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Non-pharmacologic Therapies for New-onset Low Back Pain: Predictors of Early and Long-Term Opioid Use in the United States

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Non-pharmacologic Therapies for New-onset Low Back Pain: Predictors of Early and Long-Term Opioid Use in the United States

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Abstract

Objective: This study examined the association of initial provider treatment with early and long-term opioid use in a national sample of patients with new-onset low back pain (LBP).

Design: A retrospective cohort study of patients with new-onset LBP from 2008-2013.

Setting: The study evaluated outpatient and inpatient claims from patient visits, pharmacy claims, and inpatient and outpatient procedures with initial providers seen for new onset LBP.

Participants: 216,504 individuals aged 18 or older across the United States who were diagnosed with new-onset LBP and were opioid-naïve were included. Participants had commercial or Medicare Advantage insurance through a private health plan.

Primary and Secondary Outcome Measures: The primary independent variables are initial provider and early conservative therapy (chiropractic, physical therapy and acupuncture). Early opioid use (within 30 days of the index visit) following new LBP visit and long-term opioid use (within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months).

Results: Early use of opioids was 22% in the first 30 days. Patients who received initial treatment from chiropractors or physical therapists had decreased odds of early opioid use compared to those who received initial treatment from primary care physicians (PCPs) [AOR (95% CI): 0.10 (0.09,0.10) and 0.15 (0.13,0.17) respectively]. Compared to PCP visits, initial chiropractic and physical therapy also were associated with decreased odds of long-term opioid use in a propensity-score matched sample [OR (95% CI): 0.21 (0.16, 0.27) and 0.29 (0.12, 0.69) respectively].

Conclusions: Initial visits to chiropractors or physical therapists is associated with substantially decreased early and long-term use of opioids. Incentivizing use of conservative therapists may be a strategy to reduce risks of short- and long-term opioid use.

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Article Summary

- This is a nationwide study comparing short and long term opioid use among patients with low back pain who seek initial care from non-pharmacologic conservative therapists, physician specialists and PCPs.
- We go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP, using rigorous definitions of recent onset.
- We provide a broader depiction of conservative therapy than prior studies, as we included chiropractors and acupuncturists, as well as other MD specialists.
- This study assesses the impact of state access to physical therapy on choice of initial provider.
- This is a claims study; therefore, causation cannot be inferred, and the number of patient characteristics we could assess is limited.

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Data availability statement: No additional data available

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Introduction

Over the past decade, there has been a concerning increase in opioid use in the United States, with over 12 million Americans reporting long-term opioid use or misuse in 2015.[1-3] The National Survey on Drug Use and Health reported over 42,000 prescription opioid-related deaths in 2016, with total estimated costs of prescription opioid use reaching $78.5 billion.[4,5] One of the most common conditions for which opioids are prescribed is low back pain (LBP).[2-4] Several studies have reported that opioids are the most frequently prescribed medication for treatment of LBP,[4,5] and more than half of opioid users report having a history of back pain.[6] This frequency of opioid prescribing is particularly concerning given that LBP is one of the three most common conditions for which Americans seek medical care.[2,7]

Given the high prevalence of LBP, several treatment guidelines have been issued for treatment, and specifically discourage opioids to treat pain. The American College of Physicians (ACP) and the Centers for Disease Control (CDC) recommend non-pharmacologic treatments including exercise, physical therapy (PT), spinal manipulation, acupuncture, and massage.[2,8] These guidelines indicate that opioids should not be considered as a treatment option for LBP unless recommended treatments fail and if the benefits of their use outweigh the risk for the individual patient.[2,8] Despite these recommendations, non-pharmacologic therapies like chiropractic care, PT, and acupuncture are rarely used for treatment of acute pain, and physicians frequently prescribe opioids for acute onset LBP.[8-11]

Several studies have attempted to elucidate the predictors of opioid use among patients with LBP. Comparisons of the treatment patterns of primary care physicians (PCPs) and conservative therapists suggest that the use of non-pharmacologic therapies for LBP may decrease the likelihood of opioid use.[9] Despite these findings, there has been little research

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comparing early and long-term opioid use among patients seeking initial care from various providers, including primary care physicians, chiropractors, physical therapists, and acupuncturists as well as patients seeing orthopedic surgeons, neurosurgeons and emergency physicians.[12,13] The purpose of this study is to examine the association of type of initial provider with subsequent early and long-term opioid use in a national sample of patients with new-onset LBP whose treatment could reasonably be managed by non-pharmacologic therapy.

