

Predictors of Opioid Use among Active-Duty Soldiers Following Postoperative Prescription

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Abstract

Introduction: Opioid misuse is costly in terms of morbidity, mortality, and humanitarian and economic burden. One risk factor related to opioid misuse and dependence is prescription following surgical procedures, and an estimated 12.5% of individuals who are prescribed opioids will misuse them. **Materials and Methods:** Active-Duty Soldiers undergoing third molar extraction (n = 45) were recruited at Womack Army Medical Center and provided access to the CPMRx mobile application to track their postoperative pain and use of prescribed pain medication (Percocet), as well as electronic monitoring pill bottles to provide timestamps for all instances of opioid use. Linear regression analyses modeled predictors of opioid use and misuse, including individual factors (e.g., smoking status) and clinical factors (e.g., time in surgery, ketamine use). **Results:** People who smoke used two times as many opioids following surgery as people who do not currently smoke. Soldiers with more than a high school education used less than half as those with only a high school education. Overall opioid use patterns showed that 45% of patients used 10 or fewer, and more than half used 12 or fewer. About a quarter of patients used all 21 pills. Bivariate results revealed associations between smoking status and education with opioid use. Smoking status was also related to postoperative pain, but only from Day 4 and later. Overall, the model predicting total opioid use was significant and accounted for 82% of the variance in opioids used. In addition to pain on Postoperative Day 4, education, smoking status, and age emerged as significant predictors. **Conclusions:** Feedback from the CPM clinical decision support tools prompted a reduction in the standard prescription from 25 to 16 pills. Clinicians were able to reduce overprescription by more than 10,000 opioids annually for a single surgery type, preventing excess medication from possible diversion or misuse in the Ft. Bragg community.

Keywords

Opioid Misuse, Postoperative Prescription, Prevention

1. Introduction

The cost of opioid overdose, misuse, and dependence in the U.S. has been estimated at \$78.5 billion annually [1], including reduced quality of life from opioid use disorder and the value of life lost due to fatal opioid overdose increases that estimate to more than \$1 trillion [2]. Opioid misuse costs the Civilian Health and Medical Program of the Department of Veterans Affairs (CHAMPVA) more than \$1.13 billion annually [2]. The opioid epidemic affects the capacities of military medicine and preparedness, Veteran's health, and national security, along with public health, law enforcement, healthcare, and social welfare [3].

Research has shown that one risk factor related to opioid misuse is prescription following minor and major surgical procedures [4], making this a critical time to intervene. For the patient being prescribed opioids, there is a need to ensure appropriate use to prevent habit-forming behaviors during postoperative recovery, as it has been estimated that 12.5% of people who are prescribed opioids misuse them [5]. Military Veterans wounded in combat misuse prescription opioids at an even higher rate (46.2% [6]). The most commonly prescribed opioids for chronic pain management and surgical recovery, oxycodone and hydrocodone, are also the most commonly involved opioids in overdose deaths [7]. Extant data suggest that nonmedical prescription-opioid use is a strong risk factor for heroin use initiation among both civilian [8] and Veteran populations [9]. For members of the patient's family and others in the community, it is important that excess prescription opioids not be available for misuse; indeed, more than half of people who misused prescription pain relievers reported obtaining them from a friend or relative, either for free, by purchasing them, or by taking them without asking, and an additional 35.7% got them through a prescription by a single doctor [10]. Several recent studies have also noted wide variation in post-operative prescribing practices and systemic overprescription [11]-[13], which may inadvertently promote continued opioid use after their indication is no longer warranted.

Decreasing the total number of pills prescribed after surgeries could substantially reduce the risk for opioid misuse. Studies on post-operative opioid consumption suggest that 50% - 60% of opioids prescribed for acute pain relief by surgeons go unused in a variety of specialties [13] [14]. Educational efforts on prescribing practices have been successful in reducing opioid prescribing by 50% - 60% without a negative impact on effective pain management [13] [14]. Taken together, these findings underscore the criticality of managing the use of opioids in the postoperative period as an essential point of intervention in combating the opioid crisis.

To combat this problem, federal, state, and professional organizations across surgical specialties have been working to develop evidence-based guidelines for the appropriate management of pain. These guidelines have included recommendations from the American Pain Society, such as adding non-opioid pain medications to the treatment plan and developing/refining policies and procedures for safe and effective pain control [15]. In order to achieve these goals, surgeons in multiple specialties have been analyzing their prescription habits and as mentioned above, have been using this information to reduce the opioids they prescribe without sacrificing pain relief [13] [14] [16] [17].

