

Data Paper

Opioid Prescription Practices Among Orthopedic Surgeons: An Analysis of the Medicare Part D Database from 2013-2021

Nithin Gupta, BS^{1a}, Nikhil Godbole, BS^{2b}, Elliss Wahlberg, BS^c, Udit Dave, BS^{2d}, Morgan Turnow, DO^{3e}, Hunter Pharis, DO^{3f}, Taylor Manes, DO^{3g}, Tyler Williamson, DO^{4h}, Jignesh Patel, DO³ⁱ

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- a Nithin Gupta is a fourth-year medical student at Campbell University School of Osteopathic Medicine in Lillington, NC. He is passionate about providing mentorship and teaching students to grow their network. He also has a strong interest in using research as a tool to advance orthopedic surgery and improve patient outcomes. His current research interests include frailty, spine, and trauma. Outside of medicine, he enjoys hiking, snowboarding, and watching all sports.

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- b Nikhil Godbole is a 4th year medical student at Tulane University School of Medicine applying into general surgery. Nikhil's research interests include traumatic injury, surgical oncology, and postoperative pain management.

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- c Elliss Wahlberg, who grew up in the suburbs of Chicago, found her passion for orthopedic surgery early on through her involvement in sports. Later, she pursued this passion in medical school at Pikeville, Kentucky, where she began to lay the foundation for her future career.

[Conflicts of Interest Statement for Elliss Wahlberg](#)

- d Udit Dave is a clinical research fellow for Dr. Nikhil Verma and Dr. Jorge Chahla at Midwest Orthopaedics at Rush University, Department of Sports Medicine. Udit recently completed his fourth year at the Tulane University School of Medicine. Udit is from Long Island, NY and completed his undergraduate degree in Biology of Global Health at Georgetown University. As an undergraduate student, Udit participated in basic science research investigating embryological innervation of the inner ear. Prior to beginning medical school, he contributed to sports medicine research at the Hospital for Special Surgery, focusing on sex-based disparities in concussion incidence across multiple sports. Udit is also the author of Hidden Heroes: The Role of Physicians in Sports, a print book that explores the role of orthopedics in empowering professional athletes to return to the top of their sports after suffering major injuries. The book was an Amazon #1 New Release, and Udit was featured on ESPN twice to discuss his book writing process. As a medical student at Tulane, Udit contributed to research in a variety of orthopedics topics including trauma resource allocation, shoulder arthroplasty, knee arthroscopy, and the use of social media in residency training. As a medical student, he participated in an additional research fellowship at the Hospital for Special Surgery to build upon his work with sex-based disparities in sports medicine. His current research interests include disparities in clinical outcomes, knee arthroscopy, and healthcare economics.

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- e Dr. Morgan Turnow is a second year orthopedic surgery resident at OhioHealth Doctor's Hospital in Columbus, OH. She attended medical school at the University of Pikeville Kentucky College of Osteopathic Medicine. She is passionate about enhancing research and educational opportunities for medical students. Her current research interests include shoulder and elbow surgery, sports medicine, and education in orthopedics. Outside of medicine, she enjoys traveling, college football, and spending time with her pets.

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- f Dr. Hunter Pharis is an orthopedic resident at Doctors Hospital in Columbus, Ohio, with a strong interest in upper extremity surgery. He is deeply committed to orthopedic research and its application to enhance patient care. Outside of his professional pursuits, he enjoys spending quality time with his family and newborn baby.

[Conflicts of Interest Statement for Dr. Hunter Pharis](#)

- g Dr. Taylor Manes is a second year orthopedic surgery resident at OhioHealth Doctor's Hospital in Columbus, OH. He attended medical school at A.T. Still University Kirksville College of Osteopathic Medicine. He is passionate about providing mentorship and networking resources for medical students while taking a keen interest in furthering research in the orthopedic world. His current research interests include hand, sports medicine, and shoulder and elbow surgery. Outside of medicine, he enjoys spending time with his family and friends and loves to watch the Kansas City Chiefs win.

