

# Opioid use for a first-incident upper extremity fracture in 220,440 patients without recent prior use in Ontario, Canada: a retrospective cohort study

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**Objective:** To describe opioid use for a first upper extremity fracture in a cohort of patients who did not have recent opioid use.

**Design:** Descriptive epidemiological study.

**Setting:** Emergency Department, Hospital.

**Patients/Participants:** We obtained health administrative data records of adults presenting with a first adult upper extremity fracture from 2013 to 2017 in Ontario, Canada. We excluded patients with previous fractures, opioid prescription in the past 6 months or hospitalization >5 days after the fracture.

**Intervention:** Opioid prescription.

**Main Outcome Measurements:** We identified the proportion of patients filling an opioid prescription within 7 days of fracture. We described this based on different upper extremity fractures (ICD-10), Demographics (age, sex, rurality), comorbidity (Charlson Comorbidity Index, Rheumatoid arthritis, Diabetes), season of injury, and social marginalization (Ontario Marginalization Index—a data algorithm that combines a wide range of demographic indicators into 4 distinct dimensions of marginalization). We considered statistical differences ( $P < .01$ ) that reached a standardized mean difference of 10% as being clinically important (standardized mean difference [SMD]  $\geq 0.1$ ).

**Results:** From 220,440 patients with a first upper extremity fracture (50% female, mean age 50), opioids were used by 34% of cases overall (32% in males, 36% in females,  $P < .001$ ,  $SMD \geq 0.1$ ). Use varied by body region, with those with multiple or proximal fractures having the highest use: multiple shoulder 64%, multiple regions 62%, shoulder 62%, elbow 38%, wrist 31%, and hand 21%; and was higher in patients who had a nerve/tendon injury or hospitalization ( $P < .01$ ,  $SMD \geq 0.1$ ). Social marginalization, comorbidity, and season of injury had clinically insignificant effects on opioid use.

**Conclusions:** More than one-third of patients who are recent-non-users will fill an opioid prescription within 7 days of a first upper extremity fracture, with usage highly influenced by fracture characteristics.

Level of Evidence: Level II

**Keywords:** epidemiology, fractures, opioid, upper extremity

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## 1. Introduction

Upper extremity fractures are amongst the most common injuries seen in emergency departments.<sup>[1,2]</sup> Pain management is a routine component of fracture care and seeks to provide pain relief with minimal adverse effects. At least 10% of opioid naïve patients continue to fill opioid prescriptions 90 days after a hand surgery procedure.<sup>[3]</sup> In the past 15 years, deaths related to drug overdoses in the United States have tripled, mostly because of the increase in opioid-related deaths.<sup>[4]</sup> Similarly, in Canada, deaths involving prescription opioid analgesics, including hydrocodone, oxycodone, hydromorphone, and methadone, have surpassed deaths from heroin and cocaine combined.<sup>[5]</sup> The pandemic has exacerbated the problem.<sup>[6,7]</sup> A systematic review identified prescriber behavior, user behavior/characteristics, environmental and systemic determinants of opioid use and death.<sup>[8]</sup> The increase in opioid overdose deaths aligns with a proportional increase in opioid prescribing rates making it important to understand the extent to which patients who are not currently taking an opioid are being exposed to opioid use through their fracture pain management.

Differences in opiate prescriptions after trauma reflect prescribing patterns and patient/provider decisions, which may differ by injury characteristics. Use of opioids may be anticipated in patients presenting with more severe trauma and in those recently using opioids. In opioid naïve patients their first exposure to opioids is a potential pathway to future addiction.<sup>[3]</sup> Further, opioids are known to increase the risk of fracture,<sup>[9]</sup> which is problematic since patients with a first fracture are at risk of secondary fractures.<sup>[10,11]</sup> Since upper extremity fractures are diverse in terms of their demographic distributions, etiology, and associated trauma, it is important to understand current opioid prescription patterns, and how they vary by fracture types and patient demographics. While health service data does not allow us to assess the appropriateness of any individual opioid prescription, population-level health service data can document current levels of opioid use and what factors are associated with use, for example, fracture severity or patient characteristics. Further, prescription rate data, once established, can serve as a benchmark for setting new targets and assessing the effects of opioid reduction policies.

The purposes of this study were to describe opioid use in a cohort of adult patients receiving care for their first upper extremity fracture in Ontario, Canada between 2013 and 2017, who were not current or recent users of opioids.

## 2. Materials and methods

**Design:** We conducted this retrospective cohort study of people incurring a first incident upper extremity fracture using population-level health administrative data in Ontario, Canada's largest province.

### 2.1. Data sources and ethical use

Ontario administers health care using a single-payer, universally accessible system. Administrative data sets were linked using unique encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences (ICES). Patient and fracture data were extracted from a combination of hospital admission/discharge records (Discharge Abstract Database), outpatient surgery (Same Day Surgery), emergency hospital visits (National Ambulatory Care Reporting System), physician billing data (Ontario Health Insurance Program database), and general use

data sets containing sociodemographic data (Registered Persons Database). Details of ICES data holdings, privacy regulations, and data dictionary are publicly available.<sup>[12]</sup> ICES is a prescribed entity under section 45 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect personal health information, without consent, for the purpose of analysis or compiling statistical information with respect to the management of, evaluation or monitoring of the allocation of resources to or planning for all or part of the health system. Projects conducted under section 45, do not require individual review by a Research Ethics Board, but are reviewed and approved by the ICES Privacy and Legal Office.

### 2.2. Fracture identification

We included all adult patients with a fracture diagnosis from an emergency room visit or were admitted to hospital with a fracture diagnosis within 5 days of their initial ER visit from January 1, 2013 to December 31, 2017. Only the first fracture occurring during the observation period was included. We further excluded non-Ontario residents, individuals who were not eligible for healthcare services in Ontario within the past 10 years, and those with evidence of a prior upper extremity fracture as an adult (over the previous 10 years). Finally, we excluded patients with previous opioid use as determined by a filled prescription within 6 months before the index fracture, or who experienced hospitalization for more than 5 days after fracture due to the possibility that opioids were administered during the hospital stay. The final cohort of patients were considered as "opioid naïve," or at minimum not recent opioid users.

### 2.3. Fracture description

Fractures were described by region, specific types, open/closed, season, whether the fracture required hospitalization (within 1 day), and whether a tendon or nerve injury was identified. Fracture ICD-10 codes were grouped together based on clinical relevance; compiling open and closed fractures, and codes where multiple codes were used for the same type of fracture (See Tables, Supplemental Digital Content 1 for fracture codes, [http:// links.lww.com/OTAI/A38](http://links.lww.com/OTAI/A38)). ICD-10 codes describing multiple concurrent fractures of the shoulder, radius and ulna or forearm, metacarpals or digits were combined and identified as multiple fractures within those body regions. Where concurrent fracture codes were used from different body regions (e.g., shoulder and hand), this was coded as fracture in more than 1 region (See Tables, Supplemental Digital Content 1 for fracture codes, <http:// links.lww.com/OTAI/A38>).

Associated nerve injury was grouped as a major nerve injury when codes for specific major nerves in the upper arm (ulnar, median, radial, axillary, musculocutaneous), forearm (median, ulnar, radial), or wrist (median/ulnar) were identified; and as any nerve injury by collapsing all specific and nonspecific nerve codes for each of these 3 areas. Tendon injury and hospitalization within 1 day of fracture were extracted. Season of fracture injury was divided into four 3-month intervals, starting in January, to make the exposure time relatively equivalent.

### 2.4. Patient demographics and comorbid health status

Sex and age were extracted with age classified into subgroups: ages 18 to 40 (young adults), 41 to 50 (younger middle-aged adults), 51 to 65 (older middle-age), 66 to 80 (older adults), and

81+ (very old adults). These age categories were selected as they represent different lifespan and bone health issues, with younger adults expected to have stronger bones and more traumatic fractures, with a shift to more fragility fractures in those 50+ years age, and that the oldest group would have the highest level of frailty.<sup>[13–16]</sup>

Overall comorbidity data was described based on the Charlson Comorbidity Index,<sup>[17]</sup> which sums weighted diagnostic codes (from 1 to 6) based on an adjusted risk of mortality.<sup>[17,18]</sup> A score of zero indicates that no comorbidities were found. The Ontario Diabetes Database<sup>[19]</sup> and Ontario Rheumatoid Arthritis Data-base<sup>[20,21]</sup> were used to identify these diagnoses using ICES-developed and validated cohorts.