To address this critical issue, Continuous Precision Medicine (CPM) has developed a software-based intervention (CPMRx) to support patients and clinicians in safely monitoring and administering opioid pain therapies. The suite of software includes a mobile application for patients, which includes a behavioral health intervention, and a clinical decision support tool for healthcare providers, which provides feedback about pain and medication use trends. CPMRx software delivers a user-friendly platform that (a) allows users to report dose-by-dose pain scores, (b) helps users consider whether a dose is needed, and (c) creates usage traceability. The software allows a user to report their pain score (0 - 10 Likert scale) when a dose is taken and includes a user-directed “gamification” component. This component delivers positive reinforcement cues to the user for managing their pain within recommended treatment protocols, with the goal of providing education and incentivizing patients to make smarter and more informed decisions about dose frequency and amount. The software collects and organizes data that can be accessed by clinicians to view trending analysis for pain scores, adherence to treatment plans, and time between doses.

The overarching purpose of the current study was to determine logistical feasibility of deploying a mobile application postoperatively within a military treatment facility, including the extent to which CPMRx could provide actionable insights to clinicians regarding estimates of opioid use, pain trends, and differences in opioid use across subpopulations.

2. Materials and Methods

2.1. Participants

Active-Duty Soldiers between the ages of 18 and 30 years undergoing third molar extraction with bone involvement ($N=45$) were recruited at Womack Army Medical Center (Ft. Bragg, NC) and provided access to the CPMRx mobile application to track their postoperative pain and use of prescribed pain medication (Percocet), as well as electronic monitoring pill bottles to provide timestamps for all instances of opioid use. Patients who were unable to take oral opioid medications (due to allergy, intolerance, or history of prior misuse) or who were currently taking opioid medications to manage other acute or chronic pain were excluded from the study. The study was approved by the Naval Medical Center Portsmouth IRB Office and all participants provided written informed consent.

2.2. Measures

Outcome Measures. The primary outcome for this study was the *total number of prescribed opioids used* and the secondary outcome was opioid misuse during the postoperative period. *Opioid misuse* was defined as any situation in which opioid use was outside of prescribed parameters (e.g., in greater amounts or more often than prescribed), and included unintentional misuse (such as misunderstanding of instructions) or possible aberrant behaviors (such as recreational use or diversion). A member of the clinical study team reviewed all data to determine whether or not opioid misuse occurred. Total number of prescribed ibuprofen used was also obtained.

Independent Variables. Reviews of electronic medical records were conducted to obtain potential covariates and control variables, including sociodemographic characteristics, mental and physical health history, and clinical characteristics related to the surgery.

Sociodemographic variables were collected from electronic medical records, including age (in years), gender (male, female, other), race (White, Black, Other), and smoking status (currently smokes, previously smoked, never smoked). *Clinical factors* were also recorded, including use of Ketorolac, Ketamine, Dexamethasone, and antibiotics, as well as time in surgery.

2.3. Procedures

Following standard of care, pre-operative appointments for third molar extraction were scheduled for all patients who were going to undergo third molar extraction (*i.e.*, wisdom tooth removal). During these appointments, patients were educated about the procedure and underwent a physical and a history to ensure they were eligible for the procedure. Also following standard of care, female patients were required to submit to a urine pregnancy test and screen negative to proceed. The oral surgeon wrote a prescription for 21 pills of 5 mg/325 mg oxycodone/acetaminophen (brand name: Percocet) and 30 pills of 800 mg of ibuprofen (brand name: Motrin). Participants self-managed their pain at home and used the CPMRx mobile app to record self-reported pain scores and pain medication usage. All patients were advised to use ibuprofen as first line for pain and to use Percocet for breakthrough pain on an as-needed basis. All prescribed pain medications were placed in electronic monitoring pill bottles to record the exact date and time that the bottle was opened.

2.4. Statistical Analysis

All analyses were run using SAS software, Version 9.4 (SAS Institute Inc., Cary, NC). Descriptive statistics were computed to describe the overall sample and assess the distributions of all core model variables. Bivariate analyses were used to identify covariates for inclusion in our subsequent multivariate analysis and significant relationships were graphed. A linear regression analysis model was conducted to examine predictors of total postoperative opioid use, including individ-

ual factors (e.g., smoking status) and clinical factors (e.g., time in surgery, ketamine use), and any covariates that were significant or nearly significant in bivariate analyses.