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- h Dr. Tyler Williamson is an orthopedic resident at the University of Texas Health San Antonio. He has a strong interest in shoulder and elbow surgery, as well as orthopedic sports medicine.

¹ Campbell University, ² Tulane University, ³ Orthopedic Surgery, OhioHealth, ⁴ Orthopedic Surgery, The University of Texas Health Science Center at San Antonio

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Introduction

Orthopedic surgeons have historically been identified as one of the most frequent prescribing specialties for opioid medications. Although there are indications for the short-term use of opioids post-operatively, efforts have been made through legislature, hospital protocols, and advanced techniques, to reduce the length of time for which opioid analgesics are required.

Methods

The Medicare Part D Database (individuals 65+ years old) was queried for prescriptions made by orthopedic surgeons for the years 2013-2021. Variables of interest included total claims, number of beneficiaries, and prescription length. The top ten opioids were identified using the total claims for each opioid. The South, Northeast, West, and Midwest regions of the United States were used as defined by the US Census Bureau. Linear regression was used to determine changes in claims and prescription length over time. Z-test of proportions was used to compare changes in beneficiaries. All statistical analyses were performed using R Studio (4.2.3), with $p < 0.05$ indicating statistical significance.

Results

In 2021, Alabama and Alaska had the highest and lowest number of total claims and claims per surgeon for the top 10 opioids, respectively. Regional analyses demonstrated the Northeast region had the largest percent decrease (-33.84%), while the South had the highest number of total claims, claims per surgeon, and beneficiaries per 10,000 people. Hydromorphone demonstrated the largest decrease in prescription length (-35.96%, $p < 0.001$) while Oxymorphone had the largest increase (10.29%, $p < 0.001$). Finally, Oxymorphone had the greatest percent reduction in total claims (-92.51%, $p < 0.001$) over the study period.

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i Dr. Jignesh Patel is board certified, and fellowship trained orthopedic surgeon with 18 years of experience in Columbus, Ohio. He is the Orthopedic Surgery Residency Program Director for OhioHealth and Adjunct Clinical Assistant Professor of Orthopedic Surgery at the Ohio University Heritage College of Osteopathic Medicine. He graduated from Wayne St. University, Detroit, MI with a bachelor's degrees in biology and history. He also received a master's degree in Biological Sciences. Dr. Patel went on to the Lake Erie College of Osteopathic Medicine for medical school. Medical school was followed by a residency in orthopedic surgery at Michigan State University-Pontiac Osteopathic Hospital. His training prepared him for a one-year fellowship in Adult Reconstruction at Desert Orthopedic Center, Las Vegas, Nevada. Dr. Patel has research interest in hip and knee replacement, orthopedic trauma, value-based science, and prevention of infection. He has publications in numerous peer-reviewed journals. Finally, he sits on the Editorial Board for the American Osteopathic Academy of Orthopedics, the Peer-Review Committee for OhioHealthy, and the Surgical Clinical Guidance Committee for OhioHealth. Dr. Patel divides his time between the responsibilities as program director and clinical practice. He has a passion for mentorship of medical students and residents as well as educating patients and families regarding orthopedic treatment options and surgery. In his free time, Dr. Patel enjoys spending time with his wife and two children. He also enjoys playing guitar and golf.

[Conflicts of Interest Statement for Dr. Jignesh Patel](#)

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Conclusion

There has been a significant reduction in opioid prescriptions by orthopedic surgeons from 2013-2021, however, certain regions, such as the South, still have relatively high prescription lengths and number of prescriptions for opioid analgesics. Further, studies should seek to identify the specific factors influencing reduced opioid prescriptions to implement these in regions in which further reductions may be necessary.

