APPENDIX:

Appendix Table 1: State rules and regulations and their passage or effective date.

State	State	Bill	Opioid rule passed or into effect	Legislation type
Alaska	AK	HB 159	7/25/2017	7-day duration
Alabama	AL	none	3/1/17	none
Arizona	AZ	SB 1001	1/26/18	5-day duration
Arkansas	AR	none	3/1/17	none
California	CA	none	3/1/17	none
Colorado	CO	SB 22	5/21/18	7-day duration
Connecticut	CT	HB 5053	5/30/2016	7-day duration
Delaware	DE	Division of Professional Regulation limit	4/1/2017	7-day duration
District of Columbia	DC	none	3/1/17	none
Florida	FL	HB 21	7/1/18	3-day duration

Georgia	GA	none	3/1/17	none
Hawaii	HI	SB 505	7/3/2017	7-day duration
Idaho	ID	none	3/1/17	none
Illinois	IL	none	3/1/17	none
Indiana	IN	SB 226	7/1/2017	7-day duration
Iowa	IA	HB 2377	5/14/18	No specific duration or amount
Kansas	KS	none	3/1/17	none
Kentucky	KY	HB 333	6/29/2017	3-day duration
Louisiana	LA	HB 192	8/1/2017	7-day duration
Maine	ME	SB 671	4/19/2016	100 MME per day, 7-day duration
Maryland	MD	HB 1432	5/25/2017	No specific duration or amount
Massachusetts	MA	HB 4506	3/14/2016	7-day duration
Michigan	MI	Public Acts 246-255 of 2017	12/1/2017	7-day duration

Minnesota	MN	SF 2a	5/30/2017	4-day duration
Mississippi	MS	none	3/1/17	none
Missouri	MO	Medicaid only	3/27/17	7-day duration
Montana	MT	none	3/1/17	none
Nebraska	NE	Medicaid only	10/1/16	150 tablets
Nevada	NV	AB 474	6/16/2017	90 MME per day, 14-day limit
New Hampshire	NH	HB 1423	1/1/17	7-day duration
New Jersey	NJ	SB 3	2/15/2017	5-day duration
New Mexico	NM	none	3/1/17	none
New York	NY	SB 8139	6/22/2016	7-day duration
North Carolina	NC	HB 243	1/1/18	7-day duration
North Dakota	ND	none	3/1/17	none
Ohio	OH	Ohio State Medical Board rules	8/31/2017	30 MME per day, 7-day duration
Oklahoma	OK	SB 1446	11/1/18	7-day duration

Oregon	OR	Oregon Health Authority	10/25/18	No specific duration or amount
Pennsylvania	PA	SB 1367	11/2/2016	7-day duration
Rhode Island	RI	SB 2823	6/28/2016	30 MME per day, 7-day duration
South Carolina	SC	SC DHHS	5/1/18	90 MME per day, 5-day duration
South Dakota	SD	none	3/1/17	none
Tennessee	TN	HB 1831	5/1/18	3-day duration
Texas	TX	HB 2174	9/1/19	10-day duration
Utah	UT	HB 50	3/22/2017	7-day duration
Vermont	VT	Vermont Department of Health rules	7/1/2017	24-32 MME per day
Virginia	VA	Virginia Board of Medicine regulations	3/15/2017	7-day duration
Washington	WA	HB 1427, Medicaid only	7/23/17	42 tablets
West Virginia	WV	SB 273	3/27/18	7-day duration

Wisconsin	WI	none	3/1/17	none
Wyoming	WY	none	3/1/17	none

Appendix Table 2: Baseline patient and operative characteristics. 1-month pre-operative to 1-month post-operative = 30PRE-30POST. 1-month pre-operative to 3-months post-operative = 30PRE-90POST. 3-months post-op to 1-year post-op = 90POST-365POST. 1-month pre-operative to 1-year post-operative = 30PRE-365POST.

Baseline patient and operative characteristics	**30PRE-30POST (n=75933)**	**30PRE-90POST (n=74915)**	**30PRE-365POST (n=58290)**
Age			
18 to 19	56 (0.1%)	56 (0.1%)	37 (0.1%)
20 to 24	350 (0.5%)	349 (0.5%)	227 (0.4%)
25 to 29	1083 (1.4%)	1076 (1.4%)	716 (1.2%)
30 to 34	2374 (3.1%)	2338 (3.1%)	1653 (2.8%)
35 to 39	3689 (4.9%)	3637 (4.9%)	2618 (4.5%)
40 to 44 years	4849 (6.4%)	4772 (6.4%)	3560 (6.1%)
45 to 49 years	6697 (8.8%)	6557 (8.8%)	4929 (8.5%)

50 to 54 years	9508 (12.5%)	9337 (12.5%)	7153 (12.3%)
55 to 59 years	10259 (13.5%)	10091 (13.5%)	7871 (13.5%)
60 to 64 years	9297 (12.2%)	9150 (12.2%)	7270 (12.5%)
65 to 69 years	8141 (10.7%)	8043 (10.7%)	6474 (11.1%)
70 to 74 years	11021 (14.5%)	10947 (14.6%)	9069 (15.6%)
75 to 79 years	8267 (10.9%)	8221 (11%)	6713 (11.5%)
80 to 84 years	342 (0.5%)	341 (0.5%)	n/a
Male sex	26118 (34.4%)	25802 (34.4%)	19714 (33.8%)
Obesity	20906 (27.5%)	20575 (27.5%)	15794 (27.1%)
Pre-operative opioid use			
One pre-op opioid prescription	9455 (12.5%)	9386 (12.5%)	7720 (13.2%)
Two or more pre-op opioid prescriptions	12982 (17.1%)	12131 (16.2%)	9566 (16.4%)
Charlson comorbidity index			
CCI 0	37963 (50%)	37536 (50.1%)	25866 (44.4%)
CCI 1	16097 (21.2%)	15883 (21.2%)	13533 (23.2%)
CCI 2	8033 (10.6%)	7898 (10.5%)	6888 (11.8%)

CCI 3	4897 (6.4%)	4803 (6.4%)	4239 (7.3%)
CCI 4	2644 (3.5%)	2587 (3.5%)	2327 (4%)
CCI 5 or more	4317 (5.7%)	4226 (5.6%)	3764 (6.5%)
Mean CCI (SD)	1.17 (1.82)	1.16 (1.82)	1.32 (1.89)
Year			
2010	4770 (6.3%)	4725 (6.3%)	3836 (6.6%)
2011	9548 (12.6%)	9415 (12.6%)	7725 (13.3%)
2012	9787 (12.9%)	9643 (12.9%)	8018 (13.8%)
2013	10133 (13.3%)	9953 (13.3%)	8434 (14.5%)
2014	10199 (13.4%)	10067 (13.4%)	8520 (14.6%)
2015	9822 (12.9%)	9677 (12.9%)	8269 (14.2%)
2016	9439 (12.4%)	9310 (12.4%)	7918 (13.6%)
2017	8766 (11.5%)	8654 (11.6%)	5570 (9.6%)
2018	3469 (4.6%)	3471 (4.6%)	n/a

Appendix Table 3: Unadjusted opioid filling outcomes across the study timeframes. 1-month pre-operative to 1-month post-operative = 30PRE-30POST. 1-month pre-operative to 3-months post-operative = 30PRE-90POST. 3-months post-op to 1-year post-op =

90POST-365POST. 1-month pre-operative to 1-year post-operative = 30PRE-365POST. Means calculated among patients that filled at least one opioid prescription.

Timeframe	Oxycodone 5-mg pills (first prescription)	Oxycodone 5-mg pills (cumulative)	1 or more opioid prescriptions	2 or more opioid prescriptions
30PRE-30POST	33.3	54.3	47793 (62.9%)	15773 (20.8%)
30PRE-90POST	32.6	72	48553 (64.8%)	20968 (28%)
90POST-365POST	40.3	146.6	23119 (39.7%)	13803 (23.7%)
30PRE-365POST	33.6	144.2	43000 (73.8%)	26683 (45.8%)

Appendix Table 4: 1-month pre-op to 1-month post-op adjusted estimates of the impact of the listed factors on first oxycodone prescription volume, cumulative prescribing, and odds of refill. Estimate mean or odds ratio (95% CI, p-value). Age reported as per-year impact. Reference controls for multilevel variables included CCI level of 0, no pre-operative opioid filling, year 2010, and state

of Florida. Red coloring was used to highlight differences that achieved statistical significance and also exceeded a clinical relevance thresholds.