### 2.5. Neighborhood social marginalization

Rurality was defined using the Rurality Index for Ontario score. Social marginalization was defined using the Ontario Marginalization Index an Ontario specific version of The Canadian Marginalization Index. The indices are census-based composite community-level indicators that combine a wide range of demographic indicators into 4 distinct social dimensions (material deprivation, dependency, residential instability, ethnic concentration).<sup>[22,23]</sup> They were developed using a theoretical framework based on previous work on deprivation and marginalization and then empirically derived using principal component factor analysis. A full description is published online.<sup>[24]</sup> A quintile score is associated with geographic areas, so that each quintile represents 20% of the reference population. Those in lower quartiles are considered more deprived or more marginalized. The relationship between marginalization and comorbidity has been described using ICES data.<sup>[25]</sup>

### 2.6. Opioid outcome: prescription fill rates

Opioid use postfracture was defined as having filled a prescription for an opioid within 7 days of fracture. Opioid prescriptions were identified using Drug Identification Numbers (See List, Supplemental Digital Content 2 for opioid Drug Identification Numbers, <http://links.lww.com/OTAI/A39>).

### 2.7. Data analysis

We described the cohort demographics, the opioid use by fracture type (region, specific fracture code groups (See Tables, Supplemental Digital Content 1 for fracture codes, <http://links.lww.com/OTAI/A38>), associated fracture injuries (tendon/nerve), associated hospitalization, season of injury, age, sex, comorbid health and neighborhood rurality, and social marginalization indicators (Ontario Marginalization Index) categories. Statistically significant differences within subgroups were tested by ANOVA. Given our large sample and associated high power, we considered a P value of <.01 to be statistically significant and a standardized mean difference of 10% (SMD > 0.10) to indicate that statistical differences were clinically relevant. All analyses were conducted using SAS Enterprise Guide v 7.15.

## 3. Results

### 3.1. Description of cohort

We found 220,440 first fracture cases in adults who were not recent opioid users, after excluding people with upper extremity fractures who were not eligible or did not have critical data

(Fig. 1). Most exclusions were due to the cases being outside our cohort age (178K) or having a prior fracture (44K). Loss from the cohort due to confirmed or presumed prior opioid prescription was 46K, highest in shoulder fractures (Table 1). The mean age of the eligible cohort was 50 years and 50% female. There was substantial variation in age and sex distributions for the different fracture types (Table 1) with proximal humerus fractures having the oldest mean age and metacarpal fractures having the youngest.

### 3.2. Opioid prescriptions by fracture type

Among this cohort, 75,543 (34%) filled a prescription for opioids within 7 days (Table 2 for proportions and SMD, Table 1 for 95% confidence intervals). Use varied by body region, with patients who had multiple or proximal fractures having the highest use when compared to patients having fractures in other regions: multiple shoulder 64%, multiple regions 62%, shoulder 62%, elbow 38%, wrist 31%, and hand 21%. Across all subtypes of shoulder region fractures, more than half of the patients filled an opioid prescription, being highest for shaft fractures (77%) and least for scapula fractures (52%). For patients with elbow/forearm region fractures, the highest usage was in Monteggia fractures (83%) and least for coronoid fractures (25%). In the people with wrist fractures, less than 40% of the cohort filled prescriptions for any fracture subtype, with scaphoid and other carpal fractures having rates under 15%. Less than 30% of patients filled an opioid prescription for a hand fracture across all subtypes, except multiple finger fractures (48%) where usage was higher. Statistically and clinically relevant higher usage was noted in patients with fractures in more than 1 region, shoulder region, multiple shoulder, proximal humerus, humerus shaft, open fractures, fractures with an associated nerve or tendon injury, and those where admission to hospital was required. Significantly lower use was found in patients when all types of hand fractures were combined, and specifically for scaphoid, other carpal fractures, metacarpals, and phalanx fractures (Table 2).

### 3.3. Age effects on filled opioid prescription

Overall prescription rate was lowest (28%) in the 18 to 40-year-old patient subgroup, 36% to 40% in those aged 40 to 80, and 34% in those over 80 (Table 2). Age differences were found with statistically and clinically significant higher rates of opioid use in the 51 to 80-year-old groups, and lower rates in the 18 to 40-year-old group ( $P < .001$ , SMD > 0.1).

The pattern of higher rates of prescription for patients with shoulder fractures and lower use in patients with hand fractures remained significant when examined across different age categories (Table 2). There was some variation in the age effects for different fracture types. Fracture types where there was higher opioid use in younger age groups included: elbow, distal humerus, olecranon, multiple radius and ulna, and multiple finger fractures. Fracture types where there was lower use in the oldest age groups include distal radius, wrist and hand, and metacarpal fractures.

### 3.4. Sex differences in opioid prescription

Overall, females had statistically and clinically relevant higher rates of use (36.5% vs 32%,  $P < .001$ , SMD  $\geq 0.1$ ). The proportions of opioid use for the entire cohort were similar when disaggregated by sex, for many fracture types. However, some

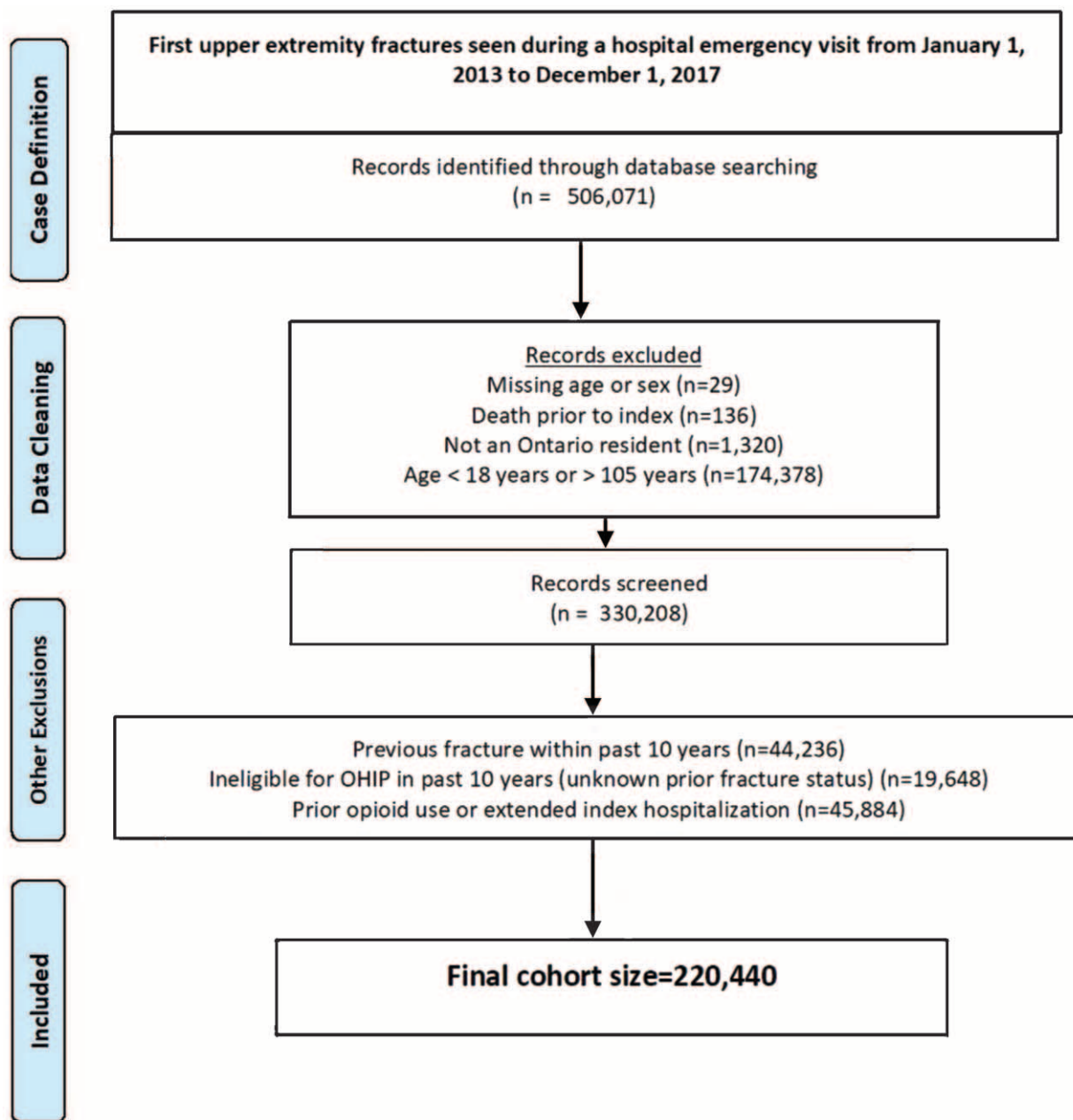


Figure 1. Case identification diagram.

sex-differences in opioid use by fracture type were found (Fig. 2A-E; Table 3 for  $P < .001$  and  $SMD > 0.10$ ). The higher usage of opioids by patients with scapula and multiple finger fractures only reached clinical relevance in men. The elevated opioid use in people who had a tendon or nerve injury only reached clinical relevance in men. Both men and women with open fractures had higher use, although the effect was much larger in males ( $SMD = 0.30$  vs  $0.11$ ). Conversely the elevated use of opioids in patients with unspecified humeral, olecranon, DIP and PP fractures only reached clinical relevance in females. The sex differences in opioid use were largest for patients with olecranon fractures (58% for females vs 48% for males). By region, females had higher rates of opioid prescription for shoulder fractures, wrist fractures, and combined hand/wrist

fractures. When comparing the differences in rates across males and females for specific fractures, females had at least 10% higher use for proximal humerus, unspecified humerus, and multiple shoulder fractures. Conversely, males had at least 10% higher prescription rates for fractures of the radius shaft (52% vs 32%), distal phalanx (29% vs 19%), and multiple finger fractures (54% vs 36%) (Fig. 2A-E).

