

Supplemental Information

Appendix 1: List of Opioid Analgesics and Benzodiazepines Included in Analyses

Opioid analgesics included benzhydrocodone, buprenorphine, butorphanol, codeine, dihydrocodeine, fentanyl, hydrocodone, hydromorphone, levorphanol, meperidine, methadone, morphine, nalbuphine, opium, oxycodone, oxymorphone, pentazocine, propoxyphene, sufentail, tapentadol, and tramadol. Buprenorphine formulations indicated for opioid use disorder were excluded, as were opioid cough-and-cold medications.

Benzodiazepines included alprazolam, chlordiazepoxide, clobazam, clonazepam, clorazepate, diazepam, estazolam, flurazepam, lorazepam, midazaloam, oxazepam, quazepam, temazepam, and triazolam. Nonoral formulations, such as rectal diazepam, were excluded.

Appendix 2: Details on Obtaining Population Denominators

Using the 2019 American Community Survey (ACS), SAS PROC SURVEYFREQ, and the ACS person-level weights (PWGTP), we estimated the number of US children and young adults aged 0 to 21 years. We also estimated population denominators by age group (ages 0–11 vs 12–21 years), sex (male or female), and Census region.

To assess the validity of our approach to calculate prevalence estimates, we analyzed data from the 2019 IBM MarketScan Commercial Database, which contains claims from 27 million Americans aged 0 to 64 years with private, employer-sponsored insurance. Among a sample of 5 010 587 children and young adults aged 0 to 21 years with continuous

enrollment and pharmacy benefit coverage throughout 2019, 207 409 (4.1%) had at least 1 dispensed opioid prescription in 2019 (similar to our estimate that 3.5% of US children and young adults across all payer types had at least 1 dispensed opioid prescription in 2019).

For a more apples-to-apples comparison, we also calculated the number of opioid prescriptions dispensed to children and young adults in 2019 in the IQVIA database for which the payer type was commercial, then used population denominators from the 2019 ACS to calculate the proportion of privately insured US children and young adults with at least 1 dispensed opioid prescription in 2019. In the IQVIA data, there were 2 447 863 opioid prescriptions dispensed to children and young adults in 2019 in which payer type was commercial; 1 989 661 unique children and young adults in the IQVIA data had at least 1 such prescription. According to the 2019 ACS, there were 52 316 339 privately insured US children and young adults aged 0 to 21 years in 2019. This suggests that 3.8% (1 989 661 of 52 316 339) of US children and young adults had at least 1 dispensed opioid prescription in 2019 (compared with 4.1% in MarketScan).

There are caveats to these comparisons. MarketScan may underestimate the rate of opioid dispensing to privately insured children and young adults because it does not capture prescriptions to patients that are paid with cash rather than reimbursed by insurance. On the other hand, MarketScan may overestimate dispensing to privately insured patients because it overwhelmingly

represents well-insured patients covered by medium to large firms whose health care access and potential rates of opioid dispensing may be higher than other privately insured patients. IQVIA data may underestimate the rate of opioid dispensing to privately insured children and young adults because some of the cash-pay prescriptions may have been for privately insured patients and because these data do not capture dispensing at hospital-specific or health system-specific pharmacies. Despite these caveats, the fact that proportions were so close do not support the contention that the exclusion of hospital pharmacies leads to a large degree of underestimation of the prevalence of dispensed opioid prescriptions in US children and young adults.

Appendix 3: Dispensed Opioid Prescriptions to Opioid-Naive Patients, by Specialty

The sample for this analysis includes 3 189 761 prescriptions with nonmissing prescriber identifiers that were written to opioid-naive patients (those without dispensed opioid prescriptions in the 90 days to 1 day before dispensing). Dentists, surgeons, and emergency medicine physicians, who typically write prescriptions for acutely painful conditions such as procedures and trauma, accounted for 75.4% of prescriptions to opioid-naive patients. Obstetricians and gynecologists, who also typically write prescriptions for acute pain (cesarean delivery or vaginal delivery), accounted for another 3.8%. Physician assistants and nurse practitioners accounted for 11.0%. Although we could not determine if these clinicians worked in medical versus surgical settings, data from the adult literature suggest that physician assistants and nurse

practitioners account for 19% of perioperative opioid prescriptions.⁴⁴ This suggests that many pediatric opioid prescriptions written by these clinicians were for surgical care. Collectively, these findings suggest that acutely painful procedures and conditions are the indication for the vast majority of opioid prescriptions to opioid-naive children and young adults (Supplemental Table 5).