Factor	30-day first oxycodone prescription	30-day cumulative oxycodone prescription	30-day refill	30-day opioid fills
Baseline estimate	31 (29.3, 32.8; p=<0.001)	47.1 (44.6, 49.5; p=<0.001)	0.45 (0.39, 0.52; p=<0.001)	1.94 (1.88, 2; p=<0.001)
Age	0 (0, 0; p=0.42)	-0.4 (-0.4, -0.3; p=<0.001)	0.97 (0.97, 0.97; p=<0.001)	-0.01 (-0.01, -0.01; p=<0.001)
Male sex	1.6 (1.1, 2.1; p=<0.001)	0.6 (-0.1, 1.3; p=0.1)	1 (0.96, 1.05; p=0.89)	0.02 (0, 0.03; p=0.067)
Obesity	1 (0.4, 1.5; p=<0.001)	0.7 (-0.1, 1.5; p=0.078)	1.02 (0.97, 1.07; p=0.39)	-0.02 (-0.04, 0; p=0.017)
Pre-operative opioid use				
One pre-op opioid prescriptions	4.8 (4.1, 5.5; p=<0.001)	17 (16, 18; p=<0.001)	2.64 (2.49, 2.78; p=<0.001)	0.21 (0.19, 0.23; p=<0.001)

Two or more pre-op opioid prescriptions	20.4 (19.8, 21; p=<0.001)	73 (72.1, 73.9; p=<0.001)	12.02 (11.48, 12.59; p=<0.001)	0.99 (0.97, 1.01; p=<0.001)
Ortho provider	-4.8 (-5.3, -4.3; p=<0.001)	n/a	n/a	-0.19 (-0.21, -0.17; p=<0.001)
Charlson comorbidity index				
CCI 0	n/a	n/a	n/a	n/a
CCI 1	0.9 (0.3, 1.5; p=0.006)	1.3 (0.4, 2.2; p=0.004)	1.09 (1.03, 1.15; p=0.001)	0.04 (0.02, 0.06; p=<0.001)
CCI 2	1.4 (0.5, 2.2; p=0.001)	1.6 (0.4, 2.8; p=0.008)	1 (0.93, 1.07; p=0.96)	0.04 (0.01, 0.07; p=0.008)
CCI 3	2.2 (1.2, 3.3; p=<0.001)	2.2 (0.7, 3.6; p=0.003)	1.1 (1.01, 1.19; p=0.032)	0.04 (0.01, 0.08; p=0.021)
CCI 4	2.9 (1.5, 4.3; p=<0.001)	1.9 (0, 3.8; p=0.051)	1.14 (1.02, 1.27; p=0.024)	0.07 (0.02, 0.11; p=0.005)
CCI 5 or more	2.5 (1.4, 3.6; p=<0.001)	2.2 (0.6, 3.7; p=0.006)	1.1 (1, 1.2; p=0.05)	0.06 (0.02, 0.1; p=0.001)

Year				
2010	n/a	n/a	n/a	n/a
2011	-0.6 (-1.8, 0.7; p=0.37)	-2.3 (-4, -0.7; p=0.006)	1.29 (1.17, 1.43; p=<0.001)	0.03 (-0.01, 0.07; p=0.188)
2012	-1.2 (-2.4, 0.1; p=0.063)	-1.7 (-3.4, -0.1; p=0.042)	1.35 (1.22, 1.5; p=<0.001)	0.04 (0, 0.08; p=0.055)
2013	-1 (-2.3, 0.2; p=0.112)	-0.9 (-2.5, 0.8; p=0.3)	1.43 (1.3, 1.59; p=<0.001)	0.02 (-0.02, 0.06; p=0.36)
2014	-1.5 (-2.7, -0.2; p=0.022)	-2.6 (-4.2, -0.9; p=0.002)	1.29 (1.17, 1.43; p=<0.001)	-0.01 (-0.05, 0.03; p=0.66)
2015	-0.6 (-1.9, 0.6; p=0.34)	-2 (-3.7, -0.4; p=0.017)	1.22 (1.1, 1.36; p=<0.001)	-0.04 (-0.08, 0.01; p=0.091)
2016	-1.5 (-2.7, -0.2; p=0.023)	-2.2 (-3.9, -0.6; p=0.009)	1.27 (1.14, 1.41; p=<0.001)	-0.04 (-0.08, 0; p=0.053)
2017	-4 (-5.3, -2.7; p=<0.001)	-5 (-6.7, -3.3; p=<0.001)	1.16 (1.04, 1.29; p=0.008)	-0.07 (-0.11, -0.02; p=0.002)

2018	-5.9 (-7.5, -4.4; p=<0.001)	-9.1 (-11.2, -6.9; p=<0.001)	0.94 (0.82, 1.08; p=0.41)	-0.11 (-0.17, -0.06; p=<0.001)
State				
AK	-3 (-9.2, 3.2; p=0.34)	-6 (-14.5, 2.4; p=0.163)	0.91 (0.56, 1.48; p=0.71)	-0.06 (-0.27, 0.15; p=0.58)
AL	-1.4 (-3.7, 1; p=0.25)	-0.9 (-4.3, 2.5; p=0.61)	1.24 (1.02, 1.5; p=0.031)	0.12 (0.05, 0.2; p=0.002)
AR	1.5 (-1.2, 4.3; p=0.27)	1.4 (-2.5, 5.4; p=0.48)	1.25 (1, 1.57; p=0.047)	0.13 (0.03, 0.22; p=0.007)
AZ	-3.3 (-5.1, -1.5; p=<0.001)	-0.6 (-3.2, 2; p=0.66)	1.09 (0.93, 1.27; p=0.28)	0.01 (-0.05, 0.07; p=0.71)
CA	0.4 (-1.3, 2; p=0.67)	-1.3 (-3.5, 1; p=0.29)	1.06 (0.92, 1.21; p=0.43)	0.02 (-0.03, 0.08; p=0.42)
CO	-3.4 (-6, -0.8; p=0.012)	-4.3 (-8.1, -0.6; p=0.023)	0.97 (0.78, 1.22; p=0.81)	0.04 (-0.05, 0.13; p=0.37)

CT	-5.6 (-7.8, -3.4; p=<0.001)	-6.9 (-10.1, -3.7; p=<0.001)	1.06 (0.87, 1.28; p=0.59)	0.06 (-0.02, 0.13; p=0.15)
DC	-6.1 (-13.1, 0.9; p=0.089)	-5 (-15.3, 5.4; p=0.35)	1.06 (0.56, 2; p=0.87)	0.03 (-0.2, 0.27; p=0.79)
DE	-1 (-4.4, 2.3; p=0.55)	1.1 (-3.9, 6.1; p=0.67)	1.16 (0.87, 1.55; p=0.3)	0 (-0.11, 0.11; p=0.99)
FL	n/a	n/a	n/a	n/a
GA	2.2 (0.6, 3.8; p=0.007)	2.7 (0.4, 5.1; p=0.022)	1.12 (0.98, 1.28; p=0.11)	0.08 (0.03, 0.13; p=0.004)
HI	-7 (-13.7, -0.3; p=0.039)	-6.1 (-15.4, 3.2; p=0.196)	1.07 (0.59, 1.93; p=0.83)	0.1 (-0.12, 0.33; p=0.36)
IA	-5.4 (-7.6, -3.3; p=<0.001)	-5.3 (-8.3, -2.2; p=<0.001)	1.17 (0.98, 1.4; p=0.079)	0.12 (0.05, 0.19; p=0.001)
ID	1.5 (-3.3, 6.3; p=0.54)	6.2 (-0.6, 13.1; p=0.076)	1.21 (0.82, 1.8; p=0.34)	0.2 (0.04, 0.36; p=0.014)

IL	-3.5 (-5.1, -2; p=<0.001)	-3.8 (-6, -1.6; p=<0.001)	1.03 (0.91, 1.18; p=0.61)	0.04 (-0.01, 0.09; p=0.131)
IN	-0.3 (-1.8, 1.2; p=0.7)	3.3 (1.1, 5.6; p=0.004)	1.32 (1.16, 1.5; p=<0.001)	0.14 (0.09, 0.19; p=<0.001)
KS	-3.8 (-6.6, -1; p=0.008)	-5.8 (-9.8, -1.9; p=0.004)	0.98 (0.77, 1.24; p=0.84)	-0.02 (-0.11, 0.07; p=0.66)
KY	0 (-1.9, 1.8; p=1)	0 (-2.7, 2.7; p=0.98)	1.11 (0.95, 1.3; p=0.175)	0.06 (0, 0.13; p=0.047)
LA	6.7 (4.8, 8.6; p=<0.001)	8.4 (5.5, 11.2; p=<0.001)	1.37 (1.17, 1.61; p=<0.001)	0.15 (0.08, 0.21; p=<0.001)
MA	-8.4 (-10.4, -6.5; p=<0.001)	-8.4 (-11.1, -5.6; p=<0.001)	1.01 (0.85, 1.19; p=0.92)	0.06 (-0.01, 0.12; p=0.083)
MD	-3.8 (-5.5, -2; p=<0.001)	-8.2 (-10.6, -5.8; p=<0.001)	0.83 (0.71, 0.96; p=0.011)	0.01 (-0.05, 0.07; p=0.73)
ME	-5.8 (-9, -2.6; p=<0.001)	-8.3 (-12.4, -4.3; p=<0.001)	0.8 (0.61, 1.04; p=0.098)	0.09 (-0.02, 0.19; p=0.119)

