Long-term prescription opioid use following surgery in the US (2017–2022): a population-based study

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Summary

Background Over the last decade, numerous efforts have been made to combat the opioid crisis globally. The impact of these strategies has not been adequately measured and may differ across populations depending on baseline risk. We compared changes in long-term prescription opioid use following surgery within a national US cohort, between 2017 and 2022.

Methods We used TRICARE claims data to identify individuals undergoing one of 14 representative surgical procedures. The rate of post-operative long-term prescription opioid use during 2020–22 was compared to 2017–19. We used modified Poisson regression analyses to adjust for confounding. We performed secondary analyses that accounted for interactions between the time period and race, pre-operative opioid use, surgical care setting and our proxy for socioeconomic status.

Findings Our data derived from TRICARE claims. We included 410,326 surgical events. Across both time periods, there were 213,212 females (52%), with a median age of 53 (IQR 22) and 207,188 individuals of White race (50%). The median co-morbidity index was 0 (IQR = 0). The rate of long-term post-operative opioid use was 11% in 2017–19, which reduced to 6% in 2020–22 (risk ratio [RR] 0.51; 95% CI 0.50, 0.52). Reductions were appreciated across all census divisions in the US and across all racial minorities, those of lower socioeconomic background and pre-operative chronic opioid users. Following multivariable analysis, there was a significant reduction in long-term prescription opioid use (RR 0.61; 95% CI 0.60, 0.63) after surgery in 2020–22 as compared to 2017–19.

Interpretation This investigation represents one of the largest and most comprehensive longitudinal assessments of opioid use following surgery. We found clinically relevant reductions in post-operative prescription opioid use in 2020–22 as compared to 2017–19. Given the representative nature of the study cohort, we believe these results are reflective of national trends.

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Significant reductions in long-term prescription opioid use following surgery in the US (2017–2022).

Research in context

Evidence before this Study

We searched PubMed and Web of Science for longitudinal studies reporting on the incidence of long-term opioid use, or opioid addiction, among adults in the US following surgical interventions. We employed the following search terms ("addiction, opiate") AND ("surgery"). The search was re-performed in the revision stage and considered articles published up to September 30, 2024. The search identified 62 studies, none of which specifically evaluated changes in the rates of long-term prescription opioid use over a longitudinal time frame similar to our own. Most of the studies focused on pain management strategies, or the characterization of opioid use and risk factors for prolonged use in the context of specific surgical procedures such as joint arthroplasty, lumbar fusion surgery, sports medicine procedures, hysterectomy and Cesarean delivery. At present, the question remains as to the impact of recent systemic approaches intended to reduce the use of prescription opioids and the predilection for long-term use. Information is particularly lacking in the setting of high-risk patients such as those already using opioid medications and individuals undergoing high intensity surgical procedures.

Added value of this study

This investigation represents one of the largest and most comprehensive longitudinal assessments around changes in prescription opioid use following surgery. This investigation was able to evaluate long-term prescription opioid use in patients undergoing surgery following the release of the CDC and VA/DoD guidelines in a manner that also accounted for changes in healthcare delivery that occurred during the COVID-19 pandemic. We found significant and clinically relevant reductions in long-term post-operative prescription opioid use in 2020–22 as compared to 2017–19. Reductions were appreciated across all census divisions in the United States and across all subgroups, including racial minorities, those of lower socioeconomic background and pre-operative chronic opioid users.

Implications of all the available evidence

Given the representative nature of the cohort under study, we believe these results are reflective of US national trends. The changes in long-term prescription opioid use after surgery realized over the course of 2017–2022 may indicate increased familiarity, on the part of both patients and providers, with the clinical practice guidelines that were promulgated by the CDC and VA/DoD. Approaches implemented in the Military Health System may have the capacity to impact greater change on a broader front if applied to the civilian healthcare setting in the US and globally.

Introduction

Over the last decade, concerted efforts have been made to combat the opioid crisis in the United States. Most efforts have focused on governmental, or other third party, regulation of opioid prescriptions at the point of issue, provider education, or risk mitigation strategies including the use of predictive models to understand the individualized risk of long-term prescription opioid use. The impact of these strategies has not been adequately measured and may differ depending on the baseline risk of long-term opioid use in the population under study, injuries or surgical procedures that prompt the issue of opioids and temporal changes in access to care and opioid prescriptions as such has been postulated to have transpired over the early stages of the Corona Virus Disease 2019 (COVID-19) pandemic.