Methods

Study Sample

We conducted a retrospective study of patients seen by a medical provider for new-onset, LBP management and who were opioid-naïve at the time of the initial visit (Boston Medical Center IRB approval number: H-36499). We used claims data from the OptumLabs® Data Warehouse (OLDW), which includes de-identified claims data for privately insured and Medicare Advantage enrollees in a large, private, U.S. health plan. The database contains longitudinal health information on enrollees, representing a diverse mixture of ages, ethnicities and geographical regions across the United States. The health plan provides comprehensive full insurance coverage for physician, hospital, and prescription drug services.

The index episode of LBP was identified using claims from 2008-2013 to ascertain pre-index visit opioid use and back conditions and to allow a follow-up period. Patients needed to have at least 24 months of medical and pharmacy available claims data prior to and after the index date. The study sample included adults aged 18 years or older with a new outpatient diagnosis of LBP who had commercial or Medicare Advantage insurance through a large, private, U.S. health plan. To qualify, LBP diagnosis appeared in the first location on a patient's

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index date insurance claim. New-onset LBP was defined as no diagnosis of LBP or back procedures, including spinal surgery, spinal injections, and spinal nerve stimulators during the 12-month period prior to the index event (Figure 1).

Exclusion Criteria

Patients were excluded if they had a prescription for opioids in the 12 months prior to the index event. Patients with a diagnosis of neoplasia in this 12-month period or within a 3-month period after the index LBP event were also excluded. Each patient was only included in the study once.

Patient characteristics

We identified patient characteristics and comorbidities using ICD-9 codes for claims in the two years prior to the index event. Characteristics included age, sex, race, insurance (commercial or Medicare Advantage), and state of residence. Medical conditions also called physical comorbidities were calculated using the Elixhauser index.[14] Other comorbidities, mental health conditions, chronic pain, and fibromyalgia are included and based on prior studies that have reported an association between such conditions and opioid use.[15,16] Mental health comorbidities were selected from the Centers for Medicare and Medicaid Services report on prevalence of mental health conditions.[17]

Dependent variables

Early opioid use was defined as an opioid fill within 30 days of the index visit. Long-term use was defined as an initial opioid fill within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months. This definition relied on previous literature.[6,18]

Independent variables

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Based on the index claim date of patients with an eligible LBP diagnosis, initial providers were characterized as physical therapist, chiropractor, acupuncturist, primary care physician, orthopedic surgeon, emergency medicine physician, neurosurgeon, or physical medicine and rehabilitation physician according to provider specialty and procedure codes. If a patient saw both a physician and a conservative therapist on the index date, the initial provider was assumed to be the physician.

Patient access to PT in every state was classified as either 'limited', 'provisional', or 'unrestricted', based on the three levels of patient access outlined by the American Physical Therapy Association.[19] These different levels were on the basis of a patient needing a prescription from a physician to access a PT. There were six states with limited access to PT, 26 states with provisional access, and 18 states with unrestricted access to PT.[19]

Statistical Analyses

The main analyses included multivariable logistic regressions with early opioid use and long-term opioid use as outcomes and entry-point provider as the main independent variable. The reference group for these comparisons was patients who visited PCP first for the LBP. All models were adjusted for age, sex, race/ethnicity, geographic region, the Elixhauser index as a continuous count of physical co-morbidities and mental health comorbidities and insurance type.

As a supplemental alternative to adjusting for baseline confounding through regression adjustment, we invoked two-to-one propensity score matching without replacement to achieve baseline covariate balance among patients who initially saw chiropractor first, saw PT first or who saw PCP first. The propensity scores were calculated as predicted probabilities of chiropractor first and PT first as opposed to PCP first as a function of the following matching variables: age, sex, race/ethnicity, baseline comorbidities, calendar year of the index visit, copay,

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deductible, plan type, history of pregnancy within 12 months, history of vehicular accidents within 12 months, and history of opioid use within the year prior to the opioid free period. The propensity score for PT also considered the state PT access category. Race and ethnicity are defined as Black, Hispanic, Asian, or White. Ethnicity was assigned by an external vendor based on a structured, rule-based system that combines analysis of first names, middle names, surnames, and surname prefixes and suffixes, with geographic reference files. Values were then categorized in OLDW to comply with data de-identification requirements. We examined the covariate balance in the matched samples through the standardized mean differences of each covariate. Finally, we applied a logistic model using the matched sample to assess the association between chiropractor compared to PCP as the initial provider seen and PT compared to PCP as the initial provider seen with the outcomes early term opioid use and separately long-term opioid use (binary variables).