3. Results

The majority of participants were male (80%, $n = 36$) and the average age was 22.1 years old. The majority of participants had a high school education (71%, $n = 32$). Fifteen participants reported having ever smoked, including ten people who reported currently smoking and 5 of them having previously smoked. Overall opioid use patterns showed that 45% of patients used 10 tablets of Percocet or fewer, and more than half used 12 or fewer. About a quarter of patients used all 21 pills. Importantly, review of electronic monitoring pill bottles revealed that no patient who used all 21 pills appeared to have used them all according to prescriber instructions (for example, the pill bottle being opened only twice but all pills being used). There were no significant correlations between the total number of opioids used during the postoperative period and any of the clinical characteristics (*i.e.*, use of Ketorolac, Ketamine, Dexamethasone, antibiotics time in surgery). Bivariate results revealed associations between smoking status and education with opioid use. Specifically, people who currently smoke used two times as many opioids following surgery as people who have never smoked (see **Figure 1**).

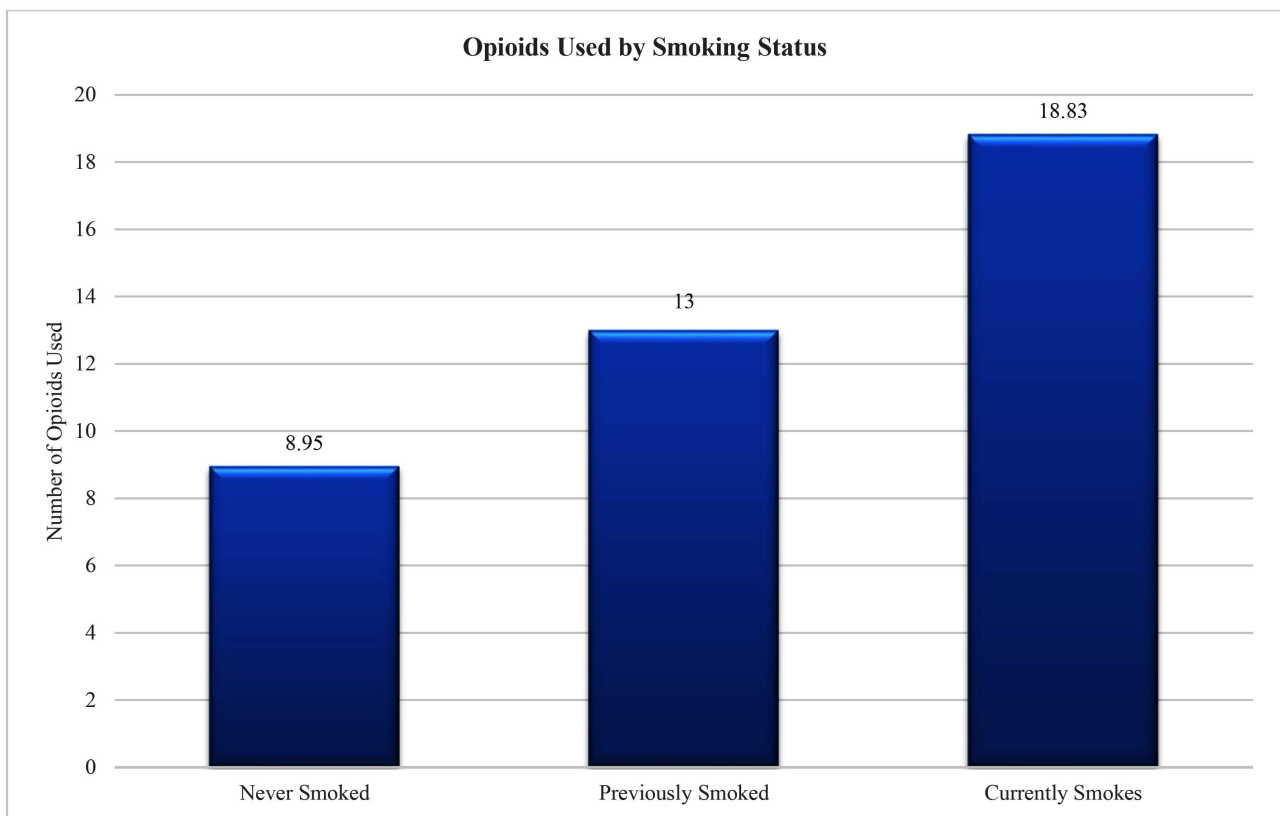


Figure 1. Number of prescription opioids used during the postoperative period by smoking status.