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INTRODUCTION

Fueled by the introduction of pain as a measure of inpatient satisfaction in 1995, the impact of the opioid epidemic within the United States has been widely discussed both publicly and within the medical literature (Alexander McIntyre, Pagani, Van Schuyver, et al. 2022). When compared to global rates, the United States has been shown to account for most of the prescription opioid use worldwide (Alexander McIntyre, Pagani, Van Schuyver, et al. 2022; Manchikanti and Singh 2008). Of note, there is a large body of high-quality evidence that supports the short-term use of opioid medications for post-operative pain (Horn and Kramer 2023). Therefore, surgeons must balance avoiding under-treatment of postoperative pain with careful titration to avoid long-term use of opioids, both of which have been shown to increase mortality, morbidity, and can lead to chronic opioid use depending on the duration of the prescription (Young et al. 2021; Garimella and Cellini 2013). For orthopedic surgery specifically, pain control is highly relevant due to the nature of the surgery, many of which require extensive dissection and incidental nerve injury or irritation, followed by an immediate postoperative physical therapy regimen (Sampognaro and Harrell 2023). As such, orthopedic surgeons have historically been identified as one of the more frequent prescribers of opioid medications, accounting for 7.7% of all opioid prescriptions in 2009 and reported to be the highest of all surgical specialties in 2020 (Alexander McIntyre, Pagani, Van Schuyver, et al. 2022; Nourae, Uzlik, Wyard, et al. 2021).

To address the improper duration of opioid prescribing practices in the United States, there have been multiple efforts at the government, state, and hospital levels (Congressional Research Service, n.d.). Studies have shown that the use of nonsteroidal anti-inflammatory drugs (NSAIDs) adjunctively with opioids can effectively control pain and reduce the need for opioids (Pham, Pickell, Yagnatovsky, et al. 2019; Murphy, Kasotakis, Haut, et al. 2023). Further, minimally invasive techniques combined with multimodal pain management protocols have demonstrated a reduction in opioid consumption by at least 50% (Siow, Mitchell,

Vuong, et al. 2022; Berardino et al. 2021). These examples demonstrate some of the many continued efforts by orthopedic surgeons to minimize the length of time for which opioids are needed postoperatively. However, there remains a paucity of literature elucidating temporal and regional trends of opioid prescribing practices among orthopedic surgeons in the United States. Thus, the purpose of this study is to identify opioid medications commonly prescribed by orthopedic surgeons, and the temporal and regional trends in claims, beneficiaries, and prescription length. In doing so, this study seeks to aid in understanding the impact of prior efforts, identifying regions in which the number of prescriptions remain elevated, and guiding the creation of targeted and effective guidelines for further reductions.

METHODS

DATA SOURCE AND VARIABLES OF INTEREST

Data was obtained by querying the Medicare Part D Database, which is a free publicly available database provided by the Centers for Medicare and Medicaid Services (CMS) (Center for Medicare Medicaid Services 2021). Results were filtered by provider type to include only orthopedic surgeons and were obtained for the years 2013-2021. Data from 2022-present has not yet been provided by the Center of Medicare and Medicaid Services. Regions used for statistical analysis were used as defined by the United States Census Bureau: South, Northeast, West, and Midwest (U.S. Census Bureau, n.d.). Populations for each region were calculated using state-level data provided by the United States Census. Variables of interest for prescriptions include total claims, number of beneficiaries, number of beneficiaries over 65, NPI number of each surgeon, and length of prescription. As this data contains non-identifiable patient information and is free/publicly available, no institutional review board approval was needed.

DESCRIPTIVE DATA

The top 10 opioids prescribed by orthopedic surgeons over the study period were the focus of this analysis. The total number of claims for each drug was calculated, which included the total number of prescriptions and refills. To determine the mean length of prescriptions, the total day supply of each drug was divided by the total claims count for that drug. The number of claims per surgeon was calculated by determining the total number of unique NPI numbers of prescribers for each drug and dividing this by the total number of claims. The total number of beneficiaries and number of beneficiaries over 65 years of age was also calculated for 2013-2021. Values for beneficiaries were represented as the proportion of the total pool of beneficiaries or beneficiaries over 65 for the respective year.