MI	-2.1 (-3.5, -0.8; p=0.002)	-2.1 (-4, -0.1; p=0.039)	0.97 (0.86, 1.09; p=0.6)	0.02 (-0.02, 0.07; p=0.31)
MN	-6.2 (-8.5, -3.8; p=<0.001)	-10.3 (-13.4, -7.2; p=<0.001)	0.83 (0.69, 1.01; p=0.06)	0.09 (0.01, 0.17; p=0.024)
MO	-1 (-3, 1; p=0.32)	-4.1 (-6.9, -1.3; p=0.004)	0.92 (0.78, 1.1; p=0.37)	0.03 (-0.03, 0.1; p=0.34)
MS	4 (0.8, 7.2; p=0.013)	1.3 (-3.2, 5.9; p=0.57)	1.12 (0.87, 1.44; p=0.38)	0.02 (-0.09, 0.12; p=0.76)
MT	-3.6 (-9.7, 2.5; p=0.24)	-9.6 (-17.5, -1.7; p=0.018)	0.87 (0.53, 1.44; p=0.6)	0.21 (0, 0.41; p=0.045)
NC	0.8 (-0.9, 2.5; p=0.35)	1.1 (-1.3, 3.5; p=0.35)	1.01 (0.87, 1.16; p=0.94)	0.06 (0, 0.11; p=0.056)
ND	-6.7 (-12, -1.5; p=0.011)	-11.3 (-18.4, -4.2; p=0.002)	0.79 (0.5, 1.25; p=0.32)	0.06 (-0.11, 0.24; p=0.47)
NE	-5 (-7.8, -2.1; p=<0.001)	-4.8 (-8.8, -0.8; p=0.018)	1.19 (0.94, 1.5; p=0.155)	0.17 (0.07, 0.27; p=<0.001)

NH	-7.7 (-11.7, -3.6; p=<0.001)	-4.6 (-10.4, 1.2; p=0.117)	0.94 (0.66, 1.35; p=0.75)	-0.07 (-0.21, 0.06; p=0.3)
NJ	-3.9 (-5.5, -2.3; p=<0.001)	-6.9 (-9.1, -4.6; p=<0.001)	0.85 (0.74, 0.98; p=0.027)	-0.03 (-0.09, 0.02; p=0.23)
NM	-4.7 (-8.4, -0.9; p=0.015)	-7.8 (-13, -2.6; p=0.004)	0.96 (0.7, 1.32; p=0.81)	0.02 (-0.11, 0.14; p=0.79)
NV	3 (0.4, 5.6; p=0.025)	1.4 (-2.5, 5.2; p=0.49)	1.02 (0.81, 1.28; p=0.87)	-0.05 (-0.14, 0.04; p=0.25)
NY	-2.9 (-4.2, -1.6; p=<0.001)	-7 (-8.8, -5.1; p=<0.001)	0.75 (0.67, 0.84; p=<0.001)	-0.08 (-0.12, -0.04; p=<0.001)
OH	-3.6 (-4.7, -2.5; p=<0.001)	-2.9 (-4.5, -1.2; p=<0.001)	1.18 (1.07, 1.3; p=<0.001)	0.09 (0.06, 0.13; p=<0.001)
OK	7.3 (5.2, 9.4; p=<0.001)	3.5 (0.6, 6.4; p=0.019)	1.08 (0.91, 1.28; p=0.36)	0.06 (-0.01, 0.13; p=0.122)
OR	-1.4 (-3.6, 0.7; p=0.19)	-5.8 (-8.6, -2.9; p=<0.001)	0.96 (0.81, 1.14; p=0.66)	0.07 (0, 0.14; p=0.068)

PA	-5.1 (-6.4, -3.8; p=<0.001)	-7.5 (-9.4, -5.7; p=<0.001)	0.95 (0.85, 1.06; p=0.38)	0.05 (0.01, 0.1; p=0.02)
RI	-5.3 (-8.9, -1.8; p=0.003)	0 (-5.4, 5.4; p=0.99)	1.67 (1.24, 2.24; p=<0.001)	0.15 (0.03, 0.27; p=0.014)
SC	2.4 (0.4, 4.3; p=0.017)	2 (-0.9, 4.8; p=0.18)	1.22 (1.04, 1.44; p=0.015)	0.09 (0.02, 0.15; p=0.011)
SD	-6.7 (-10.7, -2.7; p=0.001)	-7.9 (-13.5, -2.3; p=0.006)	0.95 (0.66, 1.36; p=0.78)	0.13 (-0.01, 0.26; p=0.062)
TN	1.3 (-0.4, 3.1; p=0.134)	1.3 (-1.3, 3.9; p=0.32)	1.23 (1.07, 1.43; p=0.005)	0.06 (0, 0.12; p=0.056)
TX	3.1 (1.7, 4.5; p=<0.001)	-0.1 (-2.1, 1.8; p=0.9)	1.04 (0.92, 1.17; p=0.52)	0.05 (0, 0.09; p=0.05)
UT	-0.5 (-4, 3.1; p=0.8)	-1.4 (-6.2, 3.4; p=0.57)	0.95 (0.72, 1.26; p=0.74)	0.14 (0.02, 0.25; p=0.023)
VA	-2.1 (-3.9, -0.3; p=0.02)	-1.4 (-3.9, 1.2; p=0.3)	1.07 (0.92, 1.24; p=0.41)	0.07 (0.01, 0.13; p=0.031)

VT	-8.2 (-16.1, -0.3; p=0.042)	-2.9 (-13.1, 7.3; p=0.57)	1.25 (0.68, 2.29; p=0.47)	0.29 (0.02, 0.56; p=0.032)
WA	-4.2 (-6.2, -2.2; p=<0.001)	-4.7 (-7.5, -1.8; p=0.001)	1.21 (1.03, 1.43; p=0.021)	0.09 (0.02, 0.16; p=0.008)
WI	-4.9 (-6.7, -3.1; p=<0.001)	-7.2 (-9.6, -4.8; p=<0.001)	0.95 (0.82, 1.11; p=0.53)	0.05 (-0.01, 0.11; p=0.123)
WV	-0.3 (-2.8, 2.2; p=0.82)	-2.6 (-6.1, 0.9; p=0.149)	1.15 (0.94, 1.41; p=0.171)	0.08 (-0.01, 0.16; p=0.077)
WY	-2.7 (-9.4, 4; p=0.43)	-6.7 (-15.3, 1.9; p=0.126)	1 (0.59, 1.69; p=1)	0.07 (-0.16, 0.29; p=0.56)

Appendix Table 5: 1-month pre-op to 3-month post-op adjusted estimates of the impact of the listed factors on first oxycodone prescription volume, cumulative prescribing, and odds of refill. Estimate mean or odds ratio (95% CI, p-value). Age reported as per-year impact. Reference controls for multilevel variables included CCI level of 0, no pre-operative opioid filling, year 2010, and state of Florida. Red coloring was used to highlight differences that achieved statistical significance and also exceeded a clinical relevance thresholds.

Factor	90-day first oxycodone prescription	90-day cumulative oxycodone prescription	90-day refill	90-day opioid fills
Baseline estimate	31.8 (30.1, 33.6; p=<0.001)	60.5 (56.9, 64.2; p=<0.001)	0.71 (0.62, 0.81; p=<0.001)	2.51 (2.42, 2.61; p=<0.001)
Age	0 (0, 0; p=0.23)	-0.4 (-0.5, -0.4; p=<0.001)	0.97 (0.97, 0.98; p=<0.001)	-0.02 (-0.02, -0.02; p=<0.001)
Male sex	1.6 (1.1, 2.1; p=<0.001)	0.4 (-0.7, 1.5; p=0.51)	1 (0.96, 1.04; p=0.94)	0.03 (0, 0.05; p=0.071)
Obesity	0.8 (0.3, 1.4; p=0.004)	1.9 (0.7, 3.1; p=0.002)	1.08 (1.04, 1.13; p=<0.001)	0.01 (-0.03, 0.04; p=0.73)
Pre-operative opioid use				
One pre-op opioid prescriptions	4.7 (4, 5.4; p=<0.001)	25.7 (24.1, 27.2; p=<0.001)	2.68 (2.55, 2.81; p=<0.001)	0.37 (0.33, 0.41; p=<0.001)
Two or more pre-op opioid prescriptions	16.9 (16.3, 17.5; p=<0.001)	115.3 (113.9, 116.7; p=<0.001)	11.98 (11.43, 12.56; p=<0.001)	1.87 (1.84, 1.91; p=<0.001)

Ortho provider	-4.4 (-4.9, -3.9; p=<0.001)	n/a	n/a	-0.27 (-0.29, -0.24; p=<0.001)
Charlson comorbidity index				
CCI 0	n/a	n/a	n/a	n/a
CCI 1	1.2 (0.6, 1.9; p=<0.001)	3.5 (2.1, 4.8; p=<0.001)	1.1 (1.05, 1.16; p=<0.001)	0.09 (0.05, 0.12; p=<0.001)
CCI 2	1.9 (1, 2.7; p=<0.001)	4 (2.3, 5.8; p=<0.001)	1.07 (1, 1.14; p=0.041)	0.08 (0.04, 0.13; p=<0.001)
CCI 3	2.7 (1.7, 3.8; p=<0.001)	5.5 (3.4, 7.7; p=<0.001)	1.14 (1.05, 1.23; p=<0.001)	0.11 (0.05, 0.17; p=<0.001)
CCI 4	2.4 (1, 3.8; p=<0.001)	4.8 (2, 7.7; p=<0.001)	1.22 (1.1, 1.35; p=<0.001)	0.13 (0.05, 0.2; p=<0.001)
CCI 5 or more	1.9 (0.7, 3; p=0.001)	5.4 (3.1, 7.7; p=<0.001)	1.18 (1.08, 1.28; p=<0.001)	0.14 (0.08, 0.2; p=<0.001)
Year				
2010	n/a	n/a	n/a	n/a