Current estimates maintain that more than 1.5 million individuals in the US are treated for opioid use disorder annually[1] and approximately 68% of all drug overdoses are opioid related,[2] with a disproportionate increase in overdose deaths since the onset of the COVID-19 pandemic.[3] At the same time, other studies have identified the ongoing risk of new persistent opioid use in patients undergoing surgery to be in the range of 3–10%.[4] Crawford et al. reported that while long-term prescription opioid use was found to have diminished following certain surgical interventions among those not using opioids before surgery, the prevalence of long-term opioid use among chronic pre-operative users actually increased over the course of the pandemic.[5] As the effects of COVID-19 on the healthcare system recede, the question remains as to what impact the systemic approaches had on prescription opioid reduction, particularly in high-risk populations such as those already using opioid medications and individuals undergoing surgery.[2,4–11]

In this context, we sought to study temporal changes using the population of the Military Health System (MHS) covered by TRICARE. TRICARE is the insurance product of the Military Health System, where beneficiaries are able to receive healthcare services through Department of Defense and/or civilian facilities. The covered population of the MHS provides several advantages for determining national estimates, including a national network that covers all US states and territories, comprehensive surveillance of prescription fills irrespective of the site of service, and a diverse demographic on racial/ethnic, socioeconomic, educational and occupational grounds that has been found to be representative of the general US population aged 18–64.[7,12–17] More than eighty percent of the covered population is comprised of civilians (e.g. dependents or retirees)[15,16,18] and MHS data has been effectively used in the past to study healthcare delivery and health policy in the setting of long-term prescription opioid use.[7,12–14,19] This study aimed to evaluate changes in long-term prescription opioid use following a battery of representative surgical procedures, contrasting the time periods 2017–2019 and 2020–2022 in order to account for changes in healthcare delivery and opioid prescribing that occurred in conjunction with the COVID-19 pandemic.

Methods

Data sources

We performed a query of the MHS Data Repository to identify all individuals, aged 18–64, insured through TRICARE, who received one or more prescriptions for a class II or III opioid analgesic following one of 14 select surgical procedures in the time period January 1, 2017–December 31, 2022. The means by which data is collected in the repository following delivery of clinical care, collated, prepared and made available to researchers has been described extensively in prior work.[12,14–16,18] In brief, the repository captures data for individuals insured through TRICARE and who receive treatment at a Department of Defense facility (i.e. direct care) or in the private sector. The repository does not capture data from Veterans Administration facilities or for care administered in combat zones.[12,14–16,18]

Study cohort selection

Surgical procedures were identified using an algorithm that combined eligible International Classification of Disease-10th revision (ICD-10) procedure codes and Current Procedural Terminology codes and included: cholecystectomy, appendectomy, inguinal hernia repair, repair of abdominal aortic aneurysm (AAA), colectomy, cataract surgery, spine surgery, rotator cuff repair, total knee arthroplasty, total hip arthroplasty, coronary artery bypass grafting (CABG), mastectomy, bariatric surgery and transurethral resection of the prostate (TURP).[12,14,17] These procedures are considered characteristic interventions for the disciplines of general surgery, vascular surgery, ophthalmology, neurosurgery, orthopaedic surgery, thoracic surgery and urology[12,14,17] with appropriate levels of heterogeneity in terms of post-operative pain and pain management protocols.[14] These procedures also have built in variation in terms of surgical intensity, which also contributes to the risk of long-term opioid use.[14] Patients who had a prior surgical intervention within 6-months of an eligible surgical procedure, or had an active diagnosis of cancer within 1-year of the surgery date were excluded. Patients could be included in the setting of multiple procedures, as long as there was at least 6-months between surgical interventions. The full list of codes used to identify surgical procedures can be found in Supplemental Materials (Supplementary Table S1).

Covariates

The records of eligible patients were abstracted to determine age at the time of surgery, self-identified race, biologic sex, US census division, sponsor rank, beneficiary category, mental health diagnoses recorded at the time of surgery, number of co-morbidities characterized according to the Charlson Co-morbidity Index[20] at the time of surgery, environment of care delivery (e.g. direct vs private-sector) and pre-operative opioid usage. Based on previously published work,[7] we surveyed prescription fills for any class II or III opioid analgesics in the 6-months prior to the date of surgery. For each eligible prescription, we determined the number of associated days based on the dosage, instructed means of use and number of pills issued. We then characterized pre-operative use through the presence of continuous refills, with no more than a seven-day abstinence period between refills, on opioid medications. Pre-operative use was then categorized as: Opioid non-user (no opioid exposure), Acute Exposure (first receipt of opioids within 30 days of surgery, Exposed (receipt of opioids within the 1-year period prior to surgery, but no evidence of continuous use), Intermediate Long-term Use (continuous use for less than 6-months before surgery) and Chronic Long-term Use (continuous use for 6-months or longer before surgery).[7]

Outcome assessment

Post-operative opioid use was surveyed using an identical approach, with long-term use identified by 6-months of uninterrupted use of opioid medications.[7,21] This definition is aligned with previously published work that validated such an approach using claims-based prescription data and found that it explained similar amounts of variance in satisfaction, disability and pain as clinically granular definitions of chronic use.[21]