STATISTICAL ANALYSIS

To determine if the change in the number of claims for each of the top 10 opioids prescribed by orthopedic surgeons over the study period was statistically significant, linear regression analysis was used. Prior to statistical analysis, total claims were normalized to the total pool for the top 10 opioids to remove bias produced by differences in total prescriptions per year. This approach was used for individual opioid analysis and to determine the significance of prescribing practice within each region for all opioids over the study period. Linear regression analysis was used to determine the significance of changes in prescription length. For total beneficiaries and beneficiaries over the age of 65, statistical analysis to determine if significant changes in the proportion of beneficiaries in 2013 and 2021 were performed using a Z-Test of proportions. All statistics were performed as using R Studio (4.2.3) and $p < 0.05$ was used to indicate statistical significance (RStudio Team 2020; Singh, Meyer, Doan, et al. 2021).

RESULTS

CURRENT AND TEMPORAL TRENDS IN OPIOID PRESCRIPTIONS ANALYZED FROM 2013-2021

Analysis of the Medicare database from 2013-2021 revealed that the top 10 most prescribed opioids by orthopedic surgeons in the United States were: hydrocodone, oxycodone, tramadol, codeine, hydromorphone, morphine, fentanyl, methadone, oxymorphone, and buprenorphine. When the top 10 opioids were pooled for 2021, the state with the lowest number of claims per surgeon was Alaska (101 claims per surgeon) and Alabama had the highest number of claims per surgeon (729 claims per surgeon). The average number of claims per surgeon within the United States during 2021 was 278 ± 139 (median: 237.36, IQR: 166.47-327.52) claims per surgeon. For 2021 beneficiaries, Alaska reported the lowest number of beneficiaries of the top 10 opioids per surgeon (10 beneficiaries per surgeon) and Florida reported the highest number of beneficiaries (63 beneficiaries per surgeon). The average number of beneficiaries per surgeon in the United States for 2021 was $38 \pm$

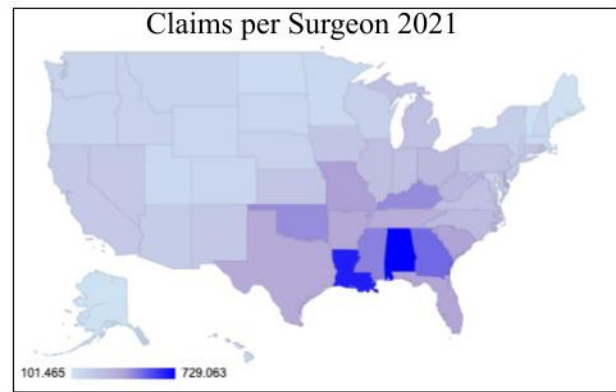


Figure 1A. Heatmap visualization of the total number of claims per surgeon in 2019 for the top 10 opioids in the United States.

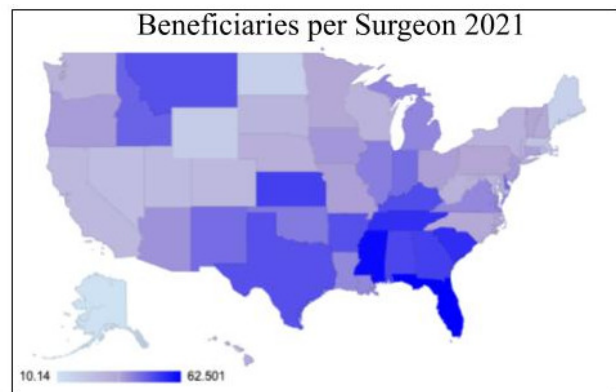


Figure 1B. Heatmap visualization of the total number of beneficiaries per surgeon in 2019 for the top 10 opioids in the United States.

11 (median: 37.33, IQR: 31.13-45.56) beneficiaries per surgeon. These results are visually represented in [Figure 1A-B](#).

Temporal trends were also analyzed for each included drug from 2013-2021 ([Table 1](#)). For all years, Hydrocodone and Oxycodone had the first and second-highest total number of claims, respectively. From 2013-2015, Buprenorphine had the lowest number of total claims and from 2016-2021, Oxymorphone had the lowest number of total claims. Of the top 10 opioids, all except for Tramadol, Codeine, and Buprenorphine, demonstrated a decrease in percent change from 2013-2021. Oxymorphone had the greatest percent decrease over the study period (-92.51%), followed by Methadone and Fentanyl (-73.61% and -67.82%, respectively). Buprenorphine had the greatest increase in total claims (185.62%). Finally, linear regression analysis demonstrated that the change in total claims for each opioid increased significantly for Oxycodone and Buprenorphine while all other opioids (except Codeine ($p = 0.086$) and Morphine ($p = 0.177$) decreased significantly.

