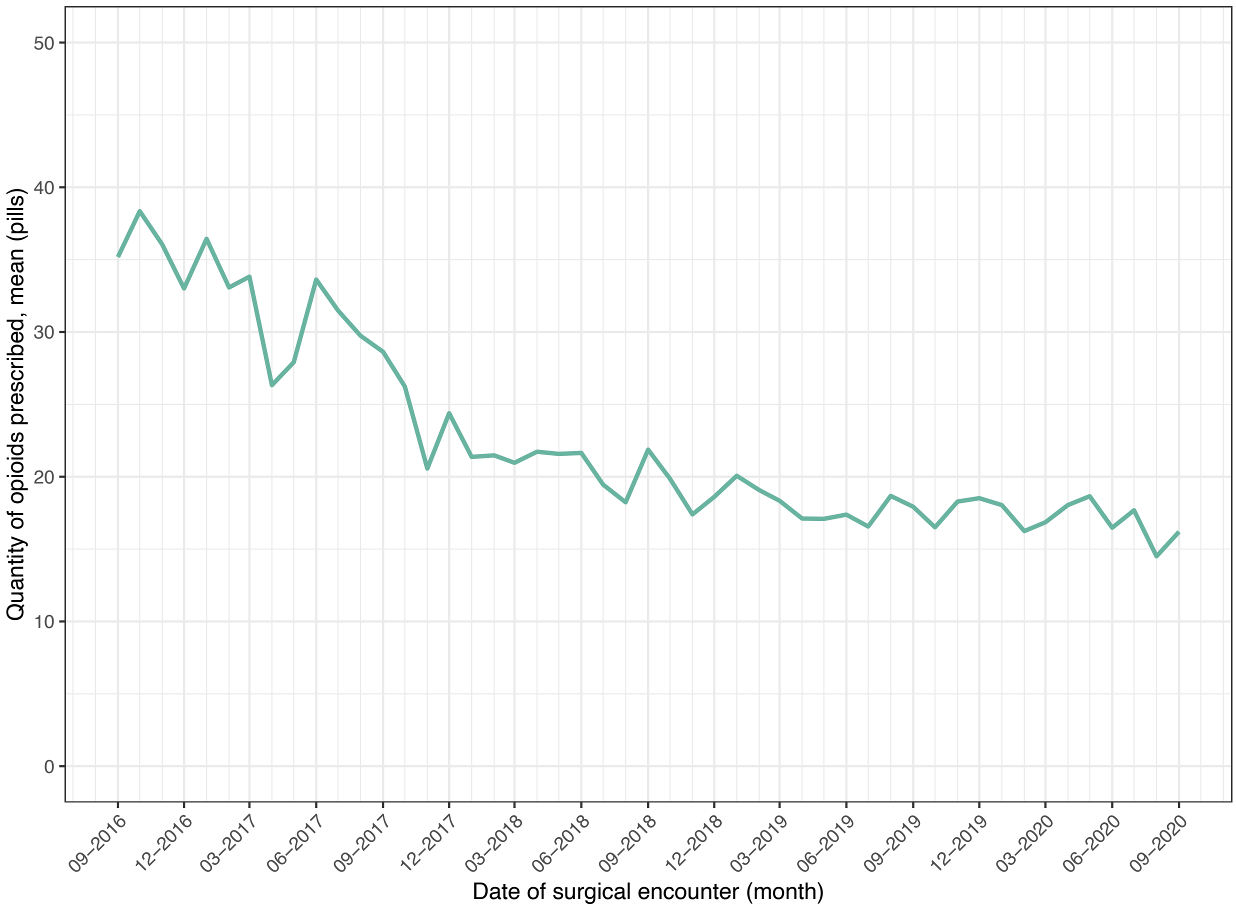
Table 1. Sample characteristics

Characteristic	**Overall Sample (N = 12,799)**
Age at surgery, mean (+/- SD)	52 (+/- 18)
Sex	
Female	5,232 / 12,799 (41%)
Male	7,567 / 12,799 (59%)
Race	
American Indian or Alaska Native	264 / 12,799 (2.1%)
Asian	1,116 / 12,799 (8.7%)
Black or African American	1,330 / 12,799 (10%)
Native Hawaiian or Other Pacific Islander	143 / 12,799 (1.1%)
White	9,806 / 12,799 (77%)
Unavailable or Unknown	140 / 12,799 (1.1%)
Ethnicity	
Hispanic	1,144 / 12,799 (8.9%)
Not Hispanic	11,574 / 12,799 (90%)
Unavailable or Unknown	81 / 12,799 (0.6%)
Insurance	
Commercial	4,217 / 12,799 (33%)
Dual Medicare and Medicaid	1,156 / 12,799 (9.0%)
Medicaid	3,625 / 12,799 (28%)
Medicare	2,911 / 12,799 (23%)
Other[a]	890 / 12,799 (7.0%)
Elixhauser index, mean (+/- SD)	2 (+/- 2)
Cancer	1,260 / 12,799 (9.8%)
Chronic pain	1,371 / 12,799 (11%)
Surgery specialty	