Statistical analysis

Long-term post-operative prescription opioid use was the outcome in this investigation and categorized as a binary variable. The time period of the index surgical procedure represented the primary predictor. Here, we compared surgeries performed in 2020–2022 to those performed in 2017–2019 as the referent. Initial unadjusted comparisons between the cohorts were made using the chi-square tests and modified Poisson regression analyses were used to determine effect size and 95% confidence interval (CI). We then performed a multivariable modified Poisson regression to adjust for confounders that were included based on conceptual causal model. The co-variates included in adjusted analyses consisted of age, biologic sex, pre-operative opioid use, race, beneficiary category, sponsor rank, census division, care setting, mental health diagnoses and co-morbidities based on known associations with the potential for long-term opioid use.[4,5,7,10,14] In adjusted analyses, we accounted for missing race (29%, 106,346/369,397) using reweighted estimating equations—an inverse probability weighting technique for imputation—

as is recommended in previous work describing best practices for analyzing MHS-claims data.[15,22] Age, biologic sex, pre-operative opioid use, race, beneficiary category, sponsor rank, census division, care setting, mental health diagnoses, co-morbidities and the time period of the index surgery were used to calculate the inverse probability of an observed race, based on known associations between these parameters and patient race.[7,13,14,19,22] The proportion of missing data among covariates is reported in Supplementary Table S2. We accounted for patients with multiple procedures by clustering all models on the patient's unique identification using cluster robust standard errors. Co-linearity was assessed using the variance inflation factor and the condition index.

In secondary tests, we accounted for interactions separately between the time periods under study and race, sponsor rank, pre-operative opioid exposure and surgical care setting. These analyses also included all other covariates present in our multivariable model. In this context, sponsor rank was used as a proxy for socioeconomic status, which is supported by previous work indicating individuals and dependents with enlisted sponsor rank are representative of lower socioeconomic strata.[15,16,23–25] In these secondary analyses, White patients in 2017–19, officers in 2017–19, opioid non-users in 2017–19 and direct care surgeries in 2017–19 were used as the respective referents. The results of all Poisson tests were expressed as risk ratios (RR) with 95% CI and p-value. In analyses that used interactions, we assessed the interaction contrast estimate with 95% CI and p-value. We assessed the adequacy of our sample through consideration of the width of the 95% CI generated from our analyses. All testing was performed using SAS v.9.4 (SAS Inst., Cary, NC). Prior to commencement, this work was found exempt by our institutional review board.

Role of the funding source

The funding source played no role in the role in the study design, data collection, data analysis, interpretation, or writing of the report.

Results

We included 410,326 surgical events in this study with 196,099 occurring in 2017–19 and 214,227 in 2020–22. Across both time periods, there was a slight preponderance of females, with a median age approximating 53, of White race, of senior enlisted sponsor rank, treated in the private sector, opioid non-users at the time of surgery and with a median co-morbidity index of 0 (IQR = 0; Table 1). A plurality of cases in both cohorts were dependents and from the South Atlantic census division. The most common surgical intervention in both time windows was spine surgery (Table 2). Given the size of our sample, all of these findings were statistically significant. There was no evidence of co-linearity. All variance inflation factors were <10 and the condition indices were also <10.

The rate of long-term post-operative opioid use was 11% (21,556/196,099) in 2017–19, which reduced to 6% (12,114/214,227) in 2020–22 (RR 0.51; 95% CI 0.50, 0.52; $p < 0.0001$). Reductions were appreciated across all census divisions in the United States (Fig. 1), with the most substantial reductions in the East South Central (14.5% [2279/15,717]–7.8% [1354/17,336]) and West South Central (13.3% [3881/29,227]–7.1% [2240/31,624]). Whereas in 2017–19 there were six regions with rates of post-operative long-term use above 10%, no region experienced a rate higher than 7.8% in 2020–22. Following multivariable analysis that adjusted for confounders, we found that there was a 39% reduction in risk of long-term prescription opioid use (RR 0.61; 95% CI 0.60, 0.63; $p < 0.0001$ for 2020–22 as compared to 2017–19 (Table 3).

Significant reductions in long-term post-operative opioid use were also appreciated among Whites and all non-White cohorts when compared to Whites in 2017–19 (Table 4). Black patients in 2017–2019 had a similar risk of long-term opioid use when compared to White referents (RR 0.97; 95% CI 0.93, 1.02; $p = 0.25$). However, during 2020–22 Black patients demonstrated a significantly lower risk of long-term opioid use when compared to White patients (RR 0.61; 95% CI 0.57, 0.64; $p < 0.0001$). While the risk of long-term opioid use was similar in 2017–19 for our proxy for socioeconomic status (Junior Enlisted RR 1.04; 95% CI 0.95, 1.15; $p = 0.38$), this figure was significantly lowered in 2020–22 and demonstrated a reduced risk as compared to the referent (RR 0.68; 95% CI 0.61, 0.75; $p < 0.0001$).