Table 1. Percent change from 2013-2019 of the total claims per year for the top 10 opioids and linear regression analysis for significance.

Opioid Name	2013	2014	2015	2016	2017	2018	2019	2020	2021	Percent Change (%)	P-Value
Hydrocodone	1907947	1728665	1303242	1209572	1080883	939575	845749	765496	769541	-59.67	0.001
Oxycodone	661586	730557	845179	848904	800137	721005	676479	633120	682916	3.22	0.002
Tramadol	541952	588473	610024	620827	600781	574894	568027	532006	514976	-4.98	6.76E-05
Codeine	68076	78432	123112	119814	109901	103299	98008	85909	72525	6.54	0.086
Hydromorphone	22012	25285	27233	27850	25661	21832	19806	19591	20396	-7.34	0.031
Morphine	16490	17376	20973	21317	20157	14744	10818	8810	7237	-56.11	0.177
Fentanyl	7257	7252	7875	7207	5628	3851	2638	2462	2335	-67.82	0.002
Methadone	4002	3476	3586	2850	2174	1675	1204	1109	1056	-73.61	3.31E-05
Oxymorphone	1750	2076	2175	1865	1130	441	426	305	131	-92.51	0.002
Buprenorphine	723	1437	2161	2338	2618	3142	3935	3441	2065	185.62	0.007
Total Claims	3231795	3183029	2945560	2862544	2649070	2384458	2227090	2052249	2073178		

TRENDS PER REGION AND ORTHOPEDIC SURGEON

When stratified by geographical region, the number of claims decreased across all US regions (Table 2). The Northeast had the largest percent decrease at -33.84%. The West had the lowest percent decrease at -21.79%. The South had the highest number of prescriptions with 1,563,824 prescriptions in 2013, followed by the Midwest, which had 753,855 prescriptions in 2013. The West and Northeast had the fewest number of prescriptions with 484,163 and 403,830 prescriptions respectively in 2013. To determine the significance of changes in opioid prescriptions in each region, the number of prescriptions in each region was normalized to the total number of prescriptions nationally (Table 2). The total number of prescribing surgeons and the number of prescriptions written per surgeon were calculated for each region. In 2013, the South had both the most surgeons and claims per surgeon (6,855 surgeons, and 228.13 claims per surgeon), followed by the Midwest (4351 surgeons, and 173.26 claims per surgeon), the West (4096 surgeons, and 118.20 claims per surgeon), and finally the Northeast (3354 surgeons, and 120.40 claims per surgeon). The number of prescribing surgeons and the number of prescriptions written per surgeon decreased in all regions by 2021. The South was still at the highest at 6381 surgeons and 171.50 claims per surgeon, followed by the Midwest (3648 surgeons and 127.74 claims per surgeon), the West (3316 surgeons and 92.45 claims per surgeon), and the Northeast (2391 claims and 79.66 claims per surgeon). The total number of beneficiaries and the ratio per capita and per surgeon were calculated by region and year (Table 3). The South had both the highest number of beneficiaries per 10,000 people and per surgeon in 2013. This was followed by the Midwest and the Northeast. The West had the least number of beneficiaries per 10,000 people and per surgeon in 2013. The order remained the same in 2021 with the West notably surpassing the Northeast in beneficiaries per 10,000 people and per surgeon.