General Surgery	1,480 / 12,799 (12%)
Neurosurgery	1,126 / 12,799 (8.8%)
Obstetrics/Gynecology	310 / 12,799 (2.4%)
Oral Maxillofacial Surgery	421 / 12,799 (3.3%)
Ophthalmology	2,427 / 12,799 (19%)
Orthopedic Surgery	4,389 / 12,799 (34%)
Otolaryngology	537 / 12,799 (4.2%)
Plastic and Reconstructive Surgery	671 / 12,799 (5.2%)
Urology	997 / 12,799 (7.8%)
Vascular Surgery	441 / 12,799 (3.4%)
Postoperative hospital length of stay, mean (+/- SD)	2 (+/- 3)
Prescribed opioid at discharge	9,574 / 12,799 (75%)
Prescribed acetaminophen at discharge	8,819 / 12,799 (69%)
Prescribed NSAID at discharge	2,926 / 12,799 (23%)
Prescribed gabapentin at discharge	1,509 / 12,799 (12%)

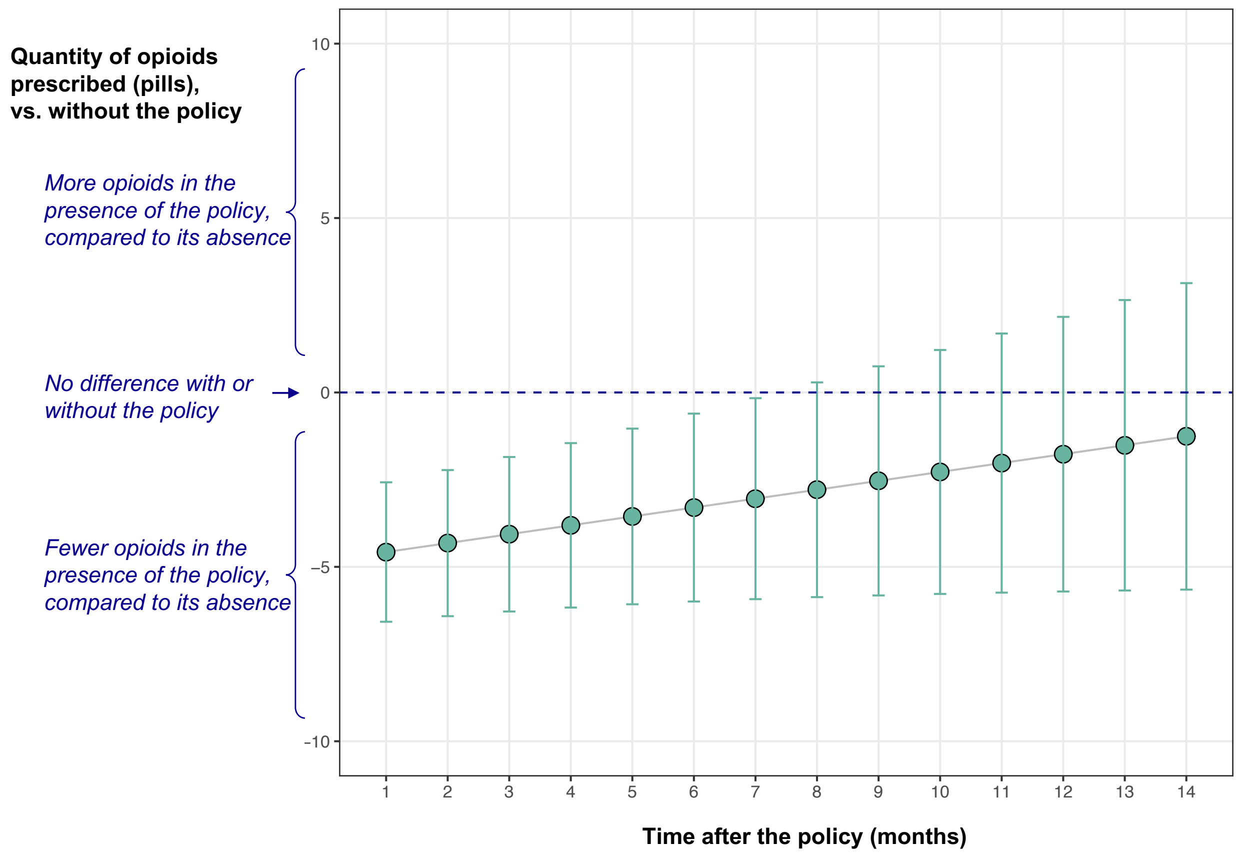
[a] "Other" insurance consists of military or other government institutional payers.

Figure 1. Contemporary trend in opioid quantity prescribed postoperatively 2016-2020