2011	-1.2 (-2.4, 0.1; p=0.061)	-4.2 (-6.7, -1.7; p=<0.001)	1.28 (1.17, 1.4; p=<0.001)	0.02 (-0.04, 0.09; p=0.5)
2012	-2.1 (-3.3, -0.8; p=0.001)	-4.3 (-6.8, -1.8; p=<0.001)	1.3 (1.19, 1.43; p=<0.001)	0.01 (-0.06, 0.08; p=0.78)
2013	-2.3 (-3.5, -1.1; p=<0.001)	-4.4 (-6.9, -1.9; p=<0.001)	1.37 (1.25, 1.5; p=<0.001)	-0.01 (-0.08, 0.05; p=0.71)
2014	-2.3 (-3.5, -1; p=<0.001)	-4.9 (-7.4, -2.5; p=<0.001)	1.29 (1.17, 1.41; p=<0.001)	-0.06 (-0.12, 0.01; p=0.11)
2015	-1.5 (-2.7, -0.2; p=0.023)	-4.8 (-7.3, -2.3; p=<0.001)	1.26 (1.15, 1.38; p=<0.001)	-0.06 (-0.13, 0; p=0.064)
2016	-2.5 (-3.8, -1.3; p=<0.001)	-5.4 (-8, -2.9; p=<0.001)	1.27 (1.16, 1.4; p=<0.001)	-0.09 (-0.16, -0.03; p=0.007)
2017	-5.2 (-6.5, -4; p=<0.001)	-8.9 (-11.5, -6.3; p=<0.001)	1.19 (1.09, 1.31; p=<0.001)	-0.12 (-0.19, -0.05; p=0.001)
2018	-6.3 (-7.9, -4.8; p=<0.001)	-16.4 (-19.6, -13.2; p=<0.001)	0.83 (0.73, 0.93; p=0.002)	-0.34 (-0.42, -0.25; p=<0.001)

State				
AK	-1.8 (-8, 4.3; p=0.56)	-6.9 (-19.8, 6; p=0.3)	0.71 (0.44, 1.15; p=0.165)	-0.08 (-0.42, 0.25; p=0.63)
AL	-0.4 (-2.8, 1.9; p=0.72)	2.1 (-3, 7.2; p=0.42)	1.23 (1.03, 1.47; p=0.021)	0.26 (0.14, 0.39; p=<0.001)
AR	1.8 (-0.9, 4.6; p=0.189)	3.2 (-2.7, 9.2; p=0.28)	1.3 (1.07, 1.6; p=0.01)	0.19 (0.05, 0.34; p=0.011)
AZ	-3.8 (-5.6, -2; p=<0.001)	0.2 (-3.7, 4.2; p=0.91)	1.16 (1.01, 1.33; p=0.04)	0.04 (-0.06, 0.14; p=0.4)
CA	0.3 (-1.3, 2; p=0.69)	-1.9 (-5.3, 1.6; p=0.29)	1.01 (0.89, 1.14; p=0.89)	0.08 (-0.01, 0.17; p=0.074)
CO	-4.6 (-7.2, -2; p=<0.001)	-9.1 (-14.8, -3.5; p=0.001)	0.83 (0.68, 1.02; p=0.076)	0.03 (-0.11, 0.18; p=0.66)
CT	-5.3 (-7.6, -3.1; p=<0.001)	-13.5 (-18.3, -8.6; p=<0.001)	0.92 (0.77, 1.1; p=0.34)	-0.04 (-0.16, 0.09; p=0.56)

DC	-4.6 (-11.7, 2.4; p=0.196)	-10.9 (-26.5, 4.6; p=0.168)	0.87 (0.49, 1.55; p=0.63)	0 (-0.39, 0.38; p=0.98)
DE	-1 (-4.4, 2.3; p=0.54)	3.2 (-4.3, 10.6; p=0.4)	1.08 (0.83, 1.4; p=0.57)	-0.08 (-0.26, 0.1; p=0.4)
FL	n/a	n/a	n/a	n/a
GA	1.8 (0.2, 3.4; p=0.027)	1.1 (-2.5, 4.6; p=0.55)	1.14 (1.01, 1.29; p=0.034)	0.1 (0.02, 0.19; p=0.02)
HI	-6.9 (-13.5, -0.2; p=0.042)	-11.6 (-25.5, 2.4; p=0.103)	0.72 (0.41, 1.27; p=0.25)	0.06 (-0.31, 0.42; p=0.76)
IA	-5.6 (-7.8, -3.4; p=<0.001)	-8.5 (-13.1, -4; p=<0.001)	0.98 (0.84, 1.16; p=0.85)	0.12 (0, 0.24; p=0.042)
ID	5.8 (1, 10.6; p=0.017)	6.8 (-3.5, 17; p=0.196)	1.01 (0.71, 1.46; p=0.94)	0.18 (-0.09, 0.44; p=0.188)
IL	-4.3 (-5.8, -2.8; p=<0.001)	-5.5 (-8.8, -2.2; p=0.001)	1 (0.89, 1.12; p=0.98)	0.05 (-0.03, 0.13; p=0.24)

IN	-0.3 (-1.8, 1.3; p=0.74)	4.6 (1.2, 8; p=0.008)	1.29 (1.14, 1.45; p=<0.001)	0.24 (0.16, 0.32; p=<0.001)
KS	-3.7 (-6.5, -0.9; p=0.009)	-10.7 (-16.7, -4.7; p=<0.001)	0.95 (0.77, 1.18; p=0.65)	-0.1 (-0.25, 0.05; p=0.21)
KY	-0.2 (-2.1, 1.6; p=0.82)	0.8 (-3.3, 4.8; p=0.71)	1.07 (0.93, 1.23; p=0.34)	0.12 (0.02, 0.22; p=0.02)
LA	6.2 (4.2, 8.1; p=<0.001)	8.6 (4.3, 12.9; p=<0.001)	1.32 (1.14, 1.53; p=<0.001)	0.2 (0.1, 0.31; p=<0.001)
MA	-8.9 (-10.8, -7; p=<0.001)	-12.2 (-16.3, -8; p=<0.001)	0.85 (0.73, 0.99; p=0.039)	0.06 (-0.04, 0.17; p=0.24)
MD	-3.1 (-4.8, -1.4; p=<0.001)	-13 (-16.6, -9.4; p=<0.001)	0.74 (0.65, 0.85; p=<0.001)	-0.05 (-0.14, 0.05; p=0.31)
ME	-7.9 (-11.1, -4.6; p=<0.001)	-14.4 (-20.5, -8.3; p=<0.001)	0.63 (0.49, 0.8; p=<0.001)	0.07 (-0.11, 0.25; p=0.44)
MI	-2.3 (-3.6, -0.9; p=0.001)	-0.9 (-3.8, 2.1; p=0.55)	1.01 (0.91, 1.12; p=0.92)	0.06 (-0.01, 0.14; p=0.107)

MN	-6.3 (-8.6, -3.9; p=<0.001)	-14.4 (-19.1, -9.8; p=<0.001)	0.73 (0.61, 0.87; p=<0.001)	0.13 (0, 0.26; p=0.052)
MO	-0.4 (-2.3, 1.6; p=0.72)	-4.6 (-8.8, -0.4; p=0.03)	0.85 (0.73, 0.98; p=0.031)	0 (-0.11, 0.11; p=0.98)
MS	4.6 (1.4, 7.8; p=0.005)	1.6 (-5.2, 8.5; p=0.64)	1.02 (0.8, 1.29; p=0.88)	0.02 (-0.15, 0.2; p=0.8)
MT	-4.1 (-10.2, 2; p=0.188)	-13.3 (-25.1, -1.4; p=0.028)	0.93 (0.6, 1.44; p=0.75)	0.42 (0.09, 0.75; p=0.012)
NC	0.8 (-0.9, 2.5; p=0.33)	-0.8 (-4.4, 2.8; p=0.68)	0.94 (0.83, 1.07; p=0.36)	0.03 (-0.06, 0.13; p=0.48)
ND	-6 (-11.2, -0.8; p=0.024)	-15 (-25.6, -4.4; p=0.005)	0.85 (0.57, 1.25; p=0.41)	0.15 (-0.14, 0.43; p=0.31)
NE	-4.3 (-7.1, -1.4; p=0.003)	-6.2 (-12.2, -0.3; p=0.041)	1.06 (0.85, 1.31; p=0.62)	0.31 (0.15, 0.47; p=<0.001)
NH	-7.3 (-11.4, -3.3; p=<0.001)	-5.3 (-13.9, 3.4; p=0.24)	0.86 (0.62, 1.18; p=0.35)	-0.11 (-0.33, 0.11; p=0.33)