#### 4. Discussion

We found that approximately one-third of patients who have not recently used opioids will fill an opioid prescription after a first upper extremity fracture, in Ontario, Canada, although this rate varies substantially across different fracture types. Factors



**Table 1****The number and rate of filled opioid prescriptions by fracture type for men and women.**

Type of 1st incident fracture	Cohort of naïve users		Men		Women	
	Opioid use n (%)	95 CI %	Opioid use n (%)	95 CI%	Opioid use n (%)	95 CI %
All 1st incident upper extremity fractures						
All fractures by region	75,543 (34)	34-34	35,241 (32)	32-32	40,302 (36)	<b>36-37</b>
Shoulder	<b>22,168 (62)</b>	61-62	9718 (60)	59-61	12,450 (64)	<b>63-64</b>
Elbow	11,276 (38)	38-39	4436 (38)	37-39	6840 (39)	38-40
Wrist	20,974 (31)	31-32	6581 (28)	27-28	14,393 (33)	<b>33-34</b>
Hand	17,462 (21)	21-21	12,910 (23)	<b>23-24</b>	4552 (17)	17-18
Hand and wrist	1226 (24)	23-26	433 (20)	19-22	793 (27)	<b>26-29</b>
Fracture in >1 region	<b>3663 (62)</b>	61-63	1596 (61)	59-62	2067 (63)	62-65
Specific fractures						
Clavicle	<b>6946 (57)</b>	57-58	4915 (60)	<b>59-61</b>	2031 (53)	51-54
Scapula	<b>1208 (52)</b>	50-54	859 (54)	51-56	349 (47)	44-51
Proximal humerus	<b>10,198 (65)</b>	65-66	2478 (61)	60-63	7720 (67)	<b>66-68</b>
Humerus shaft	<b>1307 (77)</b>	75-79	533 (78)	75-81	774 (76)	73-79
Distal humerus	<b>1040 (54)</b>	51-56	386 (50)	47-54	654 (55)	52-58
Humerus, unspecified	<b>948 (61)</b>	59-64	290 (58)	54-62	658 (63)	<b>60-66</b>
Shoulder, multiple	<b>1561 (64)</b>	62-66	643 (60)	57-63	918 (68)	<b>65-70</b>
Olecranon	<b>1510 (53)</b>	51-54	678 (48)	45-50	832 (58)	<b>55-60</b>
Coronoid	146 (25)	22-29	NR	NR	NR	NR
Monteggia	<b>30 (83)</b>	68-92	NR	NR	NR	NR
Radius head	3518 (29)	28-30	1428 (29)	28-31	2090 (29)	28-30
Multiple radius and ulna	4289 (44)	43-45	1435 (44)	42-45	2854 (45)	44-46
Ulnar shaft	390 (29)	27-32	222 (30)	27-33	168 (28)	25-32
Radius shaft	170 (43)	38-48	109 (52)	<b>46-59</b>	61 (32)	26-39
Ulna and radial shaft	<b>183 (68)</b>	62-74	91 (70)	62-77	92 (67)	58-74
Distal radius	15,336 (38)	38-39	3978 (37)	36-38	11,358 (39)	38-40
Forearm, multiple	2265 (34)	33-35	872 (33)	31-35	1393 (34)	33-37
Scaphoid	1563 (14)	13-14	911 (16)	<b>15-17</b>	652 (12)	11-13
Carpal, other	584 (14)	13-15	387 (15)	14-16	197 (12)	11-14
Metacarpal 1	414 (23)	21-25	321 (25)	<b>23-27</b>	93 (18)	15-22
Metacarpal 2	4439 (17)	16-17	3149 (16)	16-17	1290 (17)	16-18
Metacarpal, multiple	523 (28)	26-30	391 (28)	26-30	132 (27)	24-31
Proximal phalanx	561 (17)	16-18	384 (19)	<b>17-21</b>	177 (14)	12-16
Distal phalanx	5651 (26)	25-27	4495 (29)	<b>28-30</b>	1156 (19)	18-20
Phalanx, other	3952 (17)	17-18	2655 (20)	<b>19-21</b>	1297 (13)	13-14
Finger, multiple	1922 (48)	47-50	1515 (54)	<b>52-56</b>	407 (36)	33-39

CI = 95% confidence interval; for the entire cohort fractures where more than 50% of the patients received an opioid are bolded, in the sex disaggregated data results are bolded where there are statistically significant sex differences in opioid use.

associated with higher opioid use maybe partially explained by greater trauma since rates were found in patients with more proximal injury, nerve/tendon injury, or hospitalization. Our findings are consistent with studies of opioid use through pill counts following orthopedic surgery where 22 pills were used for shoulder, 11 for forearm/elbow, and 8 for hand/wrist surgery.<sup>[26]</sup> A 2015 study that examined opioid use in 1466 patients following upper extremity surgery found higher use for fractures than for soft tissue procedures.<sup>[26]</sup> This means that pain management guidelines should consider the type of fracture as an important consideration.

Prescription rates for patients with upper extremity fractures in this cohort were high considering that prior reports suggest that about 7% of patients following low-risk surgeries<sup>[27]</sup> and 49% of those having major surgery<sup>[27]</sup> receive a new opioid prescription. However, our rates were lower than those reported for patients in the United States with distal radius fracture, metacarpal, and phalangeal fractures where opioid prescriptions were filled by more than 85% of patients.<sup>[3]</sup> The data from these studies reflects the fact that Canada and the United States are amongst the highest users of opioids in the world, although this

is not associated with better pain management of extremity fractures.<sup>[28]</sup> For example, a study comparing opioid prescription rates following surgery in Canada and the US versus Sweden, found that rates were 7 times higher in North America.<sup>[29]</sup>

Since new persistent opioid use in previous non-users is a concern following minor or major surgeries<sup>[30]</sup> and upper extremity fracture,<sup>[3]</sup> reducing initial opioid exposure may be important for harm reduction. A clinical practice guideline for management of acute musculoskeletal pain published in 2019 stated that “*Because of the potential for misuse of all opioids . . . the panel recommends avoiding long-acting opioids in the acute setting (strong recommendation, moderate-quality evidence).*” Guidelines that discourage unnecessary use have been disseminated in both Canada and the US and may contribute to the changing climate around opioid prescription. However, practice guidelines alone may not necessarily be enough to change practice. While Canada, Germany, and the United States all have similar opioid practice guidelines, the opioid crisis exists in North America, but not in Germany.<sup>[31]</sup> A study of Canadian family physicians indicated that despite their positive attitudes