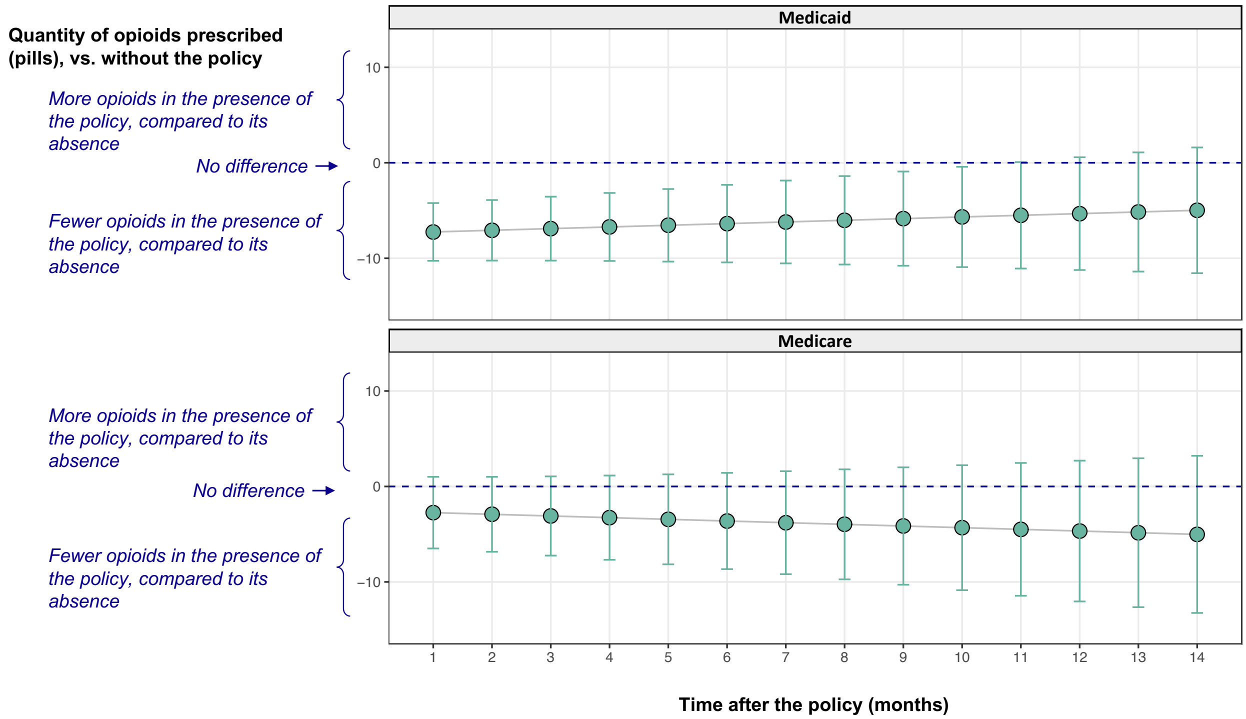
The monthly mean quantity of opioids prescribed at discharge, in pills or 5mL volumes, are shown from September 2016 to September 2020. There was a general trend towards surgeons prescribing fewer opioid pills per prescription over this period, with the mean quantity decreasing from 36 pills to 17 pills.

Figure 2. Opioid quantity prescribed in each month post-policy overall, compared to the absence of the policy



The average marginal effects interpretation of the adjusted single group ITSA estimated the mean opioid quantity (points) and 95% CI (bars) for each month post-policy, compared to what would have been predicted in the absence of the policy. Point estimates above the zero mark suggest more opioids in the presence of the policy, compared to the absence of it, and point estimates below the zero mark suggest fewer opioids in the presence of the policy, compared to the absence of it. For the sample overall, there were significantly fewer opioids per prescription in the post-policy period under the policy for months 1 through 7 following policy implementation.

Figure 3. Opioid quantity prescribed in each month post-policy for Medicaid versus Medicare patients, compared to the absence of the policy



The average marginal effects interpretation of the adjusted multi-group ITSA estimated the mean opioid quantity (points) and 95% CI (bars) for each month post-policy, compared to what would have been predicted in the absence of the policy, for Medicaid patients (top panel) and Medicare patients (bottom panel). Point estimates above the zero mark suggest more opioids in the presence of the policy, compared to the absence of it, and point estimates below the zero mark suggest fewer opioids in the presence of the policy, compared to the absence of it. For Medicaid patients, there were significantly fewer opioids per prescription in the post-policy period under the policy for months 1 through 10 following policy implementation. For Medicare patients, there was no significant difference in the presence versus the absence of the policy.

Supplementary Materials

ITSA Models Specifications

We conducted a single group ITSA specified as follows: $Yt = \beta 0 + \beta 1\ T + \beta 2\ Xt + \beta 3\ T{*}Xt$ + covariates + error, where T represented time in monthly units and Xt represented the policy. The coefficients of interest were β2 (which estimated a level change in the outcome in the month immediately following the policy) and β3 (which estimated a change in slope for the outcome over time following the policy).(1–3)

Additionally, based on evidence of non-divergent trends in the primary outcome during pre-policy period, we conducted a multi-group ITSA comparing encounters for Medicaid versus Medicare patients. This ITSA was specified as follows: $Yt = \beta 0 + \beta 1\ T + \beta 2\ Xt + \beta 3\ T{*}Xt + \beta 4$ group + β5 group*T + β6 group*Xt + β7 group*T*Xt + covariates + error, where T represented time in monthly units, Xt represented the policy, and group represented Medicaid or Medicare insurance. The coefficients of interest were β6 (which estimated between-group differences in the outcome in the month immediately following the policy) and β7 (which estimated between-group differences in slope for the outcome over time following the policy).(1–3) *eTable 1. Medication class definitions*

Medication class	Medication names (generic)
Opioid[a]	Alfentanil Buprenorphine Butorphanol Codeine Dihydrocodeine Diphenoxylate Fentanyl Hydrocodone Hydromorphone Levorphanol Meperidine Morphine Oxycodone Oxymorphone Pentazocine Propoxyphene Sufentanil Tapentadol Tramadol
Acetaminophen	Acetaminophen
NSAID	Celecoxib Diclofenac Diflunisal Etodolac Fenoprofen Flurbiprofen Ibuprofen Indomethacin Ketoprofen Ketorolac Mefenamic acid Meloxicam Nabumetone Naproxen Oxaprozin Piroxicam Sulindac Tolmetin
Gabapentin	Gabapentin Pregabalin