For all logistic models, we calculated adjusted odds ratios with 95% Wald confidence intervals. We also evaluated overall model fit, model discrimination (C statistic) and calibration (Hosmer Lemeshow test) for all logistic models (supplement Table 1). While the Hosmer Lemeshow models were significant, this was likely due to the large sample sizes used for this study. The differences between the observed and expected values within the decile groups was relatively small suggesting credible calibration of the models and statistical significance due to the large sample sizes.[20,21] We further validated the covariate-adjusted ORs of early use and long-term use as a function of initial provider using the bootstrap method.[22] The resampling rate was 200 with a two-third/one-third sampling ratio. The bootstrapped estimates were then used to construct means and 95% confidence intervals for the ORs. The estimates reported using

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bootstrapping indicated little or no differences with the actual results (supplement Tables 2 and 3).

Patient and Public Involvement

Patients and the public were not involved in this project.

Results

A total of 8,797,787 patients had a visit with a provider for LBP during the study period, and 216,504 met all inclusion/exclusion criteria (Figure 1). More than half the patients initially saw a PCP (n=114,782, 53.0%), and the next most frequent initial provider seen was chiropractor (50,041, 23.1%) followed by physical therapist 3,499 (1.6%) and acupuncturist 1,839 (0.8%). Patient demographics by initial provider are shown in Table 1. Most patients had commercial insurance (183,117, 84.7%); the remainder had Medicare Advantage coverage. Of patients with an acupuncturist as the initial provider type, nearly all (99.3%) had commercial insurance. For all other initial provider types, 87-89% of patients had commercial insurance. Approximately 18% of patients received an opioid fill within 3 days of the initial LBP visit, 22% received such a fill within the first 30 days and 1.2% met criteria for long-term use.

Initial provider was associated with short and long-term opioid use outcomes in the adjusted multivariate models (Table 2, Figure 2, supplement Table 4). Compared to seeing a PCP as initial provider, patients who first saw conservative therapists (chiropractor, acupuncturists and PTs) all had significantly decreased odds of both early and long-term opioid use. Among patients with new-onset LBP who were previously opioid-naive, those who sought initial care from chiropractors had 90% decreased odds [95% CI: (0.09,0.10)] and acupuncturists had 91% decreased odds [95% CI: (0.07,0.12)] of early opioid use compared to those who initially saw PCPs (Table 2, Figure 2). Patients who sought initial care from PTs had 85% decreased odds

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[95% CI: (0.13,0.17)] of early opioid use compared to those who initially saw PCPs. Chiropractors, acupuncturists and PTs all had major decreased odds of long term opioid use compared to those who initially saw PCPs. Orthopedic surgeons and neurosurgeons as initial providers decreased patients' odds of early opioid use, while patients seeing emergency physicians initially had significantly increased odds of early opioid use.

Several states have mandated insurance beenfits that remove cost barriers for conservative treatment. Patients in states with provisional access to PT had 1.21 (95% CI: 1.05, 1.40) times the odds of seeing a physical therapist initially compared to patients in states with limited PT access. Patients in states with unlimited access to PT had 1.67 (95% CI: 1.40, 1.98) times the odds of seeing a physical therapist initially compared to patients in states with limited PT access.

Patients with anxiety, bipolar disorder, and depression had significantly increased odds of long-term opioid use, as did those diagnosed with drug use disorders and fibromyalgia/chronic pain/fatigue (supplement Table 5).

Propensity-score matched odds of long-term opioid use were significantly lower for chiropractic care first compared to PCP first and for PT first as compared to PCP first with odds ratios consistent with findings in our primary covariate-adjusted logistic models (detailed results presented in supplement Table 6).

Discussion

Initial care from conservative therapists in those with LBP was associated with a marked decrease in the odds of short and long term opioid use. To our knowledge, this is one of the first

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national studies to compare short and long term opioid use among patients with LBP who seek initial care from non-pharmacologic conservative therapists, physician specialists and PCPs.

Several factors may help explain the protective effect of conservative therapists. Since non-physicians are unable to prescribe opioids, patients seeking conservative therapy do not receive opioid prescriptions at the index visit, and subsequent visits to an MD would be required to obtain such prescriptions. Additionally, the conservative therapy provided may result in decreased pain so that patients no longer see a need for opioid medications. Chiropractors and physical therapists are both trained to use exercises and spinal manipulation, which have been shown to be effective for treatment of LBP.[23] Therefore and importantly, use of conservative therapists may prevent the need for use of opioid or MD visits by providing evidence-based interventions.