NJ	-4.2 (-5.9, -2.6; p=<0.001)	-12 (-15.4, -8.6; p=<0.001)	0.76 (0.67, 0.87; p=<0.001)	-0.12 (-0.21, -0.03; p=0.01)
NM	-4.2 (-8, -0.5; p=0.028)	-10 (-17.8, -2.1; p=0.013)	0.87 (0.65, 1.15; p=0.32)	0.05 (-0.16, 0.25; p=0.64)
NV	3.6 (1, 6.2; p=0.007)	4.8 (-1, 10.6; p=0.102)	1.1 (0.9, 1.35; p=0.35)	-0.05 (-0.19, 0.09; p=0.49)
NY	-3.4 (-4.8, -2.1; p=<0.001)	-10.8 (-13.6, -8; p=<0.001)	0.69 (0.62, 0.77; p=<0.001)	-0.14 (-0.22, -0.07; p=<0.001)
OH	-3.6 (-4.7, -2.4; p=<0.001)	-4 (-6.4, -1.5; p=0.002)	1.07 (0.98, 1.17; p=0.122)	0.12 (0.06, 0.18; p=<0.001)
OK	8.5 (6.5, 10.6; p=<0.001)	4.9 (0.5, 9.3; p=0.028)	0.98 (0.84, 1.15; p=0.82)	0.07 (-0.05, 0.18; p=0.26)
OR	0.1 (-2, 2.2; p=0.94)	-6.1 (-10.4, -1.8; p=0.005)	0.94 (0.8, 1.09; p=0.41)	0.1 (-0.02, 0.22; p=0.091)
PA	-4.9 (-6.2, -3.5; p=<0.001)	-10.7 (-13.5, -8; p=<0.001)	0.82 (0.74, 0.91; p=<0.001)	0.01 (-0.06, 0.08; p=0.79)

RI	-5.4 (-9, -1.8; p=0.003)	-2.9 (-11, 5.2; p=0.48)	1.35 (1.02, 1.78; p=0.033)	0.18 (-0.02, 0.38; p=0.074)
SC	2.4 (0.5, 4.4; p=0.016)	2.4 (-1.9, 6.7; p=0.27)	1.11 (0.96, 1.29; p=0.155)	0.14 (0.03, 0.25; p=0.01)
SD	-6.9 (-10.9, -2.8; p=<0.001)	-10.2 (-18.6, -1.8; p=0.017)	0.86 (0.63, 1.18; p=0.36)	0.13 (-0.09, 0.35; p=0.25)
TN	1.8 (0, 3.6; p=0.047)	1.9 (-2.1, 5.8; p=0.35)	1.19 (1.04, 1.36; p=0.012)	0.08 (-0.02, 0.17; p=0.119)
TX	3.3 (1.9, 4.7; p=<0.001)	-0.2 (-3.1, 2.8; p=0.91)	0.99 (0.89, 1.1; p=0.84)	0.05 (-0.03, 0.12; p=0.21)
UT	1.8 (-1.6, 5.3; p=0.3)	-1.2 (-8.4, 6.1; p=0.75)	0.78 (0.6, 1.02; p=0.067)	0.09 (-0.1, 0.28; p=0.34)
VA	-1.9 (-3.7, -0.1; p=0.037)	-2.9 (-6.8, 1; p=0.143)	0.97 (0.84, 1.11; p=0.64)	0.1 (0, 0.19; p=0.057)
VT	-8 (-16.1, 0.1; p=0.054)	-10.6 (-25.9, 4.8; p=0.179)	1.03 (0.59, 1.79; p=0.93)	0.31 (-0.13, 0.75; p=0.167)

WA	-4.7 (-6.7, -2.7; p=<0.001)	-4.8 (-9.1, -0.5; p=0.027)	1.19 (1.03, 1.39; p=0.02)	0.2 (0.09, 0.31; p=<0.001)
WI	-5.5 (-7.2, -3.7; p=<0.001)	-12.6 (-16.2, -9; p=<0.001)	0.8 (0.7, 0.91; p=0.001)	-0.01 (-0.11, 0.09; p=0.83)
WV	-1.2 (-3.7, 1.3; p=0.35)	-4.3 (-9.5, 1; p=0.114)	0.99 (0.82, 1.19; p=0.9)	0.13 (-0.01, 0.26; p=0.071)
WY	-1 (-7.5, 5.5; p=0.75)	-8.4 (-21.2, 4.4; p=0.2)	0.9 (0.57, 1.44; p=0.67)	0.09 (-0.27, 0.44; p=0.63)

Appendix Table 6: 3-month post-op to 1-year post-op adjusted estimates of the impact of the listed factors on first oxycodone prescription volume, cumulative prescribing, and odds of refill. Estimate mean or odds ratio (95% CI, p-value). Age reported as per-year impact. Reference controls for multilevel variables included CCI level of 0, no pre-operative opioid filling, year 2010, and state of Florida. Red coloring was used to highlight differences that achieved statistical significance and also exceeded a clinical relevance thresholds.

Factor	3-month to 1-year first oxycodone prescription	3-month to 1-year cumulative oxycodone prescription	3-month to 1-year refill	3-month to 1-year opioid fills

Baseline estimate	18.9 (15, 22.8; p=<0.001)	52.3 (44.4, 60.1; p=<0.001)	0.44 (0.38, 0.51; p=<0.001)	3.87 (3.59, 4.15; p=<0.001)
Age	0.3 (0.3, 0.3; p=<0.001)	-0.2 (-0.3, -0.1; p=<0.001)	0.99 (0.98, 0.99; p=<0.001)	-0.02 (-0.03, -0.02; p=<0.001)
Male sex	2.9 (1.7, 4.1; p=<0.001)	-3.2 (-5.6, -0.9; p=0.006)	0.91 (0.87, 0.95; p=<0.001)	0.01 (-0.07, 0.1; p=0.78)
Obesity	0.4 (-0.9, 1.7; p=0.54)	5 (2.4, 7.6; p=<0.001)	1.1 (1.05, 1.16; p=<0.001)	-0.09 (-0.18, 0; p=0.056)
Pre-operative opioid use				
One pre-op opioid prescriptions	6.7 (5.2, 8.3; p=<0.001)	39 (35.7, 42.2; p=<0.001)	2.8 (2.64, 2.96; p=<0.001)	0.55 (0.45, 0.66; p=<0.001)
Two or more pre-op opioid prescriptions	14.1 (12.8, 15.3; p=<0.001)	162.8 (159.9, 165.8; p=<0.001)	10.63 (10.1, 11.19; p=<0.001)	2.93 (2.84, 3.02; p=<0.001)
Ortho provider	n/a	n/a	n/a	n/a
Charlson comorbidity index				
CCI 0	n/a	n/a	n/a	n/a

CCI 1	2.2 (0.8, 3.6; p=0.002)	7.1 (4.3, 9.9; p=<0.001)	1.13 (1.07, 1.19; p=<0.001)	0.1 (0, 0.2; p=0.061)
CCI 2	2.3 (0.5, 4.1; p=0.012)	8.8 (5.2, 12.4; p=<0.001)	1.23 (1.15, 1.32; p=<0.001)	0.12 (-0.01, 0.24; p=0.071)
CCI 3	3 (0.9, 5.2; p=0.006)	14.2 (9.9, 18.6; p=<0.001)	1.26 (1.16, 1.38; p=<0.001)	0.12 (-0.04, 0.27; p=0.137)
CCI 4	2 (-0.8, 4.8; p=0.156)	15 (9.3, 20.7; p=<0.001)	1.39 (1.24, 1.55; p=<0.001)	0.29 (0.09, 0.49; p=0.004)
CCI 5 or more	3.2 (0.9, 5.4; p=0.007)	19.1 (14.4, 23.8; p=<0.001)	1.41 (1.29, 1.54; p=<0.001)	0.25 (0.09, 0.41; p=0.003)
Year				
2010	n/a	n/a	n/a	n/a
2011	0.4 (-2.2, 3.1; p=0.74)	-7 (-12.2, -1.8; p=0.008)	0.92 (0.84, 1.02; p=0.127)	-0.17 (-0.36, 0.02; p=0.074)
2012	0.2 (-2.4, 2.8; p=0.87)	-10.1 (-15.3, -5; p=<0.001)	0.86 (0.78, 0.95; p=0.003)	-0.3 (-0.48, -0.11; p=0.002)

2013	-1.5 (-4.1, 1.1; p=0.25)	-10.8 (-16, -5.7; p=<0.001)	0.88 (0.79, 0.97; p=0.01)	-0.3 (-0.49, -0.12; p=0.001)
2014	0.1 (-2.5, 2.7; p=0.94)	-14.3 (-19.4, -9.1; p=<0.001)	0.78 (0.71, 0.87; p=<0.001)	-0.45 (-0.63, -0.26; p=<0.001)
2015	-1.1 (-3.7, 1.6; p=0.43)	-13.7 (-18.8, -8.5; p=<0.001)	0.8 (0.72, 0.88; p=<0.001)	-0.25 (-0.43, -0.06; p=0.01)
2016	-2.7 (-5.3, 0; p=0.046)	-15.4 (-20.6, -10.1; p=<0.001)	0.78 (0.7, 0.86; p=<0.001)	-0.37 (-0.56, -0.18; p=<0.001)
2017	-3.3 (-6.2, -0.4; p=0.023)	-22 (-27.6, -16.4; p=<0.001)	0.68 (0.61, 0.77; p=<0.001)	-0.49 (-0.7, -0.28; p=<0.001)
2018	n/a	n/a	n/a	n/a
State				
AK	26 (12.6, 39.5; p=<0.001)	3.6 (-24.2, 31.4; p=0.8)	1.04 (0.61, 1.78; p=0.87)	-0.81 (-1.77, 0.14; p=0.095)
AL	-2.9 (-7.9, 2.1; p=0.26)	14.5 (3.7, 25.4; p=0.009)	1.52 (1.25, 1.86; p=<0.001)	0.68 (0.32, 1.04; p=<0.001)