Similarly, the risk of long-term use was reduced in 2020–22 for opioid non-users (RR 0.32; 95% CI 0.28, 0.36; $p < 0.0001$) and acutely exposed individuals (RR 0.62; 95% CI 0.49, 0.77; $p < 0.0001$). While the risk of long-term opioid use remained predictably higher for those with pre-operative intermediate (RR 13.72; 95% CI 11.99, 15.71; $p < 0.0001$) and chronic long-term use (RR 30.16; 95% CI 27.88, 32.64; $p < 0.0001$), these figures still represented significant reductions in risk as compared to 2017–19 (Table 4).

Significant reductions in post-operative opioid use were also appreciated for both Direct Care (RR 0.53; 95% CI 0.50, 0.56; $p < 0.0001$) and the private sector (RR 0.73; 95% CI 0.70, 0.73; $p < 0.0001$) in 2020–22 when compared to 2017–19. As in 2017–19, however, the risk of long-term opioid use remained significantly higher among individuals treated in the private sector during 2020–22 when compared to Direct Care in the same timeframe (Table 4). Among pre-operative non-users, the rate of long-term opioid use was 2.1% (2078/99,139) in 2017–19. This was reduced to a rate of 0.62% (754/121,103) in 2020–22 with a significant difference appreciated between the two cohorts ($p < 0.0001$). Significant interactions were identified among almost all

	2017–2019			2020–2022		
	Sustained opioid use N (%)	Total N (%)	p-value	Sustained opioid use N (%)	Total N (%)	p-value
Total	21,554 (100)	196,099 (100)		12,114 (100)	214,227 (100)	
Sex			<0.0001			<0.0001
Male	8832 (40.98)	95,135 (48.51)		4708 (38.86)	101,974 (47.60)	
Female	12,722 (59.02)	100,964 (51.49)		7406 (61.14)	112,248 (52.40)	
Median age (IQR)	56 (14)	52 (23)	<0.0001	57 (11)	53 (22)	<0.0001
Race			<0.0001			<0.0001
White	9864 (45.76)	97,556 (49.75)		5479 (45.23)	109,632 (51.18)	
Black	1938 (8.99)	21,044 (10.73)		1119 (9.24)	22,631 (10.56)	
Asian	303 (1.41)	4461 (2.27)		156 (1.29)	4810 (2.25)	
Other	1082 (5.02)	15,228 (7.77)		604 (4.99)	16,430 (7.67)	
Missing	8367 (38.82)	57,810 (29.48)		4756 (39.26)	60,724 (28.35)	
Beneficiary category			<0.0001			<0.0001
Active duty	888 (4.12)	24,758 (12.63)		269 (2.22)	25,728 (12.01)	
Dependent	11,649 (54.05)	89,840 (45.81)		6885 (56.84)	96,204 (44.91)	
Retired	7920 (36.74)	64,321 (32.80)		4416 (36.45)	68,837 (32.13)	
Other	920 (4.27)	12,335 (6.29)		444 (3.67)	13,129 (6.13)	
Missing	177 (0.82)	4845 (2.47)		100 (0.83)	10,329 (4.82)	
Rank			<0.0001			<0.0001
Junior enlisted	1316 (6.11)	17,506 (8.93)		709 (5.85)	17,761 (8.29)	
Senior enlisted	15,584 (72.30)	121,528 (61.97)		9151 (75.54)	137,010 (63.96)	
Officers	3220 (14.94)	36,831 (18.78)		1786 (14.74)	43,581 (20.34)	
Other	1428 (6.63)	20,044 (10.22)		440 (3.63)	12,711 (5.93)	
Missing	<11	190 (0.10)		28 (0.23)	3164 (1.48)	
Census division			<0.0001			<0.0001
South Atlantic	7257 (33.67)	62,830 (32.04)		4274 (35.28)	69,824 (32.59)	
W South Central	3881 (18.01)	29,227 (14.90)		2240 (18.49)	31,624 (14.76)	
Pacific	1904 (8.83)	22,977 (11.72)		1004 (8.29)	23,041 (10.76)	
Mountain	1895 (8.79)	17,180 (8.76)		1125 (9.29)	19,111 (8.92)	
E South Central	2279 (10.57)	15,717 (8.01)		1354 (11.18)	17,336 (8.09)	
E North Central	1231 (5.71)	11,186 (5.70)		676 (5.58)	11,787 (5.50)	
W North Central	1079 (5.01)	10,597 (5.40)		570 (4.71)	11,493 (5.36)	
Middle Atlantic	525 (2.44)	5572 (2.84)		271 (2.24)	5866 (2.74)	
New England	179 (0.83)	2464 (1.26)		98 (0.81)	2500 (1.17)	
Other	179 (0.83)	5054 (2.58)		46 (0.38)	4992 (2.33)	
Missing	1145 (5.31)	13,295 (6.78)		456 (3.76)	16,653 (7.77)	
Care setting			<0.0001			<0.0001
Direct care	2978 (13.82)	49,732 (25.36)		1099 (9.07)	45,126 (21.06)	
Private sector care	18,576 (86.18)	146,367 (74.64)		11,015 (90.93)	169,101 (78.94)	
Preoperative opioid use			<0.0001			<0.0001
Non-user	2078 (9.64)	99,139 (50.56)		754 (6.22)	121,103 (56.53)	
Acute	319 (1.48)	12,043 (6.14)		188 (1.55)	16,257 (7.59)	
Exposed	8738 (40.54)	72,102 (36.77)		3691 (30.47)	65,786 (30.71)	
Intermediate	965 (4.48)	2007 (1.02)		459 (3.79)	1471 (0.69)	
Chronic	9454 (43.86)	10,808 (5.51)		7022 (57.97)	9610 (4.49)	
Mental health diagnosis[b]	6110 (28.35)	29,799 (15.20)	<0.0001	3272 (27.01)	29,334 (13.69)	<0.0001
Median charlson Co-morbidity index score (IQR)	0 (1)	0 (0)	<0.0001	0 (1)	0 (0)	<0.0001