Appendix 4: Performance on 6 Metrics of High-risk Pediatric Opioid Prescribing by Specialty (Supplemental Table 6) and Specialties Accounting for the Most High-risk Prescriptions

As with other prescriber analyses in this study, we excluded a small number of prescriptions with missing prescriber identifiers, leaving 3 943 231 prescriptions. The number in parentheses is the proportion of prescriptions from each specialty eligible for each metric that were considered high risk by the metric. Specialties are displayed in order of descending total number of pediatric opioid prescriptions, as in Table 4. For

definitions of each specialty, see footnotes of Table 4.

The tables below list the 5 specialties accounting for the most numbers of each type of high-risk prescription (Supplemental Tables 7 to 12).

Appendix 5: AMEs of Demographic Characteristics on Performance on 6 Metrics of High-risk Prescribing, 2019 IQVIA Longitudinal Prescription Database (Supplemental Table 13)

Appendix 6: Dispensed Opioid Prescriptions From Surgeons, by Surgical Subspecialty

The sample for this analysis includes the 918 154 prescriptions with nonmissing prescriber identifiers that were written by surgeons (Supplemental Table 14).

Appendix 7: Dispensed Opioid Prescriptions to Young Children and Adolescents and Young Adults and Adolescents, by Specialty

Young children were defined as patients aged 0 to 11 years. The sample for this analysis includes the 511 966 prescriptions with nonmissing prescriber identifiers

that were written to young children (Supplemental Table 15).

Adolescents and young adults were defined as patients aged 12 to 21 years.

The sample for this analysis includes the 3 431 265 prescriptions with nonmissing prescriber identifiers that were written to adolescents and young adults (Supplemental Table 16).

Appendix 8: Results When Defining High-Volume Prescribers as Those With Prescription Counts in the ≥ 99 th Percentile

When we defined high-volume prescribers as those with prescription counts at the ≥ 99 th percentile (corresponding to ≥ 144 prescriptions), 4071 prescribers were considered high-volume prescribers. Of these prescribers, 80.6% and 14.8% were dentists and surgeons, respectively. These prescribers accounted for 28.7% of all pediatric opioid prescriptions and 26.8% of high-risk prescriptions.

SUPPLEMENTAL TABLE 5 Dispensed opioid prescriptions to opioid-naive patients, by specialty

Specialty	No. Prescriptions	Percentage of All Prescriptions for Opioid-Naive Patients
Dentistry	1 397 541	43.8
Surgery	757 480	23.7
Emergency medicine	250 654	7.9
Physician assistant	212 058	6.6
Nurse practitioner	140 251	4.4
Obstetrics and/or gynecology	122 188	3.8
Family medicine	108 855	3.4
General pediatrics	47 248	1.5
Internal medicine	39 222	1.2
Pain medicine and anesthesiology	33 419	1.0
Hematology and/or oncology	13 764	0.4
Podiatry	7 124	0.2
Physical medicine and rehabilitation	3 982	0.1
Hospice and/or palliative care	760	0.0
All other prescribers	48 529	1.5
Unknown	6 686	0.2
Total	3 189 761	100.0

SUPPLEMENTAL TABLE 6 Performance on 6 metrics of high-risk pediatric opioid prescribing by specialty