[a]Opioid medications with indications for acute pain were included, based on Washington State regulatory classifications.(4, 5)

eTable 2. ICD-9 and ICD-10 diagnosis codes for clinical variable definitions

Variable	**ICD-9**[a]	**ICD-10**[a]
Chronic pain[b]	307.8, 307.89, 338.0, 338.4, 729, 729.1, 338.2*	F45.4*, G89.0, G89.2*, G89.4, M79.7
Cancer[c]	140.* - 209.*, 230.* - 239.*	C00.* - D09.*, D37.* - D49.* except not D3A (benign neuroendocrine tumors)

[a]An asterisk (*) indicates any character(s).
[b]A selection of ICD-9 and ICD-10 diagnosis codes most likely to represent chronic pain were used, adapted from prior work.(6–9)
[c]Cancer diagnoses were identified using ICD-9 and ICD-10 diagnosis codes, consistent with prior work.(10)

eTable 3. Proportions of different types of opioids prescribed postoperatively 2016-2020

	2016	**2017**	**2018**	**2019**	**2020**
Oxycodone	82%	80%	80%	83%	86%
Hydromorphone	8%	8%	9%	7%	7%
Hydrocodone	5%	6%	4%	5%	2%
Other	5%	6%	6%	5%	5%

eTable 4. Single group ITSA regression model results

	Quantity of opioids		
Predictors	**Estimates**	**95% CI**	**p**
(Intercept)	44.65	41.59 – 47.71	<0.001
Time	-0.63	-0.84 – -0.41	<0.001
Policy	-8.40	-12.14 – -4.67	<0.001
Age	-0.11	-0.15 – -0.08	<0.001
Sex [Male]	*Ref.*	-	-
Sex [Female]	-1.58	-2.65 – -0.52	0.004
Race [White]	*Ref.*	-	-
Race [American Indian or Alaska Native]	-0.43	-3.80 – 2.95	0.804
Race [Asian]	-3.91	-5.35 – -2.47	<0.001
Race [Black or African American]	-1.53	-3.08 – 0.01	0.052
Race [Native Hawaiian or Other Pacific Islander]	3.46	-2.89 – 9.81	0.286
Race [Unavailable or Unknown]	-2.28	-6.48 – 1.92	0.288
Ethnicity [Non-Hispanic]	*Ref.*	-	-
Ethnicity [Hispanic]	-1.93	-3.76 – -0.11	0.038
Ethnicity [Unavailable or Unknown]	4.93	-1.29 – 11.16	0.120
Elixhauser score	-0.93	-1.20 – -0.65	<0.001
Cancer	-0.73	-2.21 – 0.75	0.333
Chronic Pain	1.72	-0.04 – 3.48	0.055
Surgery specialty [General Surgery]	*Ref.*	-	-
Surgery specialty [Neurosurgery]	-1.10	-3.63 – 1.44	0.397
Surgery specialty [Obstetrics/Gynecology]	-9.22	-11.81 – -6.63	<0.001
Surgery specialty [Oral/Maxillofacial Surgery]	-6.81	-8.85 – -4.76	<0.001
Surgery specialty [Ophthalmology]	-18.13	-19.87 – -16.39	<0.001
Surgery specialty [Orthopedic Surgery]	18.08	16.04 – 20.12	<0.001
Surgery specialty [Otolaryngology]	-4.63	-6.93 – -2.34	<0.001
Surgery specialty [Plastic and Reconstructive Surgery]	-2.84	-5.30 – -0.37	0.024
Surgery specialty [Urology]	-8.40	-10.37 – -6.42	<0.001
Surgery specialty [Vascular Surgery]	-7.92	-10.71 – -5.14	<0.001
Postoperative hospital length of stay	0.34	0.12 – 0.56	0.003
Time * Policy	0.26	-0.00 – 0.51	0.051
Observations	7377		
R^2	0.358		

eTable 5. Multi-group ITSA regression model results for Orthopedics versus General Surgery versus Neurosurgery specialties

	Quantity of opioids		
Predictors	**Estimates**	**95% CI**	**p**
(Intercept)	70.32	65.14 – 75.51	<0.001
Time	-0.86	-1.35 – -0.38	0.001
Policy	-15.90	-24.37 – -7.43	<0.001
Group [Orthopedic Surgery]	*Ref.*	-	-
Group [General Surgery]	-20.20	-28.00 – -12.41	<0.001
Group [Neurosurgery]	-22.50	-31.78 – -13.22	<0.001
Age	-0.11	-0.16 – -0.06	<0.001
Sex [Male]	*Ref.*	-	-
Sex [Female]	-1.89	-3.62 – -0.17	0.031
Race [White]	*Ref.*	-	-
Race [American Indian or Alaska Native]	-0.77	-6.26 – 4.73	0.785
Race [Asian]	-6.05	-9.26 – -2.84	<0.001
Race [Black or African American]	-1.48	-4.43 – 1.47	0.326
Race [Native Hawaiian or Other Pacific Islander]	6.62	-6.87 – 20.11	0.336
Race [Unavailable or Unknown]	-5.65	-13.80 – 2.50	0.174
Ethnicity [Non-Hispanic]	*Ref.*	-	-
Ethnicity [Hispanic]	-2.66	-5.93 – 0.62	0.112
Ethnicity [Unavailable or Unknown]	7.75	-0.53 – 16.03	0.067
Elixhauser score	-1.35	-1.84 – -0.87	<0.001
Cancer	-4.38	-7.57 – -1.19	0.007
Chronic Pain	3.43	0.88 – 5.98	0.008
Postoperative hospital length of stay	0.23	-0.02 – 0.48	0.076
Time * Policy	0.33	-0.26 – 0.91	0.271
Time * Group [General Surgery]	-0.10	-0.91 – 0.70	0.805
Time * Group [Neurosurgery]	-0.11	-1.10 – 0.87	0.825
Policy * Group [General Surgery]	1.24	-12.47 – 14.96	0.859
Policy * Group [Neurosurgery]	-0.95	-17.61 – 15.71	0.911
Time * Policy * Group [General Surgery]	0.33	-0.62 – 1.28	0.491
Time * Policy * Group [Neurosurgery]	0.62	-0.54 – 1.79	0.292
Observations	3950		
R^2	0.206		