Note: p-values are from t-tests (continuous variables) or chi-square tests (categorical variables) and used to compared variable frequencies between those with or without sustained postoperative opioid use and did not include missing observations. Cell counts of 10 or fewer were censored and labeled <11. IQR, interquartile range.
[a]All TRICARE beneficiaries aged 18–64 yr with at least one of the select surgeries from calendar year (CY) 2017–2022. Beneficiaries were excluded if they received any surgery 6 months prior or having a neoplasm diagnosis 1 year prior. [b]Identified at time of surgery.

Table 1: **Cohort[a] demographics and post-operative long-term opioid use status, 2017–2022.**

Procedure	2017–2019			2020–2022		
	Direct care N (% of Period Total)	Private sector care N (% of Period Total)	Period Total	Direct care N (% of Period Total)	Private Sector Care N (% of Period Total)	Period Total
Spinal surgery	6557 (17.52)	30,865 (82.48)	37,422	6088 (14.90)	34,781 (85.10)	40,869
Cholecystectomy	9862 (29.84)	23,187 (70.16)	33,049	9651 (27.16)	25,880 (72.84)	35,531
Cataract surgery	6200 (22.09)	21,871 (77.91)	28,071	5827 (18.58)	25,538 (81.42)	31,365
Appendectomy	7040 (35.81)	12,621 (64.19)	19,661	6739 (31.92)	14,373 (68.08)	21,112
Rotator cuff repair	3582 (20.83)	13,614 (79.17)	17,196	3408 (16.88)	16,778 (83.12)	20,186
Total knee arthroplasty	3179 (18.80)	13,732 (81.20)	16,911	2955 (15.09)	16,632 (84.91)	19,587
Bariatric surgery	3010 (29.50)	7195 (70.50)	10,205	1901 (17.16)	9177 (82.84)	11,078
Total hip arthroplasty	1869 (18.96)	7989 (81.04)	9858	1829 (14.80)	10,527 (85.20)	12,356
Inguinal hernia repair	3882 (43.77)	4987 (56.23)	8869	3719 (36.88)	6364 (63.12)	10,083
Colectomy	1803 (25.43)	5287 (74.57)	7090	1257 (21.06)	4713 (78.94)	5970
Transurethral resection of the prostate	1255 (33.28)	2516 (66.72)	3771	869 (30.44)	1986 (69.56)	2855
Coronary artery bypass grafting	266 (10.73)	2213 (89.27)	2479	66 (3.10)	2063 (96.90)	2129
Mastectomy	1168 (72.14)	451 (27.86)	1619	880 (64.52)	484 (35.48)	1364
Abdominal aortic aneurysm	138 (32.78)	283 (67.22)	421	32 (8.82)	331 (91.18)	363

Note: Counts represent individual events of surgery, therefore, patients in the cohort could be counted under multiple surgeries as long as they occurred 6 months apart.

Table 2: **Distribution of surgeries by care setting, 2017–2022.**

the parameters that we considered (Supplementary Table S3).