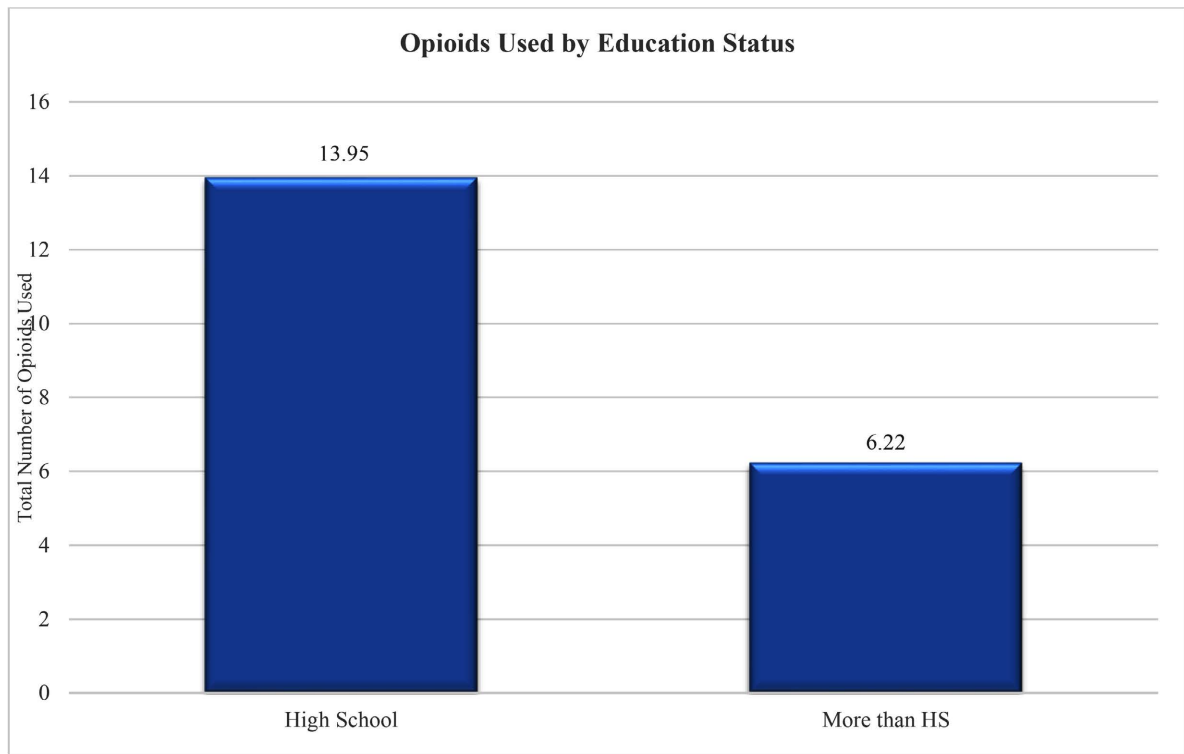


Figure 2. Total number of prescription opioids used postoperatively by education status.