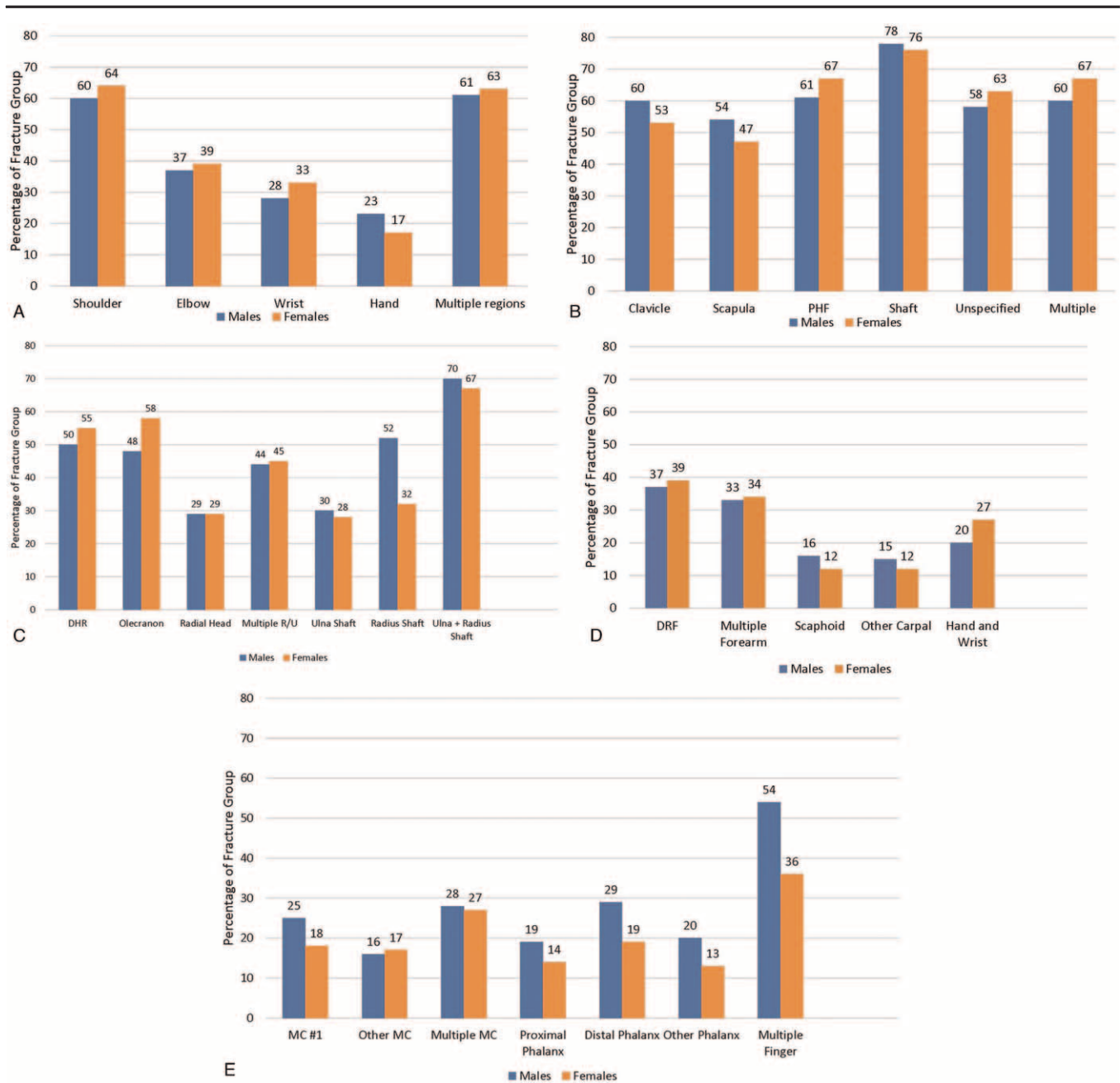
**Table 2**  
**Opioid rates by age group and characteristics of the cohort.**