Notably, state access to PT had a considerable association with choice of initial provider. Compared to states with limited access to PT, patients in states with unlimited and provisional access had 67% and 21% higher odds of visiting PT initially, respectively. Given that initial PT is associated with significant reductions in early and long-term opioid use, these trends in PT access are extremely important.

Comparisons to prior studies

Our results are consistent with prior studies showing high rates of opioid prescription fills for patients with LBP who were seen by emergency department physicians.[3,24] While there are very few studies suggesting that PT and chiropractors are used in emergency departments in the United States[25], other countries have successfully introduced PTs into emergency departments to treat patients with LBP.[26-28]

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Certain comorbidities were also associated with increased odds of opioid use. Patients with fibromyalgia, chronic pain, and fatigue and those with certain psychiatric conditions, including anxiety, bipolar disorder, and depression had greater odds of long-term opioid use than patients without these disorders. This is consistent with recent evidence suggesting that adults with mental health conditions account for half of opioid prescriptions in the United States.[29]

A recent study by Frogner et al. also found that LBP patients who saw PT initially had lower opioid use, although this study only focused on six states.[13] Sun et al. found that early physical therapy was associated with decreased opioid use among patients with musculoskeletal pain, but this study only evaluated opioid use beginning 90 days after the initial visit and did not examine any initial providers other than physical therapists.[30] Another recent study by Hayward et al. evaluated the use of non-opioid treatments from various providers, including physical therapists and physicians, however this was a descriptive study across only 16 states.[31] Our study examines the association of conservative therapy on opioid use with a sample that is national in scope. We also provide a broader depiction of conservative therapy, as we included chiropractors and acupuncturists, as well as other MD specialists. Importantly, we find that other conservative therapists including chiropractors and acupuncturists when seen first after a new episode of LBP are protective of early and long term use of opioids when compared with PCP's. Finally, we go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP, using rigorous definitions of recent onset.

Fritz et al. found that early PT was associated with decreased opioid prescriptions[32], and a review by Ojha et al. noted that early PT as treatment for musculoskeletal disorders was associated with decreased frequency of opioid prescriptions, although this was based on a limited

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number of outcomes.[33] Thackerary et al. also suggested that the odds of receiving an opioid prescription among Medicaid beneficiaries were reduced for those who had a PT consult, as compared to those who did not.[34] While these studies did not measure the odds of opioid use among patients who saw initial PT compared to other initial providers, our results are consistent with previously published reports that PT is associated with lower odds of opioid use.

Limitations

There are several limitations to this study. Analysis was conducted using claims data, limiting our generalizability beyond commercial and Medicare Advantage enrolled patients. However, the sample is national in scope and provides a range of sociodemographic and clinical characteristics. The use of claims data also limited some of the clinical patient characteristics we could assess, such as severity of the index back pain episode. The use of a count of comorbidities may not be a reliable proxy for clinical severity of an individual. However, multiple studies have shown comparable baseline pain scores for those who choose conservative therapists compared to those who choose to see physicians initially.[35-37] While they did not report a significant difference in mean pain scores, Carey et al. also suggested that there was a significant difference between adults seeking care compared to adults who did not seek care when the duration of pain was less than or greater than or equal to two weeks.[35]

Selection bias due to unmeasured characteristics of patients seeking conservative and non-conservative care and accessibility of conservative therapists may explain some of the consumer choices of initial provider and MD prescribing of opioids. However, our propensity-score matching that balanced our groups may mitigate some of this concern by attempting to control for such differences. Last, causality cannot be inferred given that this study was an observational quasi-experimental design.

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Policy Implications and Future Research

In conclusion, our results suggest that use of conservative therapists as initial providers for new-onset LBP are associated with lower odds of early and long-term use of opioids. Approaches to incentivizing use of conservative therapists might include lowering out-of-pocket costs for PT and chiropractor visits; reducing gatekeeper requirements; and increasing the number of conservative therapists available to consumers within insurance networks. Further research in other settings and prospective pragmatic trials will be useful to confirm our findings and to better understand other factors that influence choice of initial providers for LBP. Future research should include personal factors such as preferences related to opioid use, and medical, non-medical and specialists as initial providers. Factors related to health plan benefit design such as out-of-pocket costs for treatment alternatives (e.g. PT and chiropractor visits, opioids) and impact of gatekeeper requirements on care patterns should be investigated.

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Author contributions

Lewis Kazis, Omid Ameli, James Rothendler, Christine McDonough, Kathleen Carey, Howard Cabral, and Robert Saper were involved in devising the topic. Omid Ameli and Howard Cabral were responsible for the analyses of the study. All authors contributed to the computational framework of this study. All authors participated in discussion of the results and creation of the manuscript. All editors were involved in the editing of the manuscript.