Specialty	No. Prescriptions to Opioid-Naive Patients Exceeding 3-d Supply (Percentage of Prescriptions to Opioid-Naive Patients From Specialty)	No. Prescriptions to Opioid-Naive Patients Exceeding 7-d Supply (Percentage of Prescriptions to Opioid-Naive Patients From Specialty)	No. Prescriptions to Young Children for Codeine (Percentage of Prescriptions to Young Children From Specialty)	No. Prescriptions to Young Children for Tramadol (Percentage of Prescriptions to Young Children From Specialty)	No. Prescriptions to AYAs With Daily MMEs ≥50 (Percentage of Prescriptions to AYAs From Specialty)	No. Prescriptions to AYAs With Opioid-Benzodiazepine Overlap (Percentage of Prescriptions to AYAs From Specialty)
Dentist	427 173 (30.6)	8235 (0.6)	12 537 (20.7)	1071 (1.8)	108 035 (7.5)	43 118 (3.0)
Surgery	457 148 (60.4)	45 094 (6.0)	9455 (3.9)	2787 (1.2)	123 487 (18.2)	24 517 (3.6)
Physician assistant	94 126 (44.4)	8475 (4.0)	2831 (8.6)	2373 (7.2)	37 891 (15.2)	11 041 (4.4)
Emergency medicine	70 432 (28.1)	3418 (1.4)	4716 (13.9)	1222 (3.6)	12 978 (5.3)	3961 (1.6)
Nurse practitioner	60 993 (43.5)	8198 (5.8)	3094 (8.7)	3229 (9.1)	23 318 (12.8)	14 708 (8.1)
Family medicine	54 328 (49.9)	10 863 (10.0)	4306 (16.6)	5445 (21.0)	17 317 (10.3)	17 671 (10.5)
Obstetrics and/or gynecology	56 126 (45.9)	2735 (2.2)	288 (9.6)	344 (11.4)	16 021 (11.8)	2904 (2.1)
Internal medicine	21 603 (55.1)	5699 (14.5)	1374 (10.7)	3502 (27.2)	10 161 (14.0)	10 702 (14.7)
General pediatrician	17 316 (36.6)	2706 (5.7)	2270 (10.1)	213 (0.9)	5459 (12.5)	3256 (7.4)
Podiatry	5131 (72.0)	3084 (43.3)	316 (3.3)	1073 (11.3)	13 704 (27.2)	10 252 (20.4)
Pain medicine and anesthesiology	20 986 (62.8)	1600 (4.8)	1083 (30.2)	237 (6.6)	5409 (13.6)	742 (1.9)
Hematology and/or oncology	8946 (65.0)	2347 (17.1)	242 (2.6)	156 (1.7)	10 334 (36.6)	2375 (8.4)
Physical medicine and rehabilitation	3292 (82.7)	1417 (35.6)	110 (3.6)	465 (15.1)	4576 (25.4)	3316 (18.4)
Hospice and/or palliative care	467 (61.4)	220 (28.9)	3 (0.5)	7 (1.2)	820 (40.9)	679 (33.9)
All other prescribers	23 180 (47.8)	5693 (11.7)	1107 (7.6)	3013 (20.7)	7519 (11.2)	6587 (9.8)
Unknown	3738 (55.9)	1713 (25.6)	127 (5.1)	1787 (71.3)	538 (7.3)	336 (4.6)
Total No. prescriptions classified as high risk by the metric across all specialties	1 324 985	111 497	43 859	26 924	397 567	156 165

AYA, adolescent and young adult.

SUPPLEMENTAL TABLE 7 Specialties Accounting for the Most Prescriptions to Opioid-Naive Patients Exceeding a 3-Day Supply

Metric: Prescriptions to Opioid-Naive Patients Exceeding 3-d Supply	Percentage of Prescriptions to Opioid-Naive Patients Exceeding 3-d Supply
Surgery	34.5
Dentist	32.2
Physician assistant	7.1
Emergency medicine	5.3
Nurse practitioner	4.6

SUPPLEMENTAL TABLE 8 Specialties Accounting for the Most Prescriptions to Opioid-Naive Patients Exceeding a 7-Day Supply

Metric: Prescriptions to Opioid-Naive Patients Exceeding 7-d Supply	Percentage of Prescriptions to Opioid-Naive Patients Exceeding 7-d Supply
Surgery	40.4
Family medicine	9.7
Physician assistant	7.6
Dentist	7.4
Nurse practitioner	7.4