	18-40 years		41-50 years		51-65 years		66-80 years		81+ years	
	No Opioid (n = 57,889)	Opioid (n = 22,380)	No Opioid (n = 19,070)	Opioid (n = 10,611)	No Opioid (n = 33,261)	Opioid (n = 21,367)	No Opioid (n = 19,944)	Opioid (n = 13,268)	No Opioid (n = 11,730)	Opioid (n = 5,955)
Sociodemographics										
Sex, Female, N (%)	18,104 (31.3%)	7203 (32.2%)	8009 (42.0%)	4408 (41.5%)	19,796 (59.5%)	13,134 (61.5%)	13,563 (68.0%)	9552 (72.0%)	8621 (73.5%)	4,613 (77.5%)
Rurality, N (%)										
Missing	1118 (1.9%)	324 (1.4%)	291 (1.5%)	130 (1.2%)	548 (1.6%)	274 (1.3%)	253 (1.3%)	156 (1.2%)	97 (0.8%)	54 (0.9%)
Urban	47,820 (82.6%)	18,588 (83.1%)	15,835 (83.0%)	8829 (83.2%)	26,843 (80.7%)	17,437 (81.6%)	15,818 (79.3%)	10,648 (80.3%)	10,016 (85.4%)	5,044 (84.7%)
Rural	8951 (15.5%)	3468 (15.5%)	2944 (15.4%)	1652 (15.6%)	5870 (17.6%)	3656 (17.1%)	3873 (19.4%)	2464 (18.6%)	1617 (13.8%)	857 (14.4%)
Neighborhood Income, N (%)										
Quintile 1 (lowest income)	12,799 (22.1%)	4732 (21.1%)	3368 (17.7%)	1879 (17.7%)	5975 (18.0%)	3745 (17.5%)	3947 (19.8%)	2496 (18.8%)	2667 (22.7%)	1,345 (22.6%)
Quintile 2	11,668 (20.2%)	4657 (20.8%)	3597 (18.9%)	2000 (18.8%)	6381 (19.2%)	4096 (19.2%)	3937 (19.7%)	2695 (20.3%)	2635 (22.5%)	1,301 (21.8%)
Quintile 3	11,451 (19.8%)	4399 (19.7%)	3785 (19.8%)	2081 (19.6%)	6555 (19.7%)	4309 (20.2%)	3970 (19.9%)	2632 (19.8%)	2252 (19.2%)	1,142 (19.2%)
Quintile 4	11,127 (19.2%)	4457 (19.9%)	4057 (21.3%)	2249 (21.2%)	6686 (20.1%)	4366 (20.4%)	3789 (19.0%)	2511 (18.9%)	2073 (17.7%)	1,063 (17.9%)
Quintile 5 (highest income)	10,667 (18.4%)	4074 (18.2%)	4228 (22.4%)	2382 (22.4%)	7594 (22.8%)	4815 (22.5%)	4281 (21.5%)	2911 (21.9%)	2075 (17.7%)	1,094 (18.4%)
Missing	177 (0.3%)	61 (0.3%)	35 (0.2%)	20 (0.2%)	70 (0.2%)	36 (0.2%)	20 (0.1%)	23 (0.2%)	28 (0.2%)	10 (0.2%)
Ontario Marginalization Index, N (%)										
Dependency										
Quintile 1 (lowest dependency)	15,429 (26.7%)	5897 (26.3%)	5144 (27.0%)	2883 (27.2%)	6742 (20.3%)	4257 (19.9%)	2628 (13.2%)	1746 (13.2%)	1129 (9.6%)	539 (9.1%)
Quintile 2	12,068 (20.8%)	4591 (20.5%)	4020 (21.1%)	2263 (21.3%)	6842 (20.6%)	4343 (20.3%)	3287 (16.5%)	2111 (15.9%)	1597 (13.6%)	781 (13.1%)
Quintile 3	10,651 (18.4%)	4177 (18.7%)	3412 (17.9%)	1957 (18.4%)	6331 (19.0%)	4090 (19.1%)	3666 (18.4%)	2463 (18.6%)	1855 (15.8%)	960 (16.1%)
Quintile 4	9938 (17.2%)	3855 (17.2%)	3257 (17.1%)	1776 (16.7%)	6297 (18.9%)	4168 (19.5%)	4095 (20.5%)	2756 (20.8%)	2363 (20.1%)	1,171 (19.7%)
Quintile 5 (highest dependency)	9043 (15.6%)	3647 (16.3%)	3040 (15.9%)	1670 (15.7%)	6771 (20.4%)	4387 (20.5%)	6149 (30.8%)	4121 (31.1%)	4721 (40.2%)	2,468 (41.4%)
Material Deprivation										
Quintile 1 (lowest deprivation)	11,261 (19.5%)	4360 (19.5%)	4252 (22.3%)	2330 (22.0%)	7376 (22.2%)	4638 (21.7%)	4274 (21.4%)	2863 (21.6%)	2241 (19.1%)	1,129 (19.0%)
Quintile 2	11,277 (19.5%)	4380 (19.6%)	4196 (22.0%)	2268 (21.4%)	6996 (21.0%)	4455 (20.8%)	4076 (20.4%)	2681 (20.2%)	2233 (19.0%)	1,218 (20.5%)
Quintile 3	10,979 (19.0%)	4342 (19.4%)	3626 (19.0%)	2112 (19.9%)	6473 (19.5%)	4312 (20.2%)	3943 (19.8%)	2647 (20.0%)	2410 (20.5%)	1,179 (19.8%)
Quintile 4	11,041 (19.1%)	4243 (19.0%)	3384 (17.7%)	1856 (17.5%)	6215 (18.7%)	3986 (18.7%)	3997 (20.0%)	2590 (19.5%)	2476 (21.1%)	1,202 (20.2%)
Quintile 5 (highest deprivation)	12,571 (21.7%)	4842 (21.6%)	3415 (17.9%)	1983 (18.7%)	5923 (17.8%)	3854 (18.0%)	3535 (17.7%)	2416 (18.2%)	2305 (19.7%)	1,191 (20.0%)
Ethnic Concentration										
Quintile 1 (lowest concentration)	10,186 (17.6%)	4133 (18.5%)	3192 (16.7%)	1853 (17.5%)	6628 (19.9%)	4368 (20.4%)	4671 (23.4%)	3112 (23.5%)	2473 (21.1%)	1,296 (21.8%)
Quintile 2	10,608 (18.3%)	4378 (19.6%)	3465 (18.2%)	2012 (19.0%)	6390 (19.2%)	4465 (20.9%)	4061 (20.4%)	2897 (21.8%)	2388 (20.4%)	1,334 (22.4%)
Quintile 3	11,037 (19.1%)	4526 (20.2%)	3678 (19.3%)	2151 (20.3%)	6472 (19.5%)	4388 (20.5%)	3709 (18.6%)	2693 (20.3%)	2283 (19.5%)	1,211 (20.3%)
Quintile 4	12,351 (21.3%)	4707 (21.0%)	4095 (21.5%)	2266 (21.4%)	6593 (19.8%)	4172 (19.5%)	3614 (18.1%)	2397 (18.1%)	2316 (19.7%)	1,136 (19.3%)
Quintile 5 (highest concentration)	12,947 (22.4%)	4423 (19.8%)	4443 (23.3%)	2267 (21.4%)	6900 (20.7%)	3852 (18.0%)	3770 (18.9%)	2098 (15.8%)	2205 (18.8%)	942 (15.8%)
Neighborhood Instability										
Quintile 1	10,811 (18.7%)	3923 (17.5%)	4345 (22.8%)	2396 (22.6%)	6391 (19.2%)	3994 (18.7%)	3101 (15.5%)	1978 (14.9%)	1245 (10.6%)	645 (10.8%)
Quintile 2	10,216 (17.6%)	4105 (18.3%)	3686 (19.3%)	2106 (19.8%)	6676 (20.1%)	4302 (20.1%)	3837 (19.2%)	2529 (19.1%)	1737 (14.8%)	935 (15.7%)
Quintile 3	10,410 (18.0%)	4158 (18.6%)	3495 (18.3%)	1973 (18.6%)	6441 (19.4%)	4294 (20.1%)	3945 (19.8%)	2770 (20.9%)	2176 (18.6%)	1,105 (18.6%)
Quintile 4	11,376 (19.7%)	4445 (19.9%)	3444 (18.1%)	1954 (18.4%)	6382 (19.2%)	4228 (19.8%)	3880 (19.5%)	2656 (20.0%)	2563 (21.8%)	1,313 (22.0%)
Quintile 5	14,316 (24.7%)	5536 (24.7%)	3903 (20.5%)	2120 (20.0%)	7093 (21.3%)	4427 (20.7%)	5062 (25.4%)	3264 (24.6%)	3944 (33.6%)	1,921 (32.3%)
Missing	760 (1.3%)	213 (1.0%)	197 (1.0%)	62 (0.6%)	278 (0.8%)	122 (0.6%)	119 (0.6%)	71 (0.5%)	65 (0.6%)	36 (0.6%)
Comorbidities and health status, N (%)										
Rheumatoid Arthritis	124 (0.2%)	74 (0.3%)	138 (0.7%)	83 (0.8%)	490 (1.5%)	358 (1.7%)	590 (3.0%)	447 (3.4%)	370 (3.2%)	192 (3.2%)
Diabetes	1296 (2.2%)	604 (2.7%)	1646 (8.6%)	1008 (9.5%)	5014 (15.1%)	3479 (16.3%)	5476 (27.5%)	3875 (29.2%)	3453 (29.4%)	1,789 (30.0%)
Osteoporosis	8 (0.0%)	0 (0.0%)	3 (0.0%)	6 (0.1%)	35 (0.1%)	42 (0.2%)	138 (0.7%)	110 (0.8%)	311 (2.7%)	151 (2.5%)
Osteoarthritis	75 (0.1%)	45 (0.2%)	140 (0.7%)	79 (0.7%)	747 (2.2%)	513 (2.4%)	1172 (5.9%)	793 (6.0%)	710 (6.1%)	372 (6.2%)
Charlson comorbidity index										
0	57,504 (99.3%)	22,186 (99.1%)	18,664 (97.9%)	10,347 (97.5%)	31,609 (95.0%)	20,126 (94.2%)	17,469 (87.6%)	11,422 (86.1%)	9365 (79.8%)	4,735 (79.5%)
1	251 (0.4%)	124 (0.6%)	229 (1.2%)	146 (1.4%)	793 (2.4%)	603 (2.8%)	1055 (5.3%)	831 (6.3%)	996 (8.5%)	546 (9.2%)
2	98 (0.2%)	51 (0.2%)	107 (0.6%)	59 (0.6%)	480 (1.4%)	352 (1.6%)	774 (3.9%)	543 (4.1%)	658 (5.6%)	321 (5.4%)
3+	36 (0.1%)	19 (0.1%)	70 (0.4%)	59 (0.6%)	379 (1.1%)	286 (1.3%)	646 (3.2%)	472 (3.6%)	711 (6.1%)	353 (5.9%)
Fracture Characteristics, N (%)										
Fracture region										
> 1 region	704 (1.2%)	1156 (5.2%)	236 (1.2%)	488 (4.6%)	525 (1.6%)	1044 (4.9%)	411 (2.1%)	614 (4.6%)	299 (2.5%)	254 (4.3%)
Shoulder	2932 (5.1%)	4437 (19.8%)	1382 (7.2%)	2459 (23.2%)	3206 (9.6%)	6205 (29.0%)	2910 (14.6%)	5281 (39.8%)	2633 (22.4%)	3,032 (50.9%)
Elbow	5569 (9.6%)	3319 (14.8%)	2254 (11.8%)	1582 (14.9%)	4543 (13.7%)	3009 (14.1%)	2547 (12.8%)	1644 (12.4%)	1453 (12.4%)	727 (12.2%)
Forearm & Wrist	13,761 (23.8%)	4750 (21.2%)	5413 (28.4%)	2978 (28.1%)	12,966 (39.0%)	7350 (34.4%)	8972 (45.0%)	4394 (33.1%)	5030 (42.9%)	1,614 (27.1%)
Hand	34,923 (60.3%)	8718 (39.0%)	9785 (51.3%)	3104 (29.3%)	12,021 (36.1%)	3759 (17.6%)	5104 (25.6%)	1335 (10.1%)	2315 (19.7%)	328 (5.5%)
Fracture										
Multiple shoulder	201 (0.3%)	222 (1.0%)	79 (0.4%)	185 (1.7%)	213 (0.6%)	463 (2.2%)	184 (0.9%)	401 (3.0%)	160 (1.4%)	235 (3.9%)
Clavicle	1855 (3.2%)	2965 (13.2%)	642 (3.4%)	1185 (11.2%)	1057 (3.2%)	1632 (7.6%)	695 (3.5%)	672 (5.1%)	755 (6.4%)	373 (6.3%)
Scapula	282 (0.5%)	302 (1.3%)	159 (0.8%)	189 (1.8%)	315 (0.9%)	363 (1.7%)	198 (1.0%)	217 (1.6%)	144 (1.2%)	105 (1.8%)
Proximal Humerus	451 (0.8%)	561 (2.5%)	413 (2.2%)	680 (6.4%)	1375 (4.1%)	3113 (14.6%)	1569 (7.9%)	3364 (25.4%)	1363 (11.6%)	2,007 (33.7%)
Humerus, shaft	68 (0.1%)	285 (1.3%)	31 (0.2%)	149 (1.4%)	79 (0.2%)	372 (1.7%)	107 (0.5%)	314 (2.4%)	91 (0.8%)	147 (2.5%)
Humerus, unspecified	75 (0.1%)	102 (0.5%)	58 (0.3%)	71 (0.7%)	167 (0.5%)	262 (1.2%)	157 (0.8%)	313 (2.4%)	120 (1.0%)	165 (2.8%)
Radius Head	3533 (6.1%)	1518 (6.8%)	1324 (6.9%)	652 (6.1%)	2388 (7.2%)	943 (4.4%)	939 (4.7%)	837 (6.2%)	298 (2.5%)	65 (1.1%)
Distal Humerus	215 (0.4%)	324 (1.4%)	79 (0.4%)	99 (0.9%)	223 (0.7%)	235 (1.1%)	191 (1.0%)	207 (1.6%)	174 (1.5%)	145 (2.4%)
Olecranon	311 (0.5%)	407 (1.8%)	212 (1.1%)	211 (2.0%)	342 (1.0%)	408 (1.9%)	239 (1.2%)	301 (2.3%)	223 (1.9%)	142 (2.4%)
Coranoid	166 (0.3%)	50 (0.2%)	96 (0.5%)	36 (0.3%)	125 (0.4%)	46 (0.2%)	36 (0.2%)	12 (0.1%)	11 (0.1%)	1 (0.0%)
Monteggia	2 (0.0%)	13 (0.1%)	1 (0.0%)	5 (0.0%)	1 (0.0%)	9 (0.0%)	1 (0.0%)	1 (0.0%)	1 (0.0%)	1 (0.0%)
Multiple forearm	1334 (2.3%)	629 (2.8%)	505 (2.6%)	327 (3.1%)	1206 (3.6%)	713 (3.3%)	846 (4.2%)	400 (3.0%)	454 (3.9%)	129 (2.2%)
Distal Radius	4447 (7.7%)	2579 (11.5%)	2429 (12.7%)	2036 (19.2%)	7573 (22.8%)	5549 (26.0%)	5823 (29.2%)	3432 (25.9%)	3424 (29.2%)	1,264 (21.2%)
Scaphoid	5005 (8.6%)	734 (3.3%)	1332 (7.0%)	217 (2.0%)	1859 (5.6%)	353 (1.7%)	1004 (5.0%)	170 (1.3%)	413 (3.5%)	59 (1.0%)
Multiple Radius and Ulna	1342 (2.3%)	1007 (4.5%)	542 (2.8%)	579 (5.5%)	1464 (4.4%)	1368 (6.4%)	1141 (5.7%)	836 (6.3%)	746 (6.4%)	373 (6.3%)
Ulnar Shaft	389 (0.7%)	157 (0.7%)	141 (0.7%)	67 (0.6%)	193 (0.6%)	102 (0.5%)	125 (0.6%)	37 (0.3%)	80 (0.7%)	16 (0.3%)
Radius Shaft	63 (0.1%)	83 (0.4%)	40 (0.2%)	35 (0.3%)	58 (0.2%)	34 (0.2%)	40 (0.2%)	12 (0.1%)	24 (0.2%)	6 (0.1%)
Ulna and Radial shaft	39 (0.1%)	98 (0.4%)	6 (0.0%)	26 (0.2%)	15 (0.0%)	29 (0.1%)	13 (0.1%)	23 (0.2%)	10 (0.1%)	7 (0.1%)
Wrist & Hand	1233 (2.1%)	285 (1.3%)	426 (2.2%)	174 (1.6%)	971 (2.9%)	390 (1.8%)	644 (3.2%)	232 (1.7%)	436 (3.7%)	111 (1.9%)
Other carpal	1251 (2.2%)	185 (0.8%)	534 (2.8%)	96 (0.9%)	1091 (3.3%)	180 (0.8%)	477 (2.4%)	88 (0.7%)	189 (1.6%)	22 (0.4%)
D1 MC	763 (1.3%)	236 (1.1%)	186 (1.0%)	62 (0.6%)	225 (0.7%)	77 (0.4%)	119 (0.6%)	27 (0.2%)	69 (0.6%)	7 (0.1%)
D2-D5 MC	14,643 (25.3%)	2998 (13.4%)	2682 (14.1%)	592 (5.6%)	2740 (8.2%)	555 (2.6%)	1360 (6.8%)	202 (1.5%)	709 (6.0%)	65 (1.1%)
Multiple metacarpal	865 (1.5%)	353 (1.6%)	137 (0.7%)	66 (0.6%)	166 (0.5%)	59 (0.3%)	108 (0.5%)	28 (0.2%)	75 (0.6%)	11 (0.2%)
Proximal Phalanx	1293 (2.2%)	255 (1.1%)	419 (2.2%)	109 (1.0%)	615 (1.8%)	117 (0.5%)	241 (1.2%)	53 (0.4%)	117 (1.0%)	18 (0.3%)
Distal Phalanx	7216 (12.5%)	2310 (10.3%)	2884 (15.1%)	1202 (11.3%)	3869 (11.6%)	1472 (6.9%)	1412 (7.1%)	495 (3.7%)	451 (3.8%)	91 (1.5%)
Phalanx										