TRENDS IN PRESCRIPTION LENGTH

Prescription length was also analyzed for the top 10 opioids from 2013-2021, as shown in Table 4. In 2013, Fentanyl had the longest prescription length (28.65 days), followed by Methadone (27.96 days). In 2021, Oxycodone and Fentanyl had the longest prescription length (29.47 and 29.01 days, respectively). The opioid with the shortest prescription length in 2013 was Codeine (10.58 days), and in 2021 was Hydromorphone (7.73 days). Hydromorphone had the largest percent decrease in prescription length over the study period (-35.96%, $p < 0.001$) and Oxycodone had the greatest percent increase in prescription length (10.29%, $p < 0.001$). Codeine, Hydrocodone, Oxycodone, and Tramadol all had significantly decreased percent change in prescription length from 2013-2021. Finally, the average prescription length in 2013 and 2021 was 19.53 ± 8.11 and 17.84 ± 9.62 days, respectively. This amounted to an average percent decrease in prescription length of -13.15%

$\pm 14.71\%$ (0.26 day decrease per year, $p < 0.001$) from 2013-2021.

TRENDS IN OPIOID USE BY BENEFICIARIES

To determine whether the decrease in opioid prescriptions by orthopedic surgeons was due to a smaller population of patients receiving these drugs, the number of beneficiaries was calculated (Table 5). Hydrocodone was received by the largest number of beneficiaries in 2013 ($n = 825,157$) and 2021, although the number dropped by 45.7% in 2021 ($n = 448,023$). Oxycodone was the second most prescribed by orthopedic surgeons, with 350,156 beneficiaries in 2013, which grew significantly by 14.335% ($p < 0.001$) to 400,352 in 2021. Buprenorphine, methadone, and oxycodone were the least prescribed opiates within the study period. The same trends were evident within the elderly population aged 65 years and older, with hydrocodone having the highest number of beneficiaries 359,821 in 2013, followed by a significant 56.979% decrease ($p < 0.001$) in 2021 to 154,800 beneficiaries. Oxycodone was the second most prescribed in this population, followed by Tramadol.

DISCUSSION

In recent years, there has been increased awareness within the US healthcare system concerning the length of opioid prescription for postoperative pain management. Given that orthopedic surgeons have historically been among the top prescribers of opioids, the goal of this study was to understand the temporal and regional trends in prescribing practices for the most common opioids by orthopedic surgeons (Acuña et al. 2021; Hagedorn, Danilevich, and Gary 2019). The results demonstrated significant decreases in the number of claims and prescription length for the majority of opioids, with more variable trends for beneficiaries. Further, we show that total prescriptions and beneficiaries for all regions of the US declined. Significant geographic variations in opioid prescription practices over time were also identified.

Oxycodone and hydrocodone are among the most prescribed opioids in various orthopedic subspecialties (Rodgers et al. 2012; Hernandez, Parry, and Taunton 2017). Our analysis revealed similar trends in that hydrocodone and oxycodone remain the two most frequently prescribed opioids by orthopedic surgeons, however, the rates at which they are prescribed have been decreasing. These decreasing trends are mirrored by Boddapati et al., who found that from 2013 to 2016, the average number of opioid prescriptions per Medicare Part D beneficiary written by orthopedic surgeons decreased from 2.1 to 1.8, of which 47.1% were hydrocodone and 17.5% were oxycodone (Boddapati et al. 2021). Similarly, studies evaluating opioid use in upper extremity surgery and total knee arthroplasty have shown oxycodone and hydrocodone to be the most common agents used for postoperative pain. Interestingly, when evaluating these findings in other surgical fields, such as neurosurgery and general surgery, they also demonstrated similar use patterns, with oxycodone and hydrocodone among the

Table 2. Number of Prescriptions by region, number of surgeons per region, number of prescriptions per surgeon by region, and percent change from 2013-2021 of the top 10 opioids.

Region	Total Prescriptions (N, 2013)	Total Prescriptions (N, 2021)	P-Value (Change in prescriptions 2013-2021)	Surgeons (N, 2013)	Surgeons (N, 2021)	Claims per Surgeon (2013)	Claims per Surgeon (2021)	Percent Change 2013-2021 (%)
Midwest	753855	466002	P<0.001	4351	3648	173.26	127.74	-26.27
Northeast	403830	190475	P<0.001	3354	2391	120.40	79.66	-33.84
South	1563824	1094311	P<0.001	6855	6381	228.13	171.50	-24.83
West	484163	306549	P<0.001	4096	3316	118.20	92.45	-21.79