Discussion

Since 2013, the US health system has made a concerted effort to combat the opioid crisis in the United States, including attempts to minimize the number and strength of medications issued, limit diversion to the community and truncate the duration of initial opioid prescriptions.[1,3,9,10,12,19,26] Both the Centers for Disease Control (CDC) and the VA/DoD issued clinical practice guidelines in 2016 and 2017, respectively, intending to influence clinician decisions around prescribing opioid analgesics.[27,28] Despite these approaches, the opioid epidemic continues to confront the medical community, with the number of drug overdose deaths increasing by 16% between 2020 and 2021.[27] The total costs for treating patients with opioid use disorder and overdoses is now reported to exceed $1 trillion.[29] Many of the rigors of the COVID-19 pandemic were theorized to have adversely impacted any headway that was being made due to provider education and governmental efforts.[3,30] For example, Kline et al. reported a greater risk of increased opioid use and overdose among prior opioid users in the early stages of the pandemic.[3] Likewise, Lee et al. found that in the setting of a pain related diagnosis, patients were more likely to receive an opioid prescription for a more potent opioid than they were prior to the onset of the pandemic.[30]

This investigation is among the first to comprehensively evaluate long-term prescription opioid use in patients undergoing surgery following the release of the CDC and VA/DoD guidelines in a manner that also accounts for changes in healthcare delivery into the present. Our data included patients treated across the

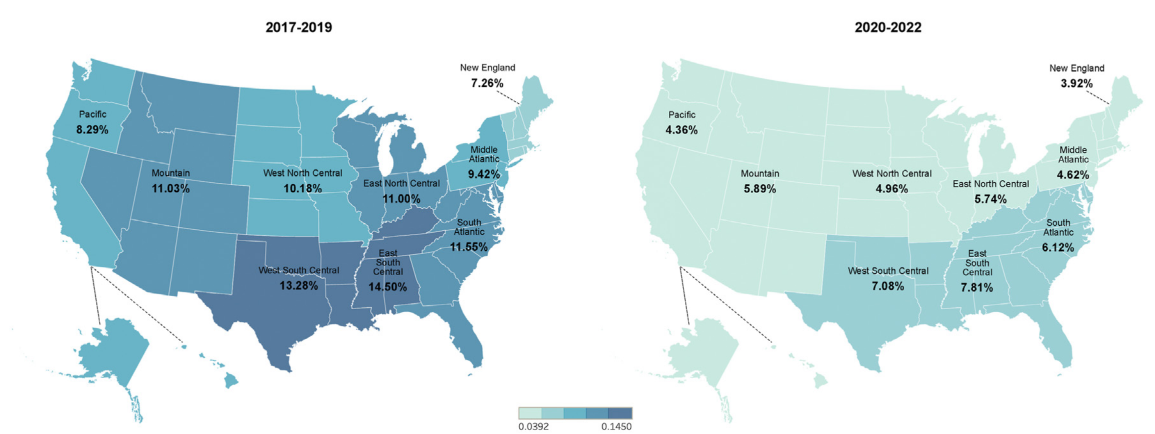

Fig. 1: **Comparisons of the rate of long-term prescription opioid use by census division in 2017–2019 and 2020–2022.**

US in a variety of healthcare contexts and considered a battery of surgical procedures with different predilections at baseline for long-term prescription opioid use.[12,14] Moreover, the procedures we included are considered representative of a variety of different surgical fields and subspecialties, including general surgery, cardiovascular surgery, ophthalmology, orthopaedic surgery, neurosurgery and urology.[2,10,12,14,16] The rates of long-term post-operative prescription opioid use for our population in 2017–19 are aligned with previously published works[4,11] and the risk factors associated with long-term use overall (Table 3) are similarly well substantiated in the literature, including age, White race, lower socioeconomic status, number of medical co-morbidities and mental health diagnoses.[4,5,7,10,14,23] The reductions in long-term prescription opioid use for our population are also similar to estimates from a separate study on opioid non-users in the MHS who received opioid medications for any indication between 2020 and 21.[19] We believe the consistency between our data and that of previously published literature on this topic endorses the external validity and translational capacity of our findings. We also would emphasize that our data include the entire population of TRICARE beneficiaries between 2017 and 2022 with over 200,000 individuals represented in each of the two time periods. Our assessment of the 95% CI associated with the point estimates indicated they were sufficiently narrow and precise to support the notion of an adequate sample for our determinations. This was particularly the case for those co-variates that did not demonstrate significance.

Indeed, we believe that our results tell an important story for healthcare providers, institutions, governmental agencies and third-party payers. Foremost, we appreciated clinically relevant and statistically significant reductions in long-term prescription opioid use across all segments of the population under study in 2020–22 as compared to 2017–19. Overall, there was a 38% reduction in the risk of long-term prescription opioid use (RR 0.62; 95% CI 0.60, 0.63; p < 0.0001) for individuals receiving surgery in 2020–22 when compared to 2017–19. This included patients treated in all census divisions and all environments of care, as well as high-risk segments of the population such as those from lower socioeconomic backgrounds and those who were long-term prescription opioid users before their surgery. We do not believe these changes can be attributed to reduction in access or procedural volume in the time period 2020–2022 as the total number of cases performed in this time window exceeds those performed in 2017–2019. Importantly, our results also indicated reductions in healthcare disparities, as Black patients in 2020–22 experienced a significantly lower risk of long-term opioid use when compared to White referents (RR 0.61; 95% CI 0.58, 0.64; p < 0.0001) as well as Black counterparts in 2017–2019.