AR	4.2 (-1.9, 10.3; p=0.174)	16.2 (3.5, 28.9; p=0.012)	1.2 (0.95, 1.53; p=0.13)	0.18 (-0.25, 0.62; p=0.4)
AZ	-2.2 (-6.2, 1.8; p=0.29)	5 (-3.6, 13.5; p=0.25)	1.13 (0.96, 1.33; p=0.13)	-0.06 (-0.35, 0.23; p=0.68)
CA	1.9 (-1.7, 5.5; p=0.3)	11 (3.6, 18.4; p=0.004)	1.12 (0.97, 1.29; p=0.124)	0.16 (-0.09, 0.42; p=0.21)
CO	-0.1 (-6.1, 6; p=0.98)	-2.5 (-14.6, 9.6; p=0.69)	0.85 (0.67, 1.09; p=0.196)	0.02 (-0.42, 0.45; p=0.94)
CT	-4.6 (-10, 0.7; p=0.091)	-14.4 (-24.5, -4.3; p=0.005)	0.82 (0.66, 1; p=0.056)	0.47 (0.09, 0.85; p=0.016)
DC	-10.2 (-28, 7.5; p=0.26)	-19.5 (-53.4, 14.3; p=0.26)	0.8 (0.39, 1.63; p=0.53)	0.06 (-1.21, 1.32; p=0.93)
DE	1.7 (-6.1, 9.5; p=0.67)	-3.2 (-19.1, 12.7; p=0.69)	0.92 (0.67, 1.25; p=0.58)	-0.14 (-0.69, 0.42; p=0.63)
FL	n/a	n/a	n/a	n/a

GA	-0.6 (-4.1, 3; p=0.76)	5.5 (-1.9, 13; p=0.146)	1.27 (1.1, 1.46; p=<0.001)	0.19 (-0.06, 0.44; p=0.14)
HI	5.8 (-9.2, 20.8; p=0.45)	-15.4 (-44.2, 13.4; p=0.29)	0.69 (0.36, 1.32; p=0.26)	-0.63 (-1.7, 0.44; p=0.25)
IA	-1.8 (-6.8, 3.2; p=0.48)	-4.9 (-14.7, 5; p=0.33)	0.99 (0.82, 1.2; p=0.91)	0.23 (-0.13, 0.59; p=0.21)
ID	-0.9 (-12.3, 10.4; p=0.87)	-2.4 (-24.9, 20.1; p=0.83)	0.89 (0.56, 1.4; p=0.6)	-0.06 (-0.87, 0.75; p=0.89)
IL	-4.4 (-7.9, -0.8; p=0.015)	-4.7 (-11.7, 2.3; p=0.19)	0.91 (0.79, 1.04; p=0.167)	0.08 (-0.17, 0.33; p=0.54)
IN	-1.7 (-5.1, 1.7; p=0.32)	4.3 (-2.9, 11.5; p=0.24)	1.13 (0.98, 1.29; p=0.089)	0.2 (-0.04, 0.45; p=0.101)
KS	2.5 (-3.9, 8.9; p=0.44)	-2.9 (-15.6, 9.8; p=0.66)	0.84 (0.65, 1.09; p=0.199)	0.2 (-0.26, 0.65; p=0.39)
KY	0.4 (-3.8, 4.6; p=0.85)	8.1 (-0.6, 16.8; p=0.067)	1.18 (1, 1.39; p=0.049)	0.42 (0.12, 0.72; p=0.007)

LA	-1.7 (-6, 2.6; p=0.44)	0.2 (-8.8, 9.2; p=0.96)	1.16 (0.98, 1.37; p=0.093)	0.36 (0.05, 0.67; p=0.021)
MA	-9.7 (-14.1, -5.2; p=<0.001)	-12.3 (-21, -3.6; p=0.006)	0.86 (0.72, 1.03; p=0.099)	0.2 (-0.12, 0.51; p=0.22)
MD	-2.3 (-6.2, 1.6; p=0.25)	-12.4 (-20, -4.8; p=0.001)	0.75 (0.64, 0.87; p=<0.001)	-0.08 (-0.36, 0.19; p=0.55)
ME	-6.2 (-14.2, 1.8; p=0.128)	-10.9 (-24.4, 2.5; p=0.111)	0.63 (0.46, 0.85; p=0.002)	0.54 (-0.03, 1.11; p=0.062)
MI	0.9 (-2.2, 4; p=0.57)	5.8 (-0.4, 12.1; p=0.067)	0.99 (0.87, 1.12; p=0.84)	0.19 (-0.03, 0.41; p=0.087)
MN	-5.9 (-11.3, -0.4; p=0.034)	-12.2 (-22.3, -2.1; p=0.018)	0.69 (0.55, 0.85; p=<0.001)	0.32 (-0.07, 0.7; p=0.105)
MO	1.3 (-3.2, 5.7; p=0.58)	2 (-6.9, 10.9; p=0.66)	1.02 (0.86, 1.21; p=0.83)	0.05 (-0.26, 0.36; p=0.75)
MS	-3.3 (-10.2, 3.6; p=0.34)	-0.2 (-14.8, 14.4; p=0.98)	0.86 (0.65, 1.14; p=0.31)	-0.05 (-0.55, 0.44; p=0.83)

MT	-7.2 (-21.1, 6.8; p=0.31)	-8.9 (-36.5, 18.6; p=0.52)	1.27 (0.75, 2.14; p=0.38)	0.34 (-0.65, 1.34; p=0.5)
NC	-1.1 (-4.8, 2.7; p=0.58)	-1.6 (-9.2, 6; p=0.68)	0.99 (0.85, 1.15; p=0.87)	0.02 (-0.25, 0.29; p=0.89)
ND	-3.2 (-15.7, 9.3; p=0.62)	-2.4 (-26, 21.2; p=0.84)	0.73 (0.44, 1.22; p=0.23)	0.84 (-0.05, 1.74; p=0.063)
NE	3.3 (-3.1, 9.7; p=0.32)	-3 (-16, 9.9; p=0.65)	1.11 (0.87, 1.43; p=0.41)	0.27 (-0.18, 0.73; p=0.24)
NH	0.2 (-9.6, 9.9; p=0.97)	-3.4 (-21.6, 14.8; p=0.71)	0.77 (0.53, 1.14; p=0.192)	-0.11 (-0.81, 0.58; p=0.75)
NJ	-2.9 (-6.8, 0.9; p=0.135)	-13.7 (-21, -6.5; p=<0.001)	0.74 (0.64, 0.86; p=<0.001)	-0.01 (-0.29, 0.26; p=0.92)
NM	0.4 (-8.6, 9.4; p=0.93)	-11.6 (-28.7, 5.5; p=0.184)	0.76 (0.53, 1.08; p=0.125)	0 (-0.64, 0.64; p=0.99)
NV	8.6 (2.5, 14.8; p=0.006)	9.9 (-2.5, 22.4; p=0.118)	0.86 (0.67, 1.1; p=0.23)	-0.11 (-0.55, 0.33; p=0.63)

NY	0.2 (-3, 3.3; p=0.93)	-10.8 (-16.7, -4.8; p=<0.001)	0.7 (0.62, 0.8; p=<0.001)	-0.1 (-0.32, 0.13; p=0.4)
OH	-3.7 (-6.3, -1.2; p=0.005)	-5.5 (-10.8, -0.3; p=0.037)	0.92 (0.83, 1.02; p=0.131)	0.14 (-0.05, 0.32; p=0.142)
OK	13 (8.5, 17.5; p=<0.001)	15.8 (6.5, 25.1; p=<0.001)	1.06 (0.89, 1.27; p=0.51)	0.28 (-0.04, 0.6; p=0.089)
OR	0.5 (-4.1, 5.2; p=0.82)	-1.9 (-11.2, 7.4; p=0.69)	0.87 (0.72, 1.04; p=0.131)	0.14 (-0.2, 0.47; p=0.42)
PA	-4 (-7, -0.9; p=0.011)	-12.1 (-17.9, -6.3; p=<0.001)	0.74 (0.66, 0.83; p=<0.001)	-0.09 (-0.3, 0.13; p=0.42)
RI	-9.8 (-18.4, -1.3; p=0.024)	-7.8 (-24.7, 9; p=0.36)	1.09 (0.79, 1.51; p=0.6)	0.67 (0.06, 1.28; p=0.031)
SC	-0.5 (-4.8, 3.9; p=0.83)	2.6 (-6.5, 11.6; p=0.58)	1.03 (0.86, 1.22; p=0.75)	0.22 (-0.08, 0.53; p=0.154)
SD	-5.6 (-15.4, 4.2; p=0.26)	1.1 (-17.2, 19.3; p=0.91)	1.06 (0.74, 1.54; p=0.74)	-0.03 (-0.73, 0.67; p=0.93)