Table 3. Total number of beneficiaries, the ratio of beneficiaries per population and per surgeon, within each US region

		2013					2021			
Region	Total Beneficiaries	Total Population	Total Surgeons	Beneficiaries per 10,000 population	Beneficiaries per Surgeon	Total Beneficiaries	Total Population	Total Surgeons	Beneficiaries per 10,000 population	Beneficiaries per Surgeon
Midwest	344177	67560379	4351	50.94	79.10	276700	68836505	3648	40.20	75.85
Northeast	193985	55901806	3354	34.70	57.84	107435	57259257	2391	18.76	44.93
South	705826	118364400	6855	59.63	102.97	625507	127346029	6381	49.12	98.03
West	224731	74167130	4096	30.30	54.87	182073	78589763	3316	23.17	54.91

Table 4. Prescription length for top 10 opioids and percent change from 2013-2021

Opioid Name	Prescription Length (d) 2013	Prescription Length (d) 2021	Percent Change (2013-2021)	P- Value
Buprenorphine	26.58	23.00	-13.46	0.1508
Codeine	10.58	8.88	-16.06	0.0049
Fentanyl	28.65	29.07	1.45	0.1040
Hydrocodone	11.26	9.42	-16.35	0.0320
Hydromorphone	12.08	7.73	-35.96	0.0002
Methadone	27.96	27.54	-1.49	0.7110
Morphine	25.93	24.82	-4.31	0.4975
Oxycodone	12.04	8.77	-27.14	0.0007
Oxymorphone	26.72	29.47	10.29	0.0006
Tramadol	13.53	9.68	-28.47	0.0021
Mean Length of Opioid Prescription	19.53 +/- 8.11	17.84 +/- 9.62	-13.15 +/- 14.71	

most common (Singh, Meyer, Doan, et al. 2021; Tan, Yu, Feaman, et al. 2018). As such, these medications are efficacious across multiple surgical specialties, yet there have been clear efforts to minimize their duration of use (Burns et al. 2021; Feinberg et al. 2018; Chua, Nguyen, Brummett, et al. 2023; Clark, Allman, Rogers, et al. 2022; Lott et al. 2020).

Our results further demonstrate the progress made by orthopedic surgeons as seen in the reductions in beneficiaries, matching the results of similar studies within the literature (Acuña et al. 2021; Gormley, Gouveia, Sakha, et al. 2022; Scully, Schoenfeld, Jiang, et al. 2018). We further demonstrate an average percent decrease in prescription length of $-13.15\% \pm 14.71\%$ from 2013-2021, abiding with current recommendations for opioid prescription lengths of 6-15 days following a musculoskeletal surgery (Chunduri and Aggarwal 2022). A myriad of factors may play a role in these reductions, including national and state-level legislature, and institutional regulations. Importantly, there has been a recent shift towards alternative means of pain management, specifically multimodal pain control and multidisciplinary pain management protocols (Maheshwari, Avitsian, Sessler, et al. 2020). These have demonstrated effectiveness in reducing opioid consumption across orthopedic subspecialties (Elkassabany et al. 2019; Moutzouros, Jildeh, Khalil, et al. 2020; Kohring and Orgain 2017; Schieber, Guy, Seth, et al. 2019). For example, Elkassabny et al. demonstrated 45% of patients receiving multimodal pain regimens following shoulder procedures did not require breakthrough opioids (Pitchon et al. 2018).

Finally, our results demonstrate interesting regional findings that suggest the South had the highest opioid prescription volumes, prescribing surgeons, and claims per surgeon. Schieber et al. found that the states with the greatest expenditure on opioids in the year 2017 were Tennessee, Oklahoma, Delaware, and Alabama (Guo, Yedulla, Cross, et al. 2021). Likewise, Guo et al found that within the Medicare population, older male orthopedic surgeons from the Southern US prescribed the highest volume of opioids (Wyles, Hevesi, Ubl, et al. 2020). We hypothesize that

high rates of opioid prescription in Southern states may be reflective of unstandardized prescription practices among surgeons. The study findings also suggest that, between 2013-2021, the most substantial decrease in claims was in the Northeast and Western US, as seen in Maine, Massachusetts, and North Dakota from 2006-2017 (Wyles, Hevesi, Ubl, et al. 2020). Thus, the steep decline in prescription in the Northeast may be due to more restrictive regulations. For example, Massachusetts moved to restrict acute pain opioid prescriptions to 7 days post-op in 2016 at a time when more than 20 states and the CDC instituted a similar guideline [39]. Therefore, future studies may focus on implementing similar guidelines in southern states.