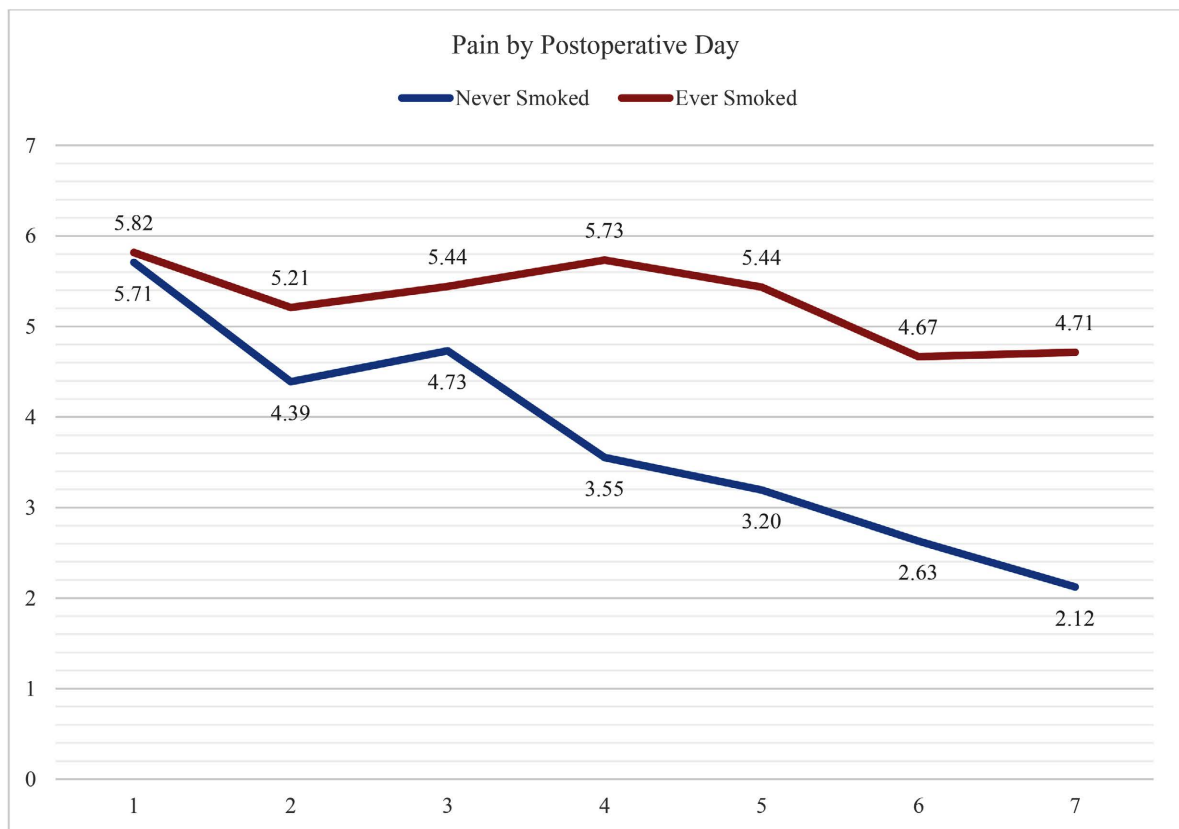


Figure 3. Self-reported pain scores by postoperative day by smoking status.

Additionally, Soldiers with more than a high school education used less than half as those with only a high school education (see **Figure 2**). Smoking status was also related to postoperative pain, but only from Day 4 and later (see **Figure 3**).

Overall, the linear regression model predicting total opioid use was significant and accounted for 82% of the variance in opioids used [$F(7) = 11.55$, $p < 0.001$, $R^2 = 0.82$]. In addition to pain on Postoperative Day 4, education, smoking status, and age emerged as significant predictors (see **Table 1**).

Table 1. Linear regression model results with significant predictors of total postoperative opioid use.

Predictor	DF	Type I Sum of Squares	F	p
Smoking Category	2	405.13	13.91	<0.001
Education	1	346.19	23.78	<0.001
Pain on Post-Op Day 4	1	252.46	17.34	<0.001
Age	1	71.55	4.91	0.04
Gender	1	2.38	0.16	0.69
Day 4 Pain * Education	1	99.18	6.81	0.02

At the community level, feedback from the CPM clinical decision support tools (pain and opioid usage trends) prompted a reduction in the standard prescription from 25 to 16 pills. Clinicians were able to reduce overprescription by more than 10,000 opioids annually for a single surgery type, preventing excess medication from possible diversion or misuse in the Ft. Bragg community.

4. Discussion

The opioid epidemic continues to be a major public health issue in the United States, and many patients receive an opioid prescription for postoperative pain control following third molar extraction. There is evidence showing that individuals who receive an opioid prescription following a minor dental surgery, such as third molar extractions, are at increased risk for opioid misuse [18]. Therefore, it is imperative to continue to identify methods to decrease opioid use both by developing alternative methods for postoperative pain control, and by understanding factors leading to increased pain and opioid use.