TN	-1.6 (-5.5, 2.3; p=0.42)	-0.4 (-8.7, 8; p=0.93)	1.13 (0.97, 1.32; p=0.117)	0.22 (-0.06, 0.5; p=0.116)
TX	3 (-0.1, 6.1; p=0.06)	5.1 (-1.2, 11.4; p=0.11)	1.07 (0.95, 1.21; p=0.29)	0.1 (-0.12, 0.32; p=0.37)
UT	-0.4 (-8.2, 7.4; p=0.92)	-13.6 (-29, 1.7; p=0.082)	0.77 (0.57, 1.04; p=0.093)	-0.08 (-0.63, 0.48; p=0.78)
VA	-5.5 (-9.7, -1.3; p=0.01)	-8.9 (-17.1, -0.7; p=0.034)	0.86 (0.73, 1.02; p=0.081)	0.06 (-0.24, 0.36; p=0.7)
VT	-11.6 (-29.8, 6.6; p=0.21)	-17.1 (-52.5, 18.3; p=0.34)	0.91 (0.44, 1.88; p=0.81)	-0.41 (-1.71, 0.89; p=0.53)
WA	-6.2 (-10.8, -1.6; p=0.008)	-3.1 (-12.4, 6.3; p=0.52)	1.04 (0.87, 1.24; p=0.69)	0.37 (0.05, 0.7; p=0.024)
WI	-6.6 (-10.8, -2.4; p=0.002)	-7.5 (-15.3, 0.3; p=0.06)	0.82 (0.7, 0.97; p=0.017)	0.18 (-0.11, 0.48; p=0.23)
WV	0.5 (-5.2, 6.1; p=0.87)	0.6 (-10.6, 11.9; p=0.91)	0.95 (0.76, 1.18; p=0.63)	0.35 (-0.05, 0.76; p=0.086)

WY	-5.4 (-22.8, 12; p=0.54)	-16.5 (-44.5, 11.5; p=0.25)	0.62 (0.33, 1.16; p=0.134)	-0.1 (-1.34, 1.14; p=0.87)

Appendix Table 7: 1-month pre-op to 1-year post-op adjusted estimates of the impact of the listed factors on first oxycodone prescription volume, cumulative prescribing, and odds of refill. Estimate mean or odds ratio (95% CI, p-value). Age reported as per-year impact. Reference controls for multilevel variables included CCI level of 0, no pre-operative opioid filling, year 2010, and state of Florida. Red coloring was used to highlight differences that achieved statistical significance and also exceeded a clinical relevance thresholds.

Factor	1-year first oxycodone prescription	1-year cumulative oxycodone prescription	1-year refill	1-year opioid fills
Baseline estimate	33.4 (31.1, 35.6; p=<0.001)	126.4 (116, 136.8; p=<0.001)	2.27 (2, 2.59; p=<0.001)	4.78 (4.53, 5.02; p=<0.001)
Age	0 (0, 0; p=0.96)	-0.7 (-0.8, -0.6; p=<0.001)	0.98 (0.97, 0.98; p=<0.001)	-0.04 (-0.04, -0.03; p=<0.001)
Male sex	1.6 (0.9, 2.3; p=<0.001)	-1.8 (-4.9, 1.3; p=0.26)	0.95 (0.92, 0.99; p=0.015)	-0.04 (-0.11, 0.03; p=0.26)

Obesity	0.5 (-0.3, 1.2; p=0.21)	5.7 (2.3, 9.2; p=0.001)	1.1 (1.05, 1.14; p=<0.001)	0.02 (-0.06, 0.1; p=0.55)
Pre-operative opioid use				
One pre-op opioid prescriptions	4.8 (3.9, 5.7; p=<0.001)	64.5 (60.2, 68.8; p=<0.001)	2.75 (2.62, 2.9; p=<0.001)	1.03 (0.93, 1.12; p=<0.001)
Two or more pre-op opioid prescriptions	14.8 (14, 15.6; p=<0.001)	273.4 (269.4, 277.3; p=<0.001)	10.63 (9.99, 11.31; p=<0.001)	5.01 (4.92, 5.09; p=<0.001)
Ortho provider	n/a	n/a	n/a	n/a
Charlson comorbidity index				
CCI 0	n/a	n/a	n/a	n/a
CCI 1	0.8 (0, 1.5; p=0.057)	9.5 (5.8, 13.1; p=<0.001)	1.05 (1, 1.1; p=0.046)	0.17 (0.09, 0.26; p=<0.001)
CCI 2	2.1 (1, 3.1; p=<0.001)	11.7 (7, 16.4; p=<0.001)	1.06 (1, 1.12; p=0.07)	0.2 (0.09, 0.31; p=<0.001)
CCI 3	2.8 (1.5, 4; p=<0.001)	18.1 (12.3, 23.9; p=<0.001)	1.08 (1.01, 1.17; p=0.035)	0.26 (0.12, 0.4; p=<0.001)

CCI 4	2.9 (1.3, 4.6; p=<0.001)	18.5 (11, 26.1; p=<0.001)	1.16 (1.05, 1.28; p=0.002)	0.39 (0.21, 0.57; p=<0.001)
CCI 5 or more	3 (1.7, 4.4; p=<0.001)	22.7 (16.5, 28.9; p=<0.001)	1.15 (1.06, 1.24; p=<0.001)	0.44 (0.29, 0.58; p=<0.001)
Year				
2010	n/a	n/a	n/a	n/a
2011	-0.3 (-1.8, 1.2; p=0.69)	-14.6 (-21.5, -7.7; p=<0.001)	1.1 (1.01, 1.2; p=0.025)	-0.09 (-0.25, 0.08; p=0.3)
2012	-1.3 (-2.8, 0.2; p=0.09)	-18.4 (-25.3, -11.6; p=<0.001)	1.14 (1.05, 1.25; p=0.002)	-0.2 (-0.36, -0.04; p=0.017)
2013	-2.2 (-3.7, -0.7; p=0.005)	-18.1 (-24.9, -11.3; p=<0.001)	1.19 (1.09, 1.29; p=<0.001)	-0.19 (-0.36, -0.03; p=0.02)
2014	-1.7 (-3.2, -0.2; p=0.026)	-22.7 (-29.5, -15.9; p=<0.001)	1.12 (1.03, 1.22; p=0.008)	-0.37 (-0.53, -0.21; p=<0.001)
2015	-2 (-3.5, -0.5; p=0.01)	-22.9 (-29.8, -16; p=<0.001)	1.07 (0.98, 1.17; p=0.124)	-0.26 (-0.42, -0.09; p=0.002)

2016	-2.8 (-4.3, -1.2; p=<0.001)	-25.7 (-32.7, -18.8; p=<0.001)	1.13 (1.03, 1.23; p=0.007)	-0.36 (-0.53, -0.2; p=<0.001)
2017	-4.9 (-6.6, -3.3; p=<0.001)	-33.9 (-41.3, -26.4; p=<0.001)	0.96 (0.88, 1.06; p=0.42)	-0.5 (-0.68, -0.33; p=<0.001)
2018	n/a	n/a	n/a	n/a
State				
AK	5.3 (-2.6, 13.1; p=0.189)	-2 (-38.9, 34.9; p=0.92)	1.03 (0.65, 1.65; p=0.9)	-0.64 (-1.49, 0.21; p=0.139)
AL	1.3 (-1.6, 4.3; p=0.38)	18.7 (4.3, 33.1; p=0.011)	1.25 (1.04, 1.51; p=0.015)	0.87 (0.55, 1.2; p=<0.001)
AR	3.7 (0.1, 7.2; p=0.042)	17 (0.2, 33.8; p=0.047)	1.26 (1.02, 1.55; p=0.033)	0.32 (-0.06, 0.71; p=0.101)
AZ	-2.1 (-4.4, 0.3; p=0.085)	5.7 (-5.6, 17.1; p=0.32)	1.1 (0.95, 1.26; p=0.21)	0.09 (-0.16, 0.35; p=0.47)
CA	0.5 (-1.6, 2.6; p=0.65)	12.7 (2.8, 22.5; p=0.012)	1.07 (0.95, 1.21; p=0.28)	0.29 (0.07, 0.52; p=0.011)

CO	-2.8 (-6.3, 0.6; p=0.104)	-11.1 (-27.2, 5; p=0.176)	0.89 (0.73, 1.09; p=0.25)	0.02 (-0.35, 0.39; p=0.93)
CT	-4.9 (-7.8, -2; p=<0.001)	-29.8 (-43.3, -16.4; p=<0.001)	0.84 (0.71, 1; p=0.052)	0.05 (-0.26, 0.36; p=0.74)
DC	-5.6 (-15, 3.9; p=0.25)	-31 (-75.9, 13.9; p=0.176)	0.79 (0.45, 1.38; p=0.41)	0.11 (-0.92, 1.13; p=0.84)
DE	-1.6 (-6, 2.8; p=0.48)	0.4 (-20.6, 21.5; p=0.97)	1.08 (0.83, 1.41; p=0.55)	-0.11 (-0.58, 0.37; p=0.67)
FL	n/a	n/a	n/a	n/a
GA	1.7 (-0.4, 3.7; p=0.111)	7.2 (-2.7, 17.1; p=0.153)	1.14 (1.01, 1.29; p=0.034)	0.3 (0.08, 0.52; p=0.008)
HI	0.7 (-7.3, 8.6; p=0.87)	-25.8 (-63.9, 12.4; p=0.186)	0.88 (0.54, 1.42; p=0.6)	-0.27 (-1.13, 0.6; p=0.54)
IA	-4.3 (-7, -1.5; p=0.003)	-14.2 (-27.2, -1.2; p=0.033)	0.88 (0.75, 1.04; p=0.122)	0.18 (-0.12, 0.48; p=0.25)