**Table 2**  
(continued).

	18-40 years		41-50 years		51-65 years		66-80 years		81+years	
	No Opioid (n = 57,889)	Opioid (n = 22,380)	No Opioid (n = 19,070)	Opioid (n = 10,611)	No Opioid (n = 33,261)	Opioid (n = 21,367)	No Opioid (n = 19,944)	Opioid (n = 13,268)	No Opioid (n = 11,730)	Opioid (n = 5,955)
Admitted as inpatient for treatment	296 (0.5%)	1693 (7.6%)	129 (0.7%)	820 (7.7%)	343 (1.0%)	1626 (7.6%)	514 (2.6%)	1084 (8.2%)	658 (5.6%)	460 (7.7%)
Season of occurrence										
Q1: January-March	13,440 (23.2%)	5476 (24.5%)	4720 (24.8%)	2796 (26.4%)	8708 (26.2%)	6140 (28.7%)	4871 (24.4%)	3511 (26.5%)	2652 (22.6%)	1,459 (24.5%)
Q2: April-Jun	14,721 (25.4%)	5706 (25.5%)	4501 (23.6%)	2496 (23.5%)	7615 (22.9%)	4698 (22.0%)	4763 (23.9%)	3054 (23.0%)	2915 (24.9%)	1,487 (25.0%)
Q3: July-Sept	16,655 (28.8%)	6467 (28.9%)	5299 (27.8%)	2901 (27.3%)	8686 (26.1%)	5404 (25.3%)	5169 (25.9%)	3339 (25.2%)	3179 (27.1%)	1,510 (25.4%)
Q4: Oct-Dec	13,073 (22.6%)	4731 (21.1%)	4550 (23.9%)	2418 (22.8%)	8252 (24.8%)	5125 (24.0%)	5141 (25.8%)	3364 (25.4%)	2984 (25.4%)	1,499 (25.2%)

Shaded areas indicate statistically significant differences ( $P < .001$ ). \*\*exact P values and std difference are hidden available.



**Figure 2.** (A) Rate of prescriptions after 1st incident fracture in naïve users by regions and sex. (B) Rate of prescriptions after 1st incident fracture in naïve users, after shoulder fracture, by sex. (C) Rate of prescriptions after 1st incident fracture in naïve users, after elbow or forearm fracture, by sex. (D) Rate of prescriptions after 1st incident fracture in naïve users after wrist fracture, by sex. (E) Rate of prescriptions after 1st incident fracture in naïve users after hand fracture, by sex.