SUPPLEMENTAL TABLE 9 Specialties Accounting for the Most Prescriptions to Young Children for Codeine

Metric: Prescriptions to Young Children for Codeine	Percentage of Prescriptions to Young Children for Codeine
Dentist	28.6
Surgery	21.6
Emergency medicine	10.8
Family medicine	9.8
Nurse practitioner	7.1

SUPPLEMENTAL TABLE 10 Specialties Accounting for the Most Prescriptions to Young Children for Tramadol

Metric: Prescriptions to Young Children for Tramadol	Percentage of Prescriptions to Young Children for Tramadol
Family medicine	20.2
Internal medicine ^a	13.0
Nurse practitioner	12.0
All other prescribers ^b	11.2
Surgery	10.4

^a Internal medicine includes physicians dually boarded in internal medicine along with family medicine or pediatrics.

^b Approximately one-third of tramadol prescribing to young children in this category was accounted for by rheumatologists and neurologists.

SUPPLEMENTAL TABLE 11 Specialties Accounting for the Most Prescriptions to AYAs With Daily MMEs \geq 50

Metric: Prescriptions to AYAs With Daily MMEs \geq 50	Percentage of Prescriptions to AYAs With Daily MMEs \geq 50
Surgery	31.1
Dentist	27.2
Physician assistant	9.5
Nurse practitioner	5.8
Family medicine	4.4

AYA, adolescent and young adult.

SUPPLEMENTAL TABLE 12 Specialties Accounting for the Most Prescriptions to AYAs With Opioid-Benzodiazepine Overlap

Metric: Prescriptions to AYAs With Opioid-Benzodiazepine Overlap	Percentage of Prescriptions to AYAs With Opioid-Benzodiazepine Overlap
Dentist	27.6
Surgery	15.7
Family medicine	11.3
Nurse practitioner	9.4
Physician assistant	7.1

AYA, adolescent and young adult.

SUPPLEMENTAL TABLE 13 Average marginal effects of demographic characteristics on performance on 6 metrics of high-risk prescribing, 2019 IQVIA Longitudinal Prescription Database

	Metric 1: Proportion of Prescriptions for Opioid-Naive Patients With Days Supplied >3	Metric 2: Proportion of Prescriptions for Opioid-Naive Patients With Days Supplied >7	Metric 3: Proportion of Prescriptions to Young Children for Codeine	Metric 4: Proportion of Prescriptions to Young Children for Tramadol	Metric 5: Proportion of Prescriptions to AYAs With High Daily Opioid Dosage	Metric 6: Proportion of Prescriptions to AYAs With Benzodiazepine Overlap
Age group, y						
0–11	Reference	Reference	N/A	N/A	N/A	N/A
12–21	–12.2 (–12.4 to –12.1)	–5.8 (–5.9 to –5.7)	N/A	N/A	N/A	N/A
Sex						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	–0.5 (–0.6 to –0.4)	0.0 (–0.0 to 0.1)	–0.6 (–0.8 to –0.4)	–0.8 (–1.1 to –0.6)	1.2 (1.1 to 1.4)	–0.6 (–0.7 to –0.5)
Unknown	3.4 (1.9 to 4.9)	5.8 (4.9 to 6.7)	–1.9 (–3.5 to –0.3)	22.6 (18.9 to 26.3)	1.5 (–0.3 to 3.3)	0.0 (–2.0 to 2.4)
Region						
Northeast	Reference	Reference	Reference	Reference	Reference	Reference
Midwest	8.1 (7.9 to 8.3)	0.5 (0.4 to 0.6)	–0.4 (–0.8 to –0.0)	–0.2 (–0.8 to 0.4)	–0.6 (–0.9 to –0.2)	–1.0 (–1.2 to –0.8)
South	9.8 (9.6 to 9.9)	1.2 (1.1 to 1.3)	2.8 (2.4 to 3.1)	0.5 (–0.0 to 1.1)	–0.3 (–0.6 to 0.0)	0.0 (–0.2 to 0.2)
West	10.2 (10.0 to 10.4)	1.3 (1.2 to 1.4)	–0.1 (–0.5 to 0.3)	–1.7 (–2.3 to –1.1)	0.5 (0.2 to 0.8)	–0.3 (–0.5 to –0.1)
Payer type						
Commercial	Reference	Reference	Reference	Reference	Reference	Reference
Medicaid and/ or other public coverage	4.8 (4.6 to 4.9)	–0.8 (–0.8 to –0.7)	–3.6 (–3.7 to –3.4)	–7.2 (–7.5 to –7.0)	–3.6 (–3.8 to –3.5)	–1.1 (–1.2 to –1.0)
Cash	6.8 (6.6 to 7.0)	5.4 (5.3 to 5.5)	11.6 (11.2 to 14.0)	7.5 (7.0 to 8.0)	–1.7 (–1.8 to –1.5)	–0.5 (–0.7 to –0.3)
Medicare	22.7 (22.1 to 23.2)	12.7 (12.2 to 13.1)	–1.8 (–2.4 to –1.2)	14.6 (13.5 to 15.7)	10.9 (10.1 to 11.7)	17.6 (16.8 to 18.4)