eTable 6. Multi-group ITSA regression model results for Medicaid versus Medicare patients

	Quantity of opioids		
Predictors	**Estimates**	**95% CI**	**p**
(Intercept)	39.78	34.99 – 44.56	<0.001
Time	-0.35	-0.74 – 0.05	0.083
Policy	-0.12	-7.17 – 6.94	0.975
Group [Medicare]	*Ref.*	-	-
Group [Medicaid]	0.09	-4.55 – 4.73	0.971
Age	-0.11	-0.15 – -0.07	<0.001
Sex [Male]	*Ref.*	-	-
Sex [Female]	-1.43	-2.67 – -0.19	0.024
Race [White]	*Ref.*	-	-
Race [American Indian or Alaska Native]	0.24	-3.70 – 4.19	0.903
Race [Asian]	-3.44	-5.13 – -1.75	<0.001
Race [Black or African American]	-1.18	-2.84 – 0.49	0.166
Race [Native Hawaiian or Other Pacific Islander]	1.21	-5.10 – 7.53	0.706
Race [Unavailable or Unknown]	-1.32	-6.24 – 3.61	0.600
Ethnicity [Non-Hispanic]	*Ref.*	-	-
Ethnicity [Hispanic]	-2.29	-4.50 – -0.08	0.043
Ethnicity [Unavailable or Unknown]	4.60	-3.71 – 12.90	0.278
Elixhauser score	-0.75	-1.03 – -0.47	<0.001
Cancer	0.05	-1.58 – 1.69	0.949
Chronic Pain	3.07	1.08 – 5.05	0.003
Surgery specialty [General Surgery]	*Ref.*	-	-
Surgery specialty [Neurosurgery]	-0.95	-4.01 – 2.11	0.544
Surgery specialty [Obstetrics/Gynecology]	-9.63	-12.92 – -6.34	<0.001
Surgery specialty [Oral/Maxillofacial Surgery]	-5.25	-7.53 – -2.97	<0.001
Surgery specialty [Ophthalmology]	-18.01	-19.95 – -16.07	<0.001
Surgery specialty [Orthopedic Surgery]	16.57	14.19 – 18.96	<0.001
Surgery specialty [Otolaryngology]	-3.58	-6.38 – -0.78	0.012
Surgery specialty [Plastic and Reconstructive Surgery]	-3.57	-6.47 – -0.67	0.016
Surgery specialty [Urology]	-8.86	-11.14 – -6.58	<0.001
Surgery specialty [Vascular Surgery]	-7.50	-10.59 – -4.41	<0.001
Postoperative hospital length of stay	0.13	-0.10 – 0.36	0.281
Time * Policy	-0.18	-0.66 – 0.31	0.477
Time * Group [Medicaid]	0.04	-0.46 – 0.55	0.868
Policy * Group [Medicaid]	-9.75	-18.73 – -0.76	0.034
Time * Policy * Group [Medicaid]	0.35	-0.26 – 0.96	0.265
Observations	4469		
R^2	0.364		