**Table 3****Opioid use by sex for fracture types and characteristics of the cohort.**

	Female				Male			
	No Opioid (n = 70111)	Opioid (n = 40302)	P	Standardized Difference	No Opioid (n = 74786)	Opioid (n = 35241)	P	Standardized Difference
Demographics								
Age group, N (%)								
18–40 years old	18,104 (25.8%)	7203 (17.9%)	<.001	0.19	39,785 (53.2%)	15,177 (43.1%)	<.001	0.2
41–50 years old	8009 (11.4%)	4408 (10.9%)		0.02	11,061 (14.8%)	6203 (17.6%)		0.08
51–65 years old	21,038 (30.0%)	14,038 (34.8%)		0.1	14,125 (18.9%)	8652 (24.6%)		0.14
66–80 years old	14,339 (20.5%)	10,040 (24.9%)		0.11	6706 (9.0%)	3867 (11.0%)		0.07
81+ years old	8621 (12.3%)	4613 (11.4%)		0.03	3109 (4.2%)	1342 (3.8%)		0.02
Fracture Characteristics, N (%)								
Fracture region								
> 1 region	<b>1191 (1.7%)</b>	<b>2067 (5.1%)</b>	<.001	<b>0.19</b>	<b>1037 (1.4%)</b>	<b>1596 (4.5%)</b>	<.001	<b>0.19</b>
Shoulder	<b>7092 (10.1%)</b>	<b>12,450 (30.9%)</b>		<b>0.53</b>	<b>6425 (8.6%)</b>	<b>9718 (27.6%)</b>		<b>0.51</b>
Elbow	10,052 (14.3%)	6519 (16.2%)		0.05	6677 (8.9%)	4014 (11.4%)		0.08
Forearm & Wrist	<b>29,552 (42.2%)</b>	<b>14,714 (36.5%)</b>		<b>0.12</b>	<b>17,944 (24.0%)</b>	<b>7003 (19.9%)</b>		<b>0.10</b>
Hand	<b>22,224 (31.7%)</b>	<b>4552 (11.3%)</b>		<b>0.51</b>	<b>42,703 (57.1%)</b>	<b>12,910 (36.6%)</b>		<b>0.42</b>
Fracture								
Multiple shoulder	<b>440 (0.6%)</b>	<b>918 (2.3%)</b>	<.001	<b>0.14</b>	<b>426 (0.6%)</b>	<b>643 (1.8%)</b>	<.001	<b>0.12</b>
Clavicle	<b>1807 (2.6%)</b>	<b>2031 (5.0%)</b>		<b>0.13</b>	<b>3323 (4.4%)</b>	<b>4915 (13.9%)</b>		<b>0.33</b>
Scapula	387 (0.6%)	349 (0.9%)		0.04	746 (1.0%)	859 (2.4%)		0.11
Proximal Humerus	<b>3825 (5.5%)</b>	<b>7720 (19.2%)</b>		<b>0.43</b>	<b>1568 (2.1%)</b>	<b>2478 (7.0%)</b>		<b>0.24</b>
Humerus, shaft	<b>244 (0.3%)</b>	<b>774 (1.9%)</b>		<b>0.15</b>	<b>151 (0.2%)</b>	<b>533 (1.5%)</b>		<b>0.14</b>
Humerus, unspecified	<b>389 (0.6%)</b>	<b>658 (1.6%)</b>		<b>0.10</b>	211 (0.3%)	290 (0.8%)		0.07
Radius Head	5180 (7.4%)	2090 (5.2%)		0.09	3442 (4.6%)	1428 (4.1%)		0.03
Distal Humerus	530 (0.8%)	654 (1.6%)		0.08	381 (0.5%)	386 (1.1%)		0.07
Olecranon	<b>612 (0.9%)</b>	<b>832 (2.1%)</b>		0.10	750 (1.0%)	678 (1.9%)		0.08
Coranoid	184 (0.3%)	71 (0.2%)		0.02	254 (0.3%)	75 (0.2%)		0.02
Monteggia	3 (0.0%)	18 (0.0%)		0.03	3 (0.0%)	12 (0.0%)		0.02
Multiple forearm	2685 (3.8%)	1393 (3.5%)		0.02	1771 (2.4%)	872 (2.5%)		0.01
Distal Radius	17,807 (25.4%)	11,358 (28.2%)		0.06	6774 (9.1%)	3978 (11.3%)		0.07
Scaphoid	<b>4919 (7.0%)</b>	<b>652 (1.6%)</b>		<b>0.27</b>	<b>4850 (6.5%)</b>	<b>911 (2.6%)</b>		<b>0.19</b>
Multiple Radius and Ulna	3543 (5.1%)	2854 (7.1%)		0.09	1847 (2.5%)	1435 (4.1%)		0.09
Ulnar Shaft	424 (0.6%)	168 (0.4%)		0.03	521 (0.7%)	222 (0.6%)		0.01
Radius Shaft	129 (0.2%)	61 (0.2%)		0.01	99 (0.1%)	109 (0.3%)		0.04
Ulna and Radial shaft	46 (0.1%)	92 (0.2%)		0.04	39 (0.1%)	91 (0.3%)		0.05
Wrist & Hand	2123 (3.0%)	793 (2.0%)		0.07	1677 (2.2%)	433 (1.2%)		0.08
Other carpal	1419 (2.0%)	197 (0.5%)		0.14	2213 (3.0%)	387 (1.1%)		0.13
D1 MC	414 (0.6%)	93 (0.2%)		0.06	965 (1.3%)	321 (0.9%)		0.04
D2–D5 MC	6257 (8.9%)	1290 (3.2%)		0.24	16,085 (21.5%)	3149 (8.9%)		0.36
Multiple metacarpal	356 (0.5%)	132 (0.3%)		0.03	1011 (1.4%)	391 (1.1%)		0.02
Proximal Phalanx	1073 (1.5%)	177 (0.4%)		0.11	1645 (2.2%)	384 (1.1%)		0.09
Distal Phalanx	4982 (7.1%)	1156 (2.9%)		0.2	11,059 (14.8%)	4495 (12.8%)		0.06
Phalanx, Other	8414 (12.0%)	1297 (3.2%)		0.34	10,628 (14.2%)	2655 (7.5%)		0.22
Multiple Finger	728 (1.0%)	407 (1.0%)		0	1310 (1.8%)	1515 (4.3%)		0.15
Open fracture	953 (1.4%)	1170 (2.9%)	<.001	0.11	3579 (4.8%)	4623 (13.1%)	<.001	0.3
Concurrent nerve injury	29 (0.0%)	100 (0.2%)	<.001	0.05	41 (0.1%)	390 (1.1%)	<.001	0.14
Concurrent tendon injury	117 (0.2%)	102 (0.3%)	.002	0.02	267 (0.4%)	791 (2.2%)	<.001	0.17
Admitted as inpatient for treatment	1183 (1.7%)	2810 (7.0%)	<.001	0.26	839 (1.1%)	3040 (8.6%)	<.001	0.35
Season of occurrence								
Q1: January–March	18,170 (25.9%)	11,677 (29.0%)	<.001	0.07	16,967 (22.7%)	8245 (23.4%)	.001	0.02
Q2: April–Jun	16,599 (23.7%)	9123 (22.6%)		0.02	18,686 (25.0%)	8781 (24.9%)		0
Q3: July–Sept	18,352 (26.2%)	9942 (24.7%)		0.03	21,361 (28.6%)	10,178 (28.9%)		0.01
Q4: Oct–Dec	16,990 (24.2%)	9560 (23.7%)		0.01	17,772 (23.8%)	8037 (22.8%)		0.02
Social Indicators								
Rurality, N (%)								
Missing	1064 (1.5%)	455 (1.1%)	<.001	0.03	1274 (1.7%)	515 (1.5%)	.003	0.02
Urban	57,771 (82.4%)	33,446 (83.0%)		0.02	60,997 (81.6%)	28,669 (81.4%)		0.01
Rural	11,276 (16.1%)	6401 (15.9%)		0.01	12,515 (16.7%)	6057 (17.2%)		0.01
Neighborhood Income, N (%)								
Quintile 1 (lowest income)	13,952 (19.9%)	7634 (18.9%)	.003	0.02	15,379 (20.6%)	6928 (19.7%)	.004	0.02
Quintile 2	13,954 (19.9%)	7979 (19.8%)		0	14,863 (19.9%)	7145 (20.3%)		0.01
Quintile 3	13,659 (19.5%)	8013 (19.9%)		0.01	14,927 (20.0%)	6951 (19.7%)		0.01

(continued)