Understanding what variables may affect postoperative opioid use provides valuable insight into how opioid use can be reduced both at a patient, and population, level. This study was designed to evaluate the quantity and duration of opioid use after third molar extraction in an active-duty population, and to ascertain what patient factors were associated with increased use. One of the striking findings of this study was the difference between people who currently smoke and people who have never smoked. People who currently smoke used two times as many opioids following surgery as people who have never smoked and had higher pain on post-

operative day four as compared to people who have never smoked. This is of particular consequence for military prescribers. While the overall incidence of smoking among U.S. active-duty service members has declined to the level of the general population, about 20%, Shrestha *et al.* found a 30% prevalence of smoking among active-duty service members ages 17 - 29 [19]. People who currently smoke in this study also reported an increased level of pain following postoperative day three as compared to people who have never smoked. A theoretical link can be made between higher levels of pain among people who currently smoke beyond postoperative day three and the impact of the mechanics of smoking on wound healing. Additionally, studies have documented the link between nicotine and pain perception, with people experiencing higher pain thresholds and tolerance following nicotine use [20]. For patients who temporarily did not smoke during their recovery, higher levels of pain may have been perceived.

Considering this finding, several further avenues of research could be explored. In a prospective study assessing pain and swelling during the first week after surgical extraction of impacted third molars, preoperative smoking did not have an effect on postoperative pain, but postoperative smoking did [21]. In this study, it was also not specifically recorded whether patients continued to smoke in the perioperative period, which could contribute to increased pain and therefore opioid use. Additionally, this finding presents an opportunity for physicians to move toward more precise prescribing practices, by adjusting prescription size based on smoking status.

The other highest predictor of opioid use was level of education. Patients who had only a high school education used significantly more opioids postoperatively than those with more than a high school degree. Several of these patients finished all opioid tablets. A possible reason for this difference could be varying degrees of health literacy related to education level; for instance, patients with higher health literacy may be more aware of the adverse effects of opioid analgesics. This is congruent with prior research indicating health literacy is a significant mediating factor in medication adherence [22]. In this study, patients received standard instructions on the day of the procedure by the nurse coordinator, however, patient education received during the preoperative evaluation appointment was not standardized and varied by provider. Further research could investigate the impact of health literacy specifically on opioid use and test the efficacy of tailored medication instructions on opioid use. Importantly, the finding regarding education and opioid use suggests that psychoeducation efforts could reduce overall opioid use, misuse, and the potential for habit-forming behaviors. There were several factors in this study that surprisingly did not correlate with increased opioid use. These included age, duration of procedure, and intraoperative medications such as dexamethasone. It should be noted that our linear regression models' R^2 value of 0.82 is particularly high for behavioral research and is likely attributed to the homogeneity of the study population and the controlled surgical context.

Several limitations to this study should be noted. As the patients were treated

at an Army OMFS residency program, the procedures were performed by multiple providers with varying degrees of expertise, which may impact postoperative pain. Additionally, some patients in the study had more extractions than others, as well as varying degrees of third molar impaction, which may have had an effect on pain and opioid use. This study was conducted with a relatively small sample size; although we had enough power to detect statistically significant differences, generalizability to other populations may be limited. Finally, the results of this study are specific to one surgery type. Future studies and implementation projects should repeat this process across other surgeries, departments, and hospitals.

Oral and maxillofacial surgeons must weigh patient comfort and the legitimate safety concerns of opioid medications when prescribing postoperative analgesics. This study found that certain variables, specifically smoking status and education level, did correlate with postoperative opioid use, while others, such as patient age and duration of procedure, did not. This provides important insight for providers to make decisions regarding both perioperative patient education and postoperative opioid prescribing. With the increasing body of knowledge regarding postoperative analgesia, providers are better able to consider the various factors that may contribute to postoperative pain and opioid use and create a patient-specific approach to care.

5. Conclusion

Feedback from the CPM clinical decision support tools prompted a reduction in the standard prescription from 25 to 16 pills. Clinicians were able to reduce overprescription by more than 10,000 opioids annually for a single surgery type, preventing excess medication from possible diversion or misuse in the Ft. Bragg community. Stratifying prescription size by predictors could further reduce excess opioids in the community, and opportunities for precision medicine in prescribing practices were identified, including smoking status. Finally, psychoeducation for patients may be effective in decreasing opioid use, including postoperative pain expectations and increased clarity on non-opioid pain management options. Replication of this process across additional surgery types (beginning with the highest surgeries by volume) could further reduce systematic overprescription and potential for opioid misuse in this community.

Presentations

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Disclaimers

The views expressed in this paper are those of the authors and do not necessarily

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Conflicts of Interest

The authors declare no conflicts of interest.

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