We have no competing interests to declare. Omid Ameli and Darshak Sanghavi work for OptumLabs but have no competing interests.

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Table 1: Patient characteristics

	Entry-point provider									
		Conservative Therapist			Physician					
	Total	Chiropractor	Physical Therapist	Acupuncture	Primary Care	Orthopedic Surgeon	Emergency Medicine	MD Other	Rehab	Neurosurgeon
Full Sample – N (%)	216,504 (100%)	50,014 (23.1%)	3,499 (1.6%)	1,839 (0.8%)	114,782 (53.0%)	9,335 (4.3)	8,746 (4.0)	4,422 (2.0)	3,246 (1.5)	578 (0.3)
Age, year – mean (STD)	48.1 (15.9)	45.7 (14.9)	47.0 (15.7)	42.4 (10.6)	47.7 (15.4)	50.1 (16.4)	50.1 (18.3)	51.3 (15.3)	46.9 (15.0)	52.2 (14.8)
Gender – N (%)										
Female	108,347 (50.1)	22,808 (45.6)	1,995 (57.1)	972 (52.9)	58,182 (50.7)	4,648 (49.8)	4,560 (52.2)	2,282 (51.6)	1,554 (47.9)	245 (42.4)
Male	107,660 (49.8)	27,193 (54.4)	>1,493 (>42.6) [xx]	>856 (>46.5) [xx]	56,517 (49.2)	4,674 (50.1)	>4,175 (>47.7) [xx]	2,140 (48.4)	>1,681 (>51.8)[xx]	333 (57.6)
Race/ethnicity - N (%)										
Black	18,907 (8.7)	2,190 (4.4)	191 (5.5)	45 (2.4)	11,755 (10.2)	802 (8.6)	1,192 (13.6)	494 (11.2)	208 (6.4)	50 (8.7)
Hispanic	20,936 (9.7)	3,766 (7.5)	263 (7.5)	224 (12.2)	12,212 (10.6)	752 (8.1)	860 (9.8)	541 (12.2)	293 (9.0)	38 (6.6)
Asian	9,344 (4.3)	1,636 (3.3)	224 (6.4)	747 (40.6)	4,885 (4.3)	354 (3.8)	270 (3.1)	194 (4.4)	218 (6.7)	15 (2.6)
White	159,503 (73.7)	40,709 (81.4)	2,666 (76.2)	732 (39.8)	81,971 (71.4)	7,046 (75.5)	6,115 (69.9)	3,013 (68.1)	2,394 (73.8)	449 (77.7)
Unknown (Missing)	7,814 (3.6)	1,713 (3.4)	155 (4.4)	91 (4.9)	3,959 (3.4)	381 (4.1)	309 (3.5)	180 (4.1)	133 (4.1)	26 (4.5)
Insurance - N (%)										
Commercial	183,117 (84.7)	44,520 (89.0)	3,048 (87.1)	1,827 (99.3)	99,842 (87.0)	7,696 (82.5)	6,236 (71.3)	3,601 (81.4)	2,891 (89.1)	472 (81.7)
Medicare Advantage	32,937 (15.2)	5,476 (11.0)	>440 (>12.6)[xx]	12 (0.7)	14,900 (13.0)	> 1628 (>17.4) [xx]	>2,499 (>28.6) [xx]	>810 (>18.3)[xx]	>344 (>10.6)[xx]	>95 (>16.4) [xx]

Table 1 Legend: Age, gender, race/ethnicity, and insurance are all statistically significant at $p<0.0001$. [XX]: Cell suppressed due to small N's with unknown gender or insurance in the corresponding column.

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Table 2: Odds of early and long-term opioid use by initial provider

Initial Provider	Early use, OR (95% CI)	Long-term, OR (95% CI)
PT vs PCP	0.15 (0.13,0.17)	0.27 (0.15,0.48)
DC vs PCP	0.10 (0.09,0.10)	0.22 (0.18,0.26)
Acupuncture vs PCP	0.09 (0.07,0.12)	0.07 (0.01,0.48)
Ortho vs PCP	0.63 (0.60,0.67)	1.10 (0.92,1.30)
Emerg Med vs PCP	2.66 (2.54,2.78)	0.92 (0.77,1.10)
Neurosgn vs PCP	0.58 (0.47,0.71)	1.50 (0.88,2.58)
MD other vs PCP	0.50 (0.46,0.54)	2.03 (1.70,2.41)
Rehab vs PCP