**Table 3**  
(continued).

	Female				Male			
	No Opioid (n=70111)	Opioid (n=40302)	P	Standardized Difference	No Opioid (n=74786)	Opioid (n=35241)	P	Standardized Difference
Quintile 4	13,632 (19.4%)	7972 (19.8%)		0.01	14,654 (19.6%)	7067 (20.1%)		0.01
Quintile 5 (highest income)	14,776 (21.1%)	8635 (21.4%)		0.01	14,766 (19.7%)	7069 (20.1%)		0.01
Missing	138 (0.2%)	69 (0.2%)		0.01	197 (0.3%)	81 (0.2%)		0.01
Ontario Marginalization Index, N (%)								
Dependency								
Quintile 1 (lowest dependency)	13,902 (19.8%)	7598 (18.9%)	<.001	0.02	17,548 (23.5%)	7972 (22.6%)	<.001	0.02
Quintile 2	13,174 (18.8%)	7298 (18.1%)		0.02	15,152 (20.3%)	7127 (20.2%)		0
Quintile 3	12,575 (17.9%)	7257 (18.0%)		0	13,933 (18.6%)	6716 (19.1%)		0.01
Quintile 4	13,098 (18.7%)	7694 (19.1%)		0.01	13,474 (18.0%)	6482 (18.4%)		0.01
Quintile 5 (highest dependency)	16,708 (23.8%)	10,201 (25.3%)		0.03	13,888 (18.6%)	6685 (19.0%)		0.01
Material Deprivation								
Quintile 1 (lowest deprivation)	14,949 (21.3%)	8623 (21.4%)	<.001	0	15,086 (20.2%)	7135 (20.2%)	<.001	0
Quintile 2	14,349 (20.5%)	8343 (20.7%)		0.01	15,033 (20.1%)	7065 (20.0%)		0
Quintile 3	13,608 (19.4%)	7985 (19.8%)		0.01	14,414 (19.3%)	6966 (19.8%)		0.01
Quintile 4	13,374 (19.1%)	7595 (18.8%)		0.01	14,361 (19.2%)	6691 (19.0%)		0.01
Quintile 5 (highest deprivation)	13,177 (18.8%)	7502 (18.6%)		0	15,101 (20.2%)	7125 (20.2%)		0
Ethnic Concentration								
Quintile 1 (lowest concentration)	13,661 (19.5%)	8207 (20.4%)	<.001	0.02	14,157 (18.9%)	7021 (19.9%)	<.001	0.03
Quintile 2	13,545 (19.3%)	8391 (20.8%)		0.04	13,955 (18.7%)	7127 (20.2%)		0.04
Quintile 3	13,572 (19.4%)	8390 (20.8%)		0.04	14,188 (19.0%)	6974 (19.8%)		0.02
Quintile 4	14,184 (20.2%)	8038 (19.9%)		0.01	15,335 (20.5%)	7027 (19.9%)		0.01
Quintile 5 (highest concentration)	14,495 (20.7%)	7022 (17.4%)		0.08	16,360 (21.9%)	6833 (19.4%)		0.06
Neighborhood Instability								
Quintile 1	12,093 (17.2%)	6611 (16.4%)	<.001	0.02	14,290 (19.1%)	6631 (18.8%)	<.001	0.01
Quintile 2	12,916 (18.4%)	7550 (18.7%)		0.01	13,827 (18.5%)	6795 (19.3%)		0.02
Quintile 3	13,015 (18.6%)	7865 (19.5%)		0.02	14,035 (18.8%)	6847 (19.4%)		0.02
Quintile 4	13,753 (19.6%)	8113 (20.1%)		0.01	14,476 (19.4%)	6893 (19.6%)		0.01
Quintile 5	17,680 (25.2%)	9909 (24.6%)		0.01	17,367 (23.2%)	7816 (22.2%)		0.02
Missing	654 (0.9%)	254 (0.6%)		0.03	791 (1.1%)	259 (0.7%)		0.03
Comorbidities and health status, N (%)								
Rheumatoid Arthritis	1414 (2.0%)	987 (2.4%)	<.001	0.03	391 (0.5%)	236 (0.7%)	.003	0.02
Diabetes	9991 (14.3%)	6760 (16.8%)	<.001	0.07	7672 (10.3%)	4533 (12.9%)	<.001	0.08
Osteoporosis	464 (0.7%)	292 (0.7%)	.224	0.01	46 (0.1%)	39 (0.1%)	.006	0.02
Osteoarthritis	2044 (2.9%)	1313 (3.3%)	.001	0.02	962 (1.3%)	577 (1.6%)	<.001	0.03
Charlson comorbidity index								
0	65,627 (93.6%)	37,219 (92.4%)	<.001	0.05	71,624 (95.8%)	33,318 (94.5%)	<.001	0.06
1	2088 (3.0%)	1485 (3.7%)		0.04	1398 (1.9%)	869 (2.5%)		0.04
2	1323 (1.9%)	889 (2.2%)		0.02	895 (1.2%)	516 (1.5%)		0.02
3+	1073 (1.5%)	709 (1.8%)		0.02	869 (1.2%)	538 (1.5%)		0.03

towards opioid reduction, they had substantial knowledge gaps and barriers to operationalizing reductions.<sup>[32]</sup> Since our data suggest that perceptions around need for opioids with more extensive trauma may be partially driving current use decisions, studies which compare opioids to over-the-counter medication in different fracture types are needed to inform changes in practice. To date, opioid versus over-the-counter trials have been conducted mainly on minor upper extremity procedures like carpal tunnel release,<sup>[33,34]</sup> and have found non-inferior pain relief with over-the-counter options.

The need to avoid opioid exposure is accentuated when the negative impacts of opioids are considered.<sup>[35]</sup> A new opioid prescription is associated with an acute risk of elevated risk of falls/fractures, attributable to the acute central nervous system effects including sedation and dizziness.<sup>[36,37]</sup> About 80% of patients using opioids experienced at least 1 adverse event, with constipation (41%), nausea (32%), and somnolence (29%) being most common.<sup>[35]</sup> A systematic review of opioid use after

orthopedic trauma concluded that patients who consume more opioids communicate greater pain intensity and less satisfaction with pain control.<sup>[28]</sup> Further, patients given opioids after a fracture who think they have been under-medicated use opioids at higher than recommended doses, and take additional opioids beyond those prescribed by their surgeons.<sup>[38]</sup>

Our study adds to prior studies by providing more detailed description of fracture, age, and sex-specific data. With some exceptions, there were similar rates of opioid prescription between males and females across different fractures. In males, greater use was found in scapula and multiple finger fractures or when there was an associated nerve or tendon injury. In open fractures, there was higher use in both males and females when compared to closed fractures, but the effect was much larger in males (SMD 0.30 vs 0.11). Since males are more likely to incur traumatic fractures, these findings are consistent with our hypothesis that opioid use is influenced by trauma severity. Sex-based differences in bone quality mean that fragility fractures are

more common in females.<sup>[39]</sup> We might expect that low trauma fractures would require less opioids for pain management. This is supported by our data in that females had higher use, but not for fragility fractures. Since there are sex differences in responses to opioids between males and females<sup>[40,41]</sup> we cannot conflate prescription rates with adequate pain relief. However, males and females do exhibit similar pain and recovery patterns following distal radius fractures.<sup>[42–44]</sup>

Although this study reported sex differences, because sex is recorded in the medical data, we cannot isolate sex and gender effects. Gendered social norms or sport/occupational exposures affect injury severity, while gender differences in pain expectations and reporting affect pain management decisions.<sup>[45,46]</sup> Provider gender-related pain biases can influence opioid prescription rates, although limited research suggests that opioid prescription following fracture is not based on either sex or race.<sup>[47]</sup> While sex/gender differences in our data were small to moderate, this does not preclude important differences in the nature of injuries and opioid-prescribing practices that could be offset in summary data. Better consideration of sex and gender into trial plans, as suggested by SAGER guidelines<sup>[48]</sup> is needed to clarify these issues.

Prescription rates were lower for the youngest and oldest of the cohort, which is consistent with surveys of orthopedics that indicate more reluctance to prescribe opioids to younger people,<sup>[49]</sup> and concerns about the use of opioids in older adults due to increased risk of complications, drug interactions, and secondary fractures.<sup>[50,51]</sup>

When considering the potential to reduce opioid exposures, both the number of fractures and the rate of opioid prescription should be considered. For example, Monteggia fractures had 1 of the highest rates of opiate prescription (83%) which is consistent with this being a highly traumatic injury. Since only 36 cases were identified, efforts to change the pain management of Monteggia fractures will have little overall impact on the “opioid crisis.” Conversely, while only 38% of patients with distal radius fractures received an opiate prescription, due to the high volume of these injuries, this represents 15,336 non-users who were potentially given a first opioid prescription for their injury. Given that many distal radius fractures are low energy fractures—particularly in females over 50—there may be an opportunity to shift practice patterns to reduce opioid exposures in this common injury. This increased recent emphasis on opioid harm reduction is evident in changing practice guidelines. While previous practices guidelines for DRF management published by The American Academy of Orthopedic Surgeons did not address opioid prescription<sup>[52]</sup>; the most current version does.<sup>[53]</sup> It states “In the absence of sufficient evidence specific to distal radius fractures, it is the opinion of the workgroup that opioid sparing and multimodal pain management strategies should be considered for patients undergoing treatment for distal radius fractures.”<sup>[53]</sup> Despite the lack of evidence, experts felt compelled to make this recommendation.

#### 4.1. Limitations

Despite the large sample and use of validated health service data codes, this study has several limitations. Ontario is 1 province and may not represent other regions of Canada or other countries. Since administrative databases were designed for health system management, there are inherent limitations to code coverage and validity. Opioid prescription is a surrogate for use and may not reflect actual use or dosage since patients often do not completely use their filled prescriptions<sup>[54]</sup> and we did not

have dosage information. We did not account for inpatient use on short-term stays since the 5-day cut off was arbitrary, nor can we account for nonprescription use of opioids. Our exclusion of prior fractures and a look back window that excluded patients with recent opioid use was intended to focus on opioid naïve patients. However, we cannot know if there were more distant or nonprescription exposures to opioids and so termed our cohort not-recent users. Because our cohort ended in 2017, it may not reflect most current practice. We cannot judge the appropriateness of any filled prescription. Finally, since administrative data does not distinguish sex/gender or include nonbinary options, the designation of males and females is not necessarily accurate for all cases, and gender was not adequately considered.

## 5. Conclusions

We conclude that opioid prescription rates vary widely by fracture type, and to lesser extent age or sex; and that the extent of fracture trauma is an important factor. Practice is challenging since opioid use became common without evidence of benefit in upper extremity fracture management, and use is now discouraged due to concerns about harms, although evidence remains lacking. Future time series analysis should investigate if opioid prescription rates change as new practice guidelines and awareness campaigns attempt to reduce exposure to opioids; and should compare alternative pain management strategies in high quality trials.

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