ID	3.3 (-3, 9.6; p=0.3)	-0.3 (-30.2, 29.5; p=0.98)	1.04 (0.72, 1.51; p=0.83)	0.06 (-0.62, 0.74; p=0.87)
IL	-3.9 (-5.9, -1.9; p=<0.001)	-9.4 (-18.7, -0.1; p=0.047)	0.87 (0.77, 0.98; p=0.019)	0.03 (-0.18, 0.25; p=0.78)
IN	-0.7 (-2.6, 1.3; p=0.51)	7 (-2.5, 16.5; p=0.15)	1.32 (1.17, 1.48; p=<0.001)	0.34 (0.13, 0.55; p=0.001)
KS	-3.4 (-7, 0.1; p=0.06)	-13 (-29.9, 3.8; p=0.13)	0.88 (0.71, 1.09; p=0.24)	-0.04 (-0.43, 0.34; p=0.82)
KY	-0.4 (-2.8, 2; p=0.77)	5.8 (-5.8, 17.3; p=0.33)	1.02 (0.88, 1.18; p=0.77)	0.31 (0.05, 0.57; p=0.019)
LA	5.3 (2.8, 7.8; p=<0.001)	10 (-1.9, 22; p=0.101)	1.17 (1.01, 1.36; p=0.04)	0.45 (0.19, 0.72; p=<0.001)
MA	-10.4 (-12.8, -7.9; p=<0.001)	-27.6 (-39.1, -16.1; p=<0.001)	0.82 (0.71, 0.95; p=0.007)	0.07 (-0.19, 0.34; p=0.58)
MD	-1.7 (-3.8, 0.5; p=0.134)	-24.7 (-34.8, -14.7; p=<0.001)	0.7 (0.62, 0.8; p=<0.001)	-0.2 (-0.44, 0.03; p=0.09)

ME	-5.2 (-9.4, -1; p=0.016)	-24.6 (-42.4, -6.8; p=0.007)	0.54 (0.42, 0.68; p=<0.001)	0.1 (-0.36, 0.55; p=0.68)
MI	-2 (-3.7, -0.2; p=0.027)	3 (-5.3, 11.3; p=0.49)	0.9 (0.81, 1; p=0.04)	0.15 (-0.04, 0.34; p=0.13)
MN	-5.9 (-8.9, -2.8; p=<0.001)	-28.2 (-41.6, -14.8; p=<0.001)	0.62 (0.52, 0.74; p=<0.001)	0.12 (-0.21, 0.45; p=0.48)
MO	-0.3 (-2.8, 2.3; p=0.84)	1.7 (-10.2, 13.5; p=0.78)	0.89 (0.77, 1.03; p=0.125)	0.08 (-0.19, 0.36; p=0.54)
MS	1.7 (-2.4, 5.8; p=0.42)	-2.5 (-21.8, 16.9; p=0.8)	0.89 (0.69, 1.14; p=0.35)	-0.04 (-0.48, 0.41; p=0.87)
MT	-6.1 (-14.3, 2.1; p=0.147)	-18.7 (-55.2, 17.8; p=0.32)	1.22 (0.77, 1.95; p=0.39)	0.61 (-0.28, 1.51; p=0.176)
NC	1 (-1.1, 3.2; p=0.35)	-2.9 (-13, 7.3; p=0.58)	0.9 (0.79, 1.02; p=0.101)	-0.02 (-0.26, 0.21; p=0.85)
ND	-3.3 (-10.1, 3.4; p=0.33)	-14.7 (-46, 16.6; p=0.36)	0.83 (0.56, 1.23; p=0.35)	0.48 (-0.25, 1.22; p=0.196)

NE	-3.2 (-6.8, 0.5; p=0.094)	-10.3 (-27.4, 6.9; p=0.24)	0.95 (0.76, 1.18; p=0.63)	0.51 (0.12, 0.91; p=0.012)
NH	-7 (-12.1, -1.9; p=0.007)	-7.1 (-31.2, 17.1; p=0.57)	0.8 (0.59, 1.08; p=0.141)	-0.39 (-0.94, 0.16; p=0.167)
NJ	-3.6 (-5.7, -1.6; p=<0.001)	-26.6 (-36.2, -17; p=<0.001)	0.68 (0.6, 0.76; p=<0.001)	-0.28 (-0.5, -0.05; p=0.015)
NM	-0.9 (-5.7, 4; p=0.72)	-17.5 (-40.3, 5.2; p=0.13)	0.76 (0.57, 1.01; p=0.058)	-0.08 (-0.6, 0.44; p=0.77)
NV	5.9 (2.5, 9.3; p=<0.001)	13.7 (-2.8, 30.2; p=0.104)	0.95 (0.77, 1.17; p=0.63)	-0.25 (-0.62, 0.12; p=0.18)
NY	-3.2 (-4.9, -1.5; p=<0.001)	-22.6 (-30.5, -14.7; p=<0.001)	0.65 (0.59, 0.72; p=<0.001)	-0.35 (-0.53, -0.16; p=<0.001)
OH	-3.5 (-4.9, -2; p=<0.001)	-10.9 (-17.8, -4; p=0.002)	0.95 (0.87, 1.03; p=0.21)	0.16 (0.01, 0.32; p=0.04)
OK	13 (10.3, 15.6; p=<0.001)	21.4 (9.1, 33.8; p=<0.001)	0.99 (0.84, 1.15; p=0.85)	0.2 (-0.09, 0.48; p=0.179)

OR	1.8 (-0.9, 4.5; p=0.2)	-7.4 (-19.7, 4.9; p=0.24)	0.82 (0.7, 0.96; p=0.012)	0.22 (-0.08, 0.51; p=0.146)
PA	-4.8 (-6.5, -3.1; p=<0.001)	-24.1 (-31.8, -16.4; p=<0.001)	0.72 (0.65, 0.8; p=<0.001)	-0.2 (-0.38, -0.01; p=0.034)
RI	-6.9 (-11.5, -2.4; p=0.003)	-12.5 (-34.8, 9.9; p=0.27)	1.05 (0.8, 1.39; p=0.73)	0.36 (-0.13, 0.85; p=0.152)
SC	3.5 (1, 6; p=0.006)	5.1 (-6.9, 17.1; p=0.41)	1.07 (0.92, 1.24; p=0.39)	0.26 (-0.01, 0.53; p=0.057)
SD	-8 (-13.2, -2.7; p=0.003)	-9.8 (-34, 14.4; p=0.43)	0.9 (0.66, 1.22; p=0.49)	0.16 (-0.41, 0.72; p=0.59)
TN	0.8 (-1.5, 3.1; p=0.49)	2.9 (-8.1, 13.9; p=0.61)	1.13 (0.98, 1.29; p=0.096)	0.3 (0.05, 0.54; p=0.018)
TX	3.9 (2.1, 5.6; p=<0.001)	6.7 (-1.7, 15; p=0.117)	0.95 (0.86, 1.06; p=0.39)	0.15 (-0.05, 0.34; p=0.14)
UT	2.7 (-1.6, 7.1; p=0.22)	-8.7 (-29.1, 11.7; p=0.4)	0.8 (0.61, 1.03; p=0.087)	-0.13 (-0.6, 0.34; p=0.58)

VA	-2.5 (-4.8, -0.2; p=0.031)	-9.8 (-20.7, 1.1; p=0.078)	0.84 (0.74, 0.97; p=0.015)	0.01 (-0.24, 0.26; p=0.95)
VT	-9.6 (-20, 0.8; p=0.07)	-30.2 (-77.1, 16.7; p=0.21)	1.15 (0.65, 2.04; p=0.63)	0.04 (-1.09, 1.16; p=0.95)
WA	-4.1 (-6.7, -1.5; p=0.002)	-7.2 (-19.6, 5.2; p=0.26)	1.02 (0.87, 1.19; p=0.79)	0.34 (0.06, 0.63; p=0.017)
WI	-6 (-8.2, -3.7; p=<0.001)	-19.4 (-29.8, -9.1; p=<0.001)	0.75 (0.66, 0.86; p=<0.001)	-0.01 (-0.26, 0.23; p=0.91)
WV	-1 (-4.2, 2.2; p=0.56)	-2.7 (-17.6, 12.2; p=0.72)	0.87 (0.72, 1.05; p=0.151)	0.28 (-0.06, 0.63; p=0.109)
WY	-3 (-11.5, 5.6; p=0.5)	-27.9 (-65, 9.2; p=0.141)	0.83 (0.52, 1.33; p=0.44)	-0.32 (-1.25, 0.61; p=0.5)

Appendix Figure 1: Initial opioid filling volume within the 90-day perioperative cohort. States with gray coloring had insufficient data (fewer than 11 patients) for statistical analysis and were excluded.

Appendix Figure 2: 90-day cumulative opioid filling volume within the 90-day perioperative cohort. States with gray coloring had insufficient data (fewer than 11 patients) for statistical analysis and were excluded.