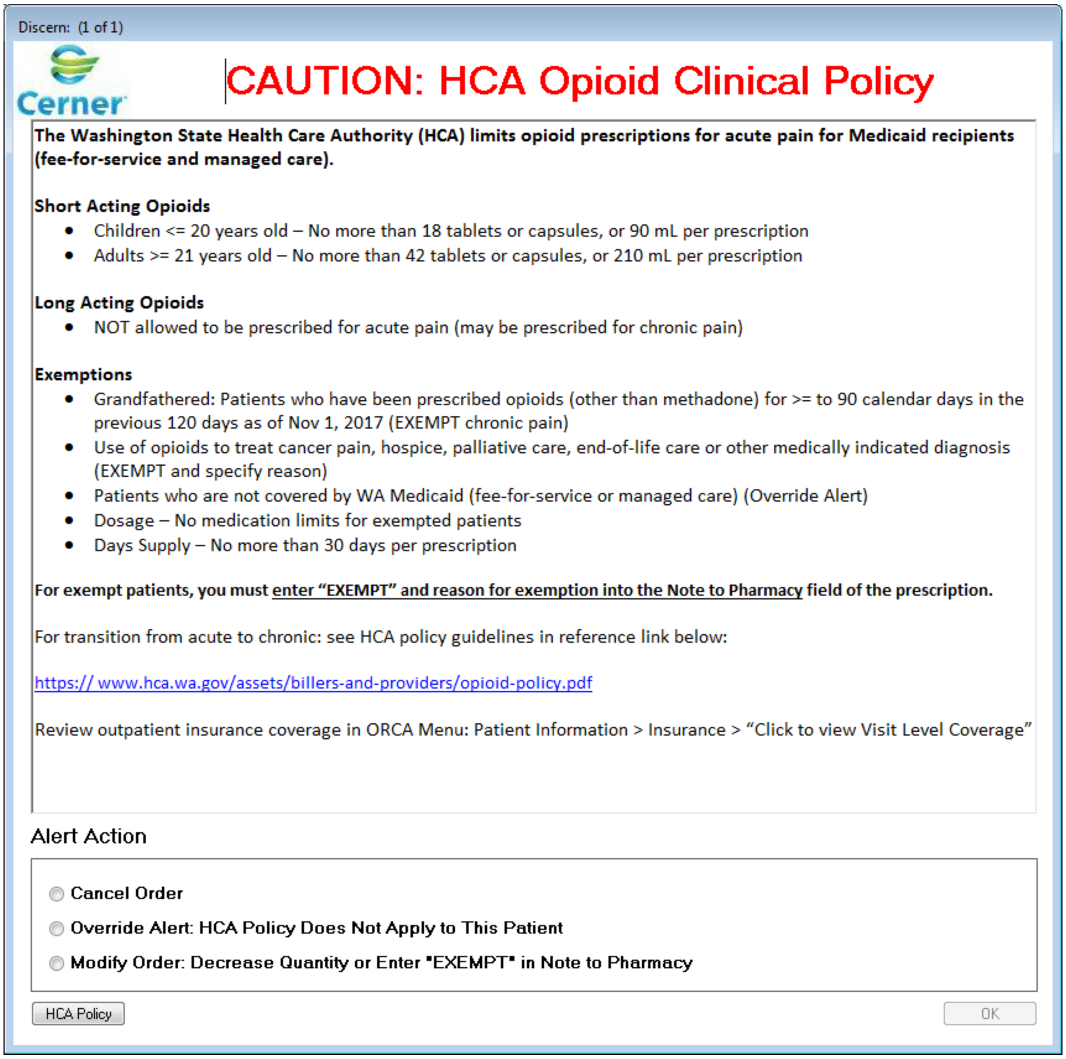
eTable 7. Sensitivity analysis: single group ITSA regression model results

	Quantity of opioids		
Predictors	**Estimates**	**95% CI**	**p**
(Intercept)	46.43	43.08 – 49.79	<0.001
Time	-0.66	-0.90 – -0.42	<0.001
Policy	-7.34	-11.54 – -3.14	0.001
Age	-0.13	-0.17 – -0.10	<0.001
Sex [Male]	*Ref.*	-	-
Sex [Female]	-1.49	-2.69 – -0.30	0.014
Race [White]	*Ref.*	-	-
Race [American Indian or Alaska Native]	-2.04	-5.94 – 1.87	0.307
Race [Asian]	-4.24	-5.84 – -2.64	<0.001
Race [Black or African American]	-0.96	-2.74 – 0.82	0.289
Race [Native Hawaiian or Other Pacific Islander]	2.67	-4.70 – 10.04	0.478
Race [Unavailable or Unknown]	-2.18	-6.83 – 2.48	0.360
Ethnicity [Non-Hispanic]	*Ref.*	-	-
Ethnicity [Hispanic]	-1.47	-3.47 – 0.53	0.151
Ethnicity [Unavailable or Unknown]	6.32	-0.85 – 13.49	0.084
Elixhauser score	-1.05	-1.39 – -0.72	<0.001
Surgery specialty [General Surgery]	*Ref.*	-	-
Surgery specialty [Neurosurgery]	-1.48	-4.51 – 1.55	0.338
Surgery specialty [Obstetrics/Gynecology]	-8.92	-11.84 – -6.00	<0.001
Surgery specialty [Oral/Maxillofacial Surgery]	-7.70	-9.95 – -5.46	<0.001
Surgery specialty [Ophthalmology]	-18.41	-20.36 – -16.47	<0.001
Surgery specialty [Orthopedic Surgery]	17.88	15.62 – 20.13	<0.001
Surgery specialty [Otolaryngology]	-6.20	-8.75 – -3.64	<0.001
Surgery specialty [Plastic and Reconstructive Surgery]	-3.12	-5.80 – -0.44	0.022
Surgery specialty [Urology]	-8.43	-10.65 – -6.21	<0.001
Surgery specialty [Vascular Surgery]	-7.29	-10.48 – -4.09	<0.001
Postoperative hospital length of stay	0.42	0.16 – 0.68	0.002
Time * Policy	0.20	-0.09 – 0.49	0.171
Observations	5964		
R^2	-0.395		