	Unadjusted models	Adjusted model
	RR (95% CI)	RR (95% CI)
Time period		
2017–2019 (ref)	Ref	Ref
2020–2022	0.51 (0.50–0.52), p < 0.0001	0.61 (0.60–0.63), p < 0.0001
Preoperative opioid use		
Non-user (ref)	Ref	Ref
Acute	1.39 (1.27–1.53), p < 0.0001	1.48 (1.29–1.71), p < 0.0001
Exposed	7.01 (6.73–7.30), p < 0.0001	6.67 (6.24–7.15), p < 0.0001
Intermediate	31.84 (30.13–33.64), p < 0.0001	27.12 (24.82–29.64), p < 0.0001
Chronic	62.75 (60.39–65.21), p < 0.0001	50.84 (47.52–54.39), p < 0.0001
Sex		
Male (ref)	Ref	Ref
Female	1.37 (1.34–1.41), p < 0.0001	1.04 (1.01–1.08), p = 0.026
Race		
White (ref)	Ref	Ref
Black	0.94 (0.90–0.99), p = 0.012	0.98 (0.94–1.02), p = 0.28
Asian	0.67 (0.60–0.74), p < 0.0001	0.82 (0.74–0.89), p < 0.0001
Other	0.72 (0.68–0.76), p < 0.0001	0.92 (0.87–0.96), p = 0.0006
Beneficiary category		
Active duty (ref)	Ref	Ref
Dependent	4.35 (4.07–4.64), p < 0.0001	1.44 (1.34–1.55), p < 0.0001
Retired	4.04 (3.79–4.31), p < 0.0001	1.42 (1.32–1.52), p < 0.0001
Other	2.34 (2.15–2.54), p < 0.0001	1.28 (1.17–1.41), p < 0.0001
Rank/Sponsor's rank		
Junior Enlisted	0.92 (0.87–0.98), p = 0.006	1.08 (1.00–1.17), p = 0.04
Senior enlisted	1.54 (1.48–1.59), p < 0.0001	1.11 (1.07–1.16), p < 0.0001
Officers (ref)	Ref	Ref
Other	0.92 (0.86–0.97), p = 0.002	1.14 (1.06–1.22), p = 0.0002
Census division		
South Atlantic (ref)	Ref	Ref
Pacific	0.73 (0.69–0.76), p < 0.0001	0.99 (0.95–1.04), p = 0.81
Mountain	0.96 (0.91–1.00), p = 0.05	1.01 (0.97–1.06), p = 0.56
W South Central	1.16 (1.12–1.20), p < 0.0001	1.07 (1.03–1.11), p = 0.0001
W North Central	0.86 (0.81–0.91), p < 0.0001	0.90 (0.84–0.97), p = 0.004
E South Central	1.26 (1.21–1.32), p < 0.0001	1.09 (1.04–1.14), p = 0.0005
E North Central	0.95 (0.90–1.01), p = 0.09	1.01 (0.94–1.09), p = 0.70
New England	0.64 (0.56–0.73), p < 0.0001	0.83 (0.70–0.98), p = 0.025
Middle Atlantic	0.80 (0.74–0.87), p < 0.0001	0.94 (0.85–1.03), p = 0.19
Other	0.26 (0.22–0.30), p < 0.0001	0.71 (0.63–0.81), p < 0.0001
Care setting of surgery		
Direct care (ref)	Ref	Ref
Private sector care	2.18 (2.11–2.26), p < 0.0001	1.24 (1.18–1.29), p < 0.0001
Mental health diagnosis vs no diagnosis[a]	2.29 (2.24–2.35), p < 0.0001	1.23 (1.19–1.27), p < 0.0001

Note: Multivariable modified Poisson regression model adjusted by all variables reported in the table, plus continuous age and Charlson Comorbidity Index score. In the adjusted RWEE regression model the total number of patients without missing values is N = 245,055 and the total number of patients removed due to missing values is N = 17,997. Results expressed as Risk Ratio (RR; 95% CI). [a]Identified at time of surgery.

***Table 3:* Binomial robust Poisson regression results for risk of post-operative long-term opioid use.**

The changes in long-term prescription opioid use after surgery realized between 2017–2019 and 2020–2022 may indicate increased familiarity and comfort with the clinical practice guidelines that were