LIMITATIONS

Our study was limited in that we did not stratify data based on orthopedic subspecialty. Future studies can compare the well-documented prescription of opioids by orthopedic trauma surgeons to the prescription of opioids among other subspecialties such as sports medicine or arthroplasty, which typically emphasize less aggressive pain control and aim to have patients return to activity as soon as possible. An additional limitation of this study is intrinsic to using a Medicare Part D database in that only patients over the age of 65 are included. Using the Medicare database provides a robust dataset with reliable measures, but it limits the generalizability of our data and entirely excludes younger patients. Lastly, opioid prescriptions are tied to a provider's specific National Provider Identifier (NPI) number. If providers utilize residents or advanced practitioners, the number of opioid prescriptions is most likely underreported in this study.

CONCLUSION

Opioids are an integral part of patient management in orthopedic surgery, however, due to their addictive nature, efforts have been made across all surgical specialties to re-

Table 5. Beneficiaries are normalized to total number for that year (proportion of total) *No beneficiaries in 2021 data

Drug Name	Total Beneficiaries, N (%) (2013)	Total Beneficiaries, N (%) (2021)	% Change	P- value	Beneficiaries 65+, N (%) (2013)	Beneficiaries 65+, N (%) (2021)	% Change	P- value
Oxymorphone*	257 (0.017)	0 (0.000)	-100	<0.001	23 (0.004)	0 (0.000)	-100	<0.001
Methadone	280 (0.019)	63 (0.005)	-77.5	<0.001	14 (0.003)	13 (0.004)	-7.14286	<0.001
Fentanyl	769 (0.052)	229 (0.018)	-70.2211	<0.001	92 (0.019)	39 (0.011)	-57.6087	<0.001
Morphine	4352 (0.293)	1724 (0.143)	-60.386	<0.001	861 (0.165)	394 (0.110)	-54.2393	<0.001
Hydrocodone	825157 (55.484)	448023 (37.187)	-45.7045	<0.001	359821(69.088)	154800 (43.413)	-56.9786	<0.001
Tramadol	266676 (17.931)	302697 (25.124)	13.5074	<0.001	64821 (12.446)	75308 (21.120)	16.1784	<0.001
Oxycodone	350156 (23.545)	400352 (33.230)	14.33532	<0.001	87315 (16.765)	111802 (31.354)	28.04444	<0.001
Hydromorphone	8124 (0.546)	10516 (0.873)	29.44362	<0.001	1142 (0.219)	2600 (0.729)	127.6708	<0.001
Codeine	31355 (2.108)	41024 (3.405)	30.83719	<0.001	6727 (1.292)	11620 (3.259)	72.73673	<0.001
Buprenorphine	68 (0.005)	171 (0.014)	151.4706	<0.001	0 (0.000)	0 (0.000)	0.000	NA

duce their use long-term. The purpose of this study was to provide an up-to-date analysis of the opioid prescribing practices of orthopedic surgeons using the Medicare Part D database. In this study, we demonstrated an overall decrease in the number of claims and beneficiaries for opioid medications from 2013-2021. We further show reductions in prescription length. Importantly, regional differences in prescription trends are clear, with greater claims and beneficiaries in the South region. It is clear that large strides have been made in the reduction of opioid prescriptions by orthopedic surgeons, likely aided by medical advancements such as minimally invasive surgery, postoperative

pain management protocols, and stringent legislation. Future studies should seek to understand the factors unique to each region that contribute to the differences shown in this study. These may be used to guide future efforts to create targeted and effective guidelines for opioid reduction in regions with greater use.

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