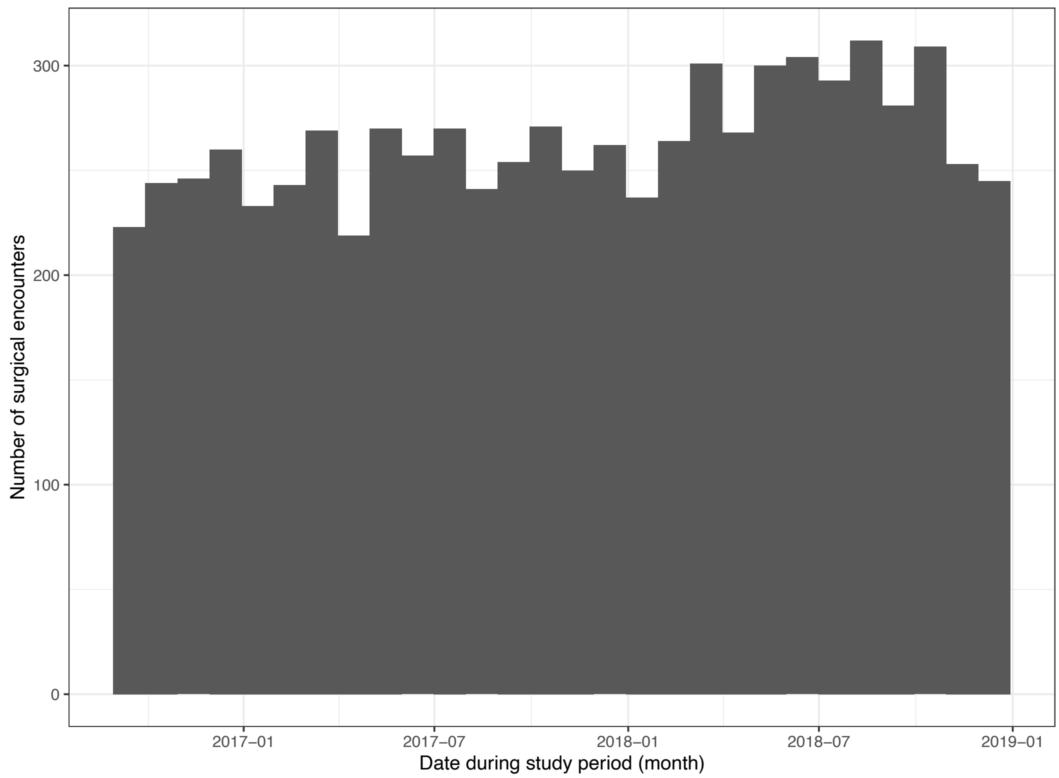
eTable 8. Sensitivity analysis: multi-group ITSA regression model results for Medicaid versus Medicare patients

	Quantity of opioids		
Predictors	**Estimates**	**95% CI**	**p**
(Intercept)	39.95	34.56 – 45.34	<0.001
Time	-0.25	-0.71 – 0.20	0.278
Policy	2.30	-5.80 – 10.40	0.578
Group [Medicare]	*Ref.*	-	-
Group [Medicaid]	1.57	-3.59 – 6.72	0.551
Age	-0.12	-0.17 – -0.07	<0.001
Sex [Male]	*Ref.*	-	-
Sex [Female]	-1.44	-2.84 – -0.03	0.045
Race [White]	*Ref.*	-	-
Race [American Indian or Alaska Native]	-1.42	-5.91 – 3.06	0.535
Race [Asian]	-3.64	-5.49 – -1.80	<0.001
Race [Black or African American]	-0.57	-2.44 – 1.29	0.546
Race [Native Hawaiian or Other Pacific Islander]	1.69	-6.22 – 9.60	0.675
Race [Unavailable or Unknown]	-1.68	-7.14 – 3.78	0.546
Ethnicity [Non-Hispanic]	*Ref.*	-	-
Ethnicity [Hispanic]	-1.66	-4.13 – 0.81	0.189
Ethnicity [Unavailable or Unknown]	5.65	-3.49 – 14.79	0.226
Elixhauser score	-0.88	-1.22 – -0.53	<0.001
Surgery specialty [General Surgery]	*Ref.*	-	-
Surgery specialty [Neurosurgery]	-0.04	-3.99 – 3.92	0.986
Surgery specialty [Obstetrics/Gynecology]	-10.43	-14.07 – -6.80	<0.001
Surgery specialty [Oral/Maxillofacial Surgery]	-5.93	-8.50 – -3.37	<0.001
Surgery specialty [Ophthalmology]	-18.23	-20.43 – -16.03	<0.001
Surgery specialty [Orthopedic Surgery]	16.34	13.64 – 19.03	<0.001
Surgery specialty [Otolaryngology]	-5.29	-8.51 – -2.06	0.001
Surgery specialty [Plastic and Reconstructive Surgery]	-4.04	-7.22 – -0.85	0.013
Surgery specialty [Urology]	-8.77	-11.39 – -6.16	<0.001
Surgery specialty [Vascular Surgery]	-6.81	-10.41 – -3.21	<0.001
Postoperative hospital length of stay	0.16	-0.11 – 0.42	0.242
Time * Policy	-0.37	-0.93 – 0.19	0.197
Time * Group [Medicaid]	-0.11	-0.69 – 0.47	0.705
Policy * Group [Medicaid]	-11.55	-21.81 – -1.29	0.027
Time * Policy * Group [Medicaid]	0.54	-0.17 – 1.24	0.135
Observations	3507		
R^2	0.367		