	2017–2019	2020–2022
Race		
White	Ref	0.61 (0.59–0.63), p < 0.0001
Asian	0.82 (0.73–0.91), p = 0.0005	0.50 (0.43–0.57), p < 0.0001
Black	0.97 (0.93–1.02), p = 0.25	0.61 (0.57–0.64), p < 0.0001
Other	0.92 (0.86–0.97), p = 0.006	0.56 (0.52–0.60), p < 0.0001
Sponsor rank		
Officers	Ref	0.59 (0.55–0.63), p < 0.0001
Junior enlisted	1.04 (0.95–1.15), p = 0.38	0.68 (0.61–0.75), p < 0.0001
Senior enlisted	1.09 (1.04–1.14), p = 0.0006	0.68 (0.64–0.71), p < 0.0001
Other	1.15 (1.06–1.24), p = 0.0004	0.64 (0.58–0.70), p < 0.0001
Preoperative opioid use		
Non-user	Ref	0.32 (0.28–0.36), p < 0.0001
Acute	1.33 (1.11–1.59), p = 0.002	0.62 (0.49–0.77), p < 0.0001
Exposed	5.87 (5.42–6.36), p < 0.0001	2.63 (2.41–2.87), p < 0.0001
Intermediate	21.20 (19.11–23.52), p < 0.0001	13.72 (11.99–15.71), p < 0.0001
Chronic	35.70 (33.04–38.58), p < 0.0001	30.16 (27.88–32.64), p < 0.0001
Surgery care setting		
Direct care	Ref	0.53 (0.50–0.56), p < 0.0001
Private sector care	1.17 (1.11–1.23), p < 0.0001	0.73 (0.70–0.73), p < 0.0001

Note: Each interaction model was adjusted for pandemic period, age, race, sponsor rank, census division, care setting, mental health diagnosis, Charlson Co-morbidity Index, and preoperative opioid use. Total number of patients in each regression model without missing values is N = 245,055 and the total number of patients removed from each regression model due to missing values is N = 17,997. Results expressed as Risk Ratio (RR; 95% CI).

Table 4: **Results of the secondary tests using multivariable binomial Poisson regression testing for associations with post-operative long-term opioid use by time period.**

stipulated by the CDC and VA/DoD on the part of both providers and patients.[28,31] Such acclimatization would be anticipated over time and thus a delayed realization of the impact several years following introduction of these measures should not be surprising. While Sutherland et al. previously reported that the 2016 CDC prescribing guidelines resulted in some reductions in the issue of opioids following surgery with absolute amounts remaining high, these data only ran through March 2018.[31] There is also some evidence that reductions in the issue of opioids in general, or after surgery, represents a global phenomenon with a turning point around 2016. For example, Jones et al. reported marked declines in the prescription of strong opioids in Canada after 2016.[32] At the same time, Gillies et al. documented reductions in opioid initiation and long-term use in New Zealand between 2014 and 2020.[33]

Importantly, although significant reductions were appreciated across both direct care and the private sector, the risk of long-term prescription opioid use was still significantly lower in the direct care setting in 2020–22. This may indicate the potential for DoD specific initiatives, such as the VA/DoD clinical practice guidelines and other approaches, to have a greater impact in the civilian sector. This represents an opportunity for further investigation to better understand the factors associated with superior reductions in long-term prescription opioid use in the direct care setting.

We recognize that this work should be interpreted in the context of specific limitations. Foremost, this study relied on claims-based data with well-known inherent drawbacks, including surgical indications, opacity around the decisions to issue refills on prescription opioids and surveillance for patients who transition out of the MHS. Similarly, we are not able to characterize compliance, diversion, instances of opioid misuse or transition to illegal substance abuse and there is prospect for confounding from unmeasured variables. Given the nature of the population under study, the findings cannot be extrapolated to patients over the age of 65, or those covered by Medicare. There are some who may question the health policy relevance of data derived from a population covered by the MHS, but it is important to note that numerous studies have demonstrated the overarching similarities between the population served by the MHS and the general US demographic aged 18–64.[14,16,18,24,25] Moreover, it should be recognized that over 75% of the surgical encounters in this series occurred in the civilian healthcare setting. In addition, we are unaware of other sources of data, including other registries, with greater prescription and clinical details that also cover the national demographic with adequate representation across racial, socioeconomic and vocational lines.

In conclusion, we found significant and clinically relevant reductions in long-term prescription opioid use following surgery in 2020–22 as compared to 2017–19. These improvements were realized in all healthcare settings, across all racial categories and in high-risk subpopulations. We believe these findings represent a burgeoning synergistic impact of governmental regulations, local and national educational efforts and the promulgation of clinical practice guidelines, especially within the context of DoD facilities. Given the representative nature of the cohort under study, we believe these results are reflective of national trends and that approaches developed by the MHS may effect greater change on a broader front if applied to the civilian health system.

Contributors

All authors had access to all of the data contained in the study. AJS, AB, and TPK had full access and verified the data.

Study Concept and Design: AJS, AB, TPK.

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Administrative, technical or material support: AJS, AB, JG, MRB, CC.

Study Supervision: AJS, CC, TPK.

Data sharing statement

The data that support the findings of this study are available from the Defense Health Agency but restrictions may apply to the availability of these data, which were used under a data sharing agreement for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of the Defense Health Agency.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100948.

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