95% CIs are in parentheses. Estimates derive from logistic regression models in which covariates were sex, region, and payer type. Age group was included as a covariate in the regressions for metrics 1 and 2 only. AYA, adolescent and young adult; N/A, not applicable.

SUPPLEMENTAL TABLE 14 Dispensed opioid prescriptions from surgeons, by surgical subspecialty

Surgical Subspecialty	No. Prescriptions	Percentage of Prescriptions From Surgeons (n = 918 154)	Percentage of all Prescriptions (n = 3 943 231)
Orthopedic surgery	298 898	32.6	7.6
Otolaryngology	246 826	26.9	6.3
General surgery	144 216	15.7	3.7
Pediatric surgery	73 412	8.0	1.9
Plastic surgery	54 831	6.0	1.4
Urology	42 057	4.6	1.1
Hand surgery	32 636	3.6	0.8
Ophthalmology	8749	1.0	0.2
Neurosurgery	6767	0.7	0.2
Colorectal surgery	4814	0.5	0.1
Vascular surgery	2588	0.3	0.1
Thoracic surgery	2100	0.2	0.1
Cardiothoracic surgery	140	0.0	0.0
Transplant surgery	120	0.0	0.0
Total	918 154	100.0	100.0

SUPPLEMENTAL TABLE 15 Dispensed opioid prescriptions to young children, by specialty

Specialty	No. Prescriptions	Percentage of all Prescriptions to Young Children
Surgery	241 299	47.1
Dentist	60 476	11.8
Nurse practitioner	35 607	7.0
Emergency medicine	33 908	6.6
Physician assistant	33 057	6.5
Family medicine	25 964	5.1
General pediatrician	22 547	4.4
Internal medicine	12 865	2.5
Podiatry	9464	1.8
Hematology and/or oncology	9451	1.8
Pain medicine and anesthesiology	3583	0.7
Obstetrics and/or gynecology	3010	0.6
Physical medicine and rehabilitation	3076	0.6
Hospice and/or palliative care	595	0.1
All other prescribers	14 559	2.8
Unknown	2505	0.5
Total	511 966	100.0

SUPPLEMENTAL TABLE 16 Dispensed opioid prescriptions to adolescents and young adults, by specialty

Specialty	No. Prescriptions	Percentage of All Prescriptions to AYAs
Dentist	1 443 894	42.1
Surgery	676 855	19.7
Physician assistant	249 137	7.3
Emergency medicine	245 570	7.2
Nurse practitioner	182 536	5.3
Family medicine	168 352	4.9
Obstetrics and/or gynecology	135 879	4.0
Internal medicine	72 674	2.1
Podiatry	50 366	1.5
General pediatrician	43 829	1.3
Pain medicine and anesthesiology	39 776	1.2
Hematology/oncology	28 204	0.8
Physical medicine and rehabilitation	17 983	0.5
Hospice and/or palliative care	2004	0.1
All other prescribers	66 875	1.9
Unknown	7331	0.2
Total	3 431 265	100.0

AYA, adolescent and young adult.