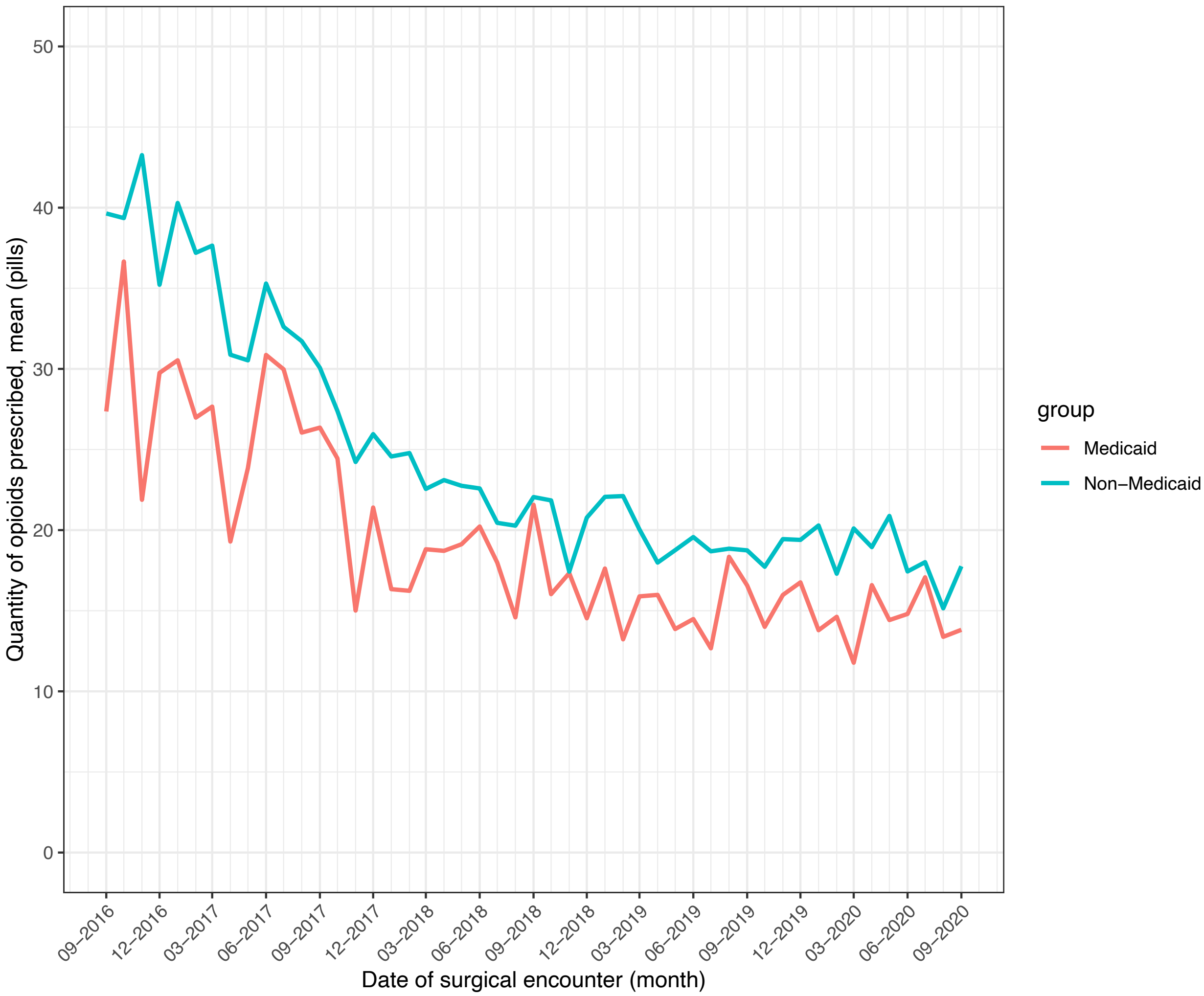
eFigure 1. Screenshot of EHR alert



eFigure 2. Histogram of surgical encounters per month over the study period



eFigure 3. Contemporary trend in opioid quantity prescribed postoperatively for Medicaid versus non-Medicaid patients from 2016-2020



References for Supplementary Material

1. Wagner AK, Soumerai SB, Zhang F, Ross-Degnan D. Segmented regression analysis of interrupted time series studies in medication use research. J Clin Pharm Ther 2002;27:299–309.
2. Bernal JL, Cummins S, Gasparrini A. Interrupted time series regression for the evaluation of public health interventions: A tutorial. Int J Epidemiol 2017;46:348–355.
3. Linden A. Conducting interrupted time-series analysis for single- and multiple-group comparisons. Stata J 2015;15:480–500.
4. Dr. Robert Bree Collaborative. Opioid Prescribing Metrics. 2017.
5. Washington State Department of Health. Washington Prescription Monitoring Program Analytic Data File Documentation. 2020.
6. Brummett CM, Waljee JF, Goesling J, et al. New persistent opioid use after minor and major surgical procedures in us adults. JAMA Surg 2017;152.
7. Santosa KB, Hu HM, Brummett CM, et al. New persistent opioid use among older patients following surgery: A Medicare claims analysis. Surgery Elsevier Inc 2020;167:732–742.
8. Mikosz CA, Zhang K, Haegerich T, et al. Indication-Specific Opioid Prescribing for US Patients With Medicaid or Private Insurance, 2017. JAMA Netw Open 2020;3:e204514.
9. Tian TY, Zlateva I, Anderson DR. Using electronic health records data to identify patients with chronic pain in a primary care setting. J Am Med Informatics Assoc 2013;20:275–280.
10. Chua KP, Brummett CM, Conti RM, Bohnert A. Association of Opioid Prescribing Patterns with Prescription Opioid Overdose in Adolescents and Young Adults. JAMA Pediatr 2020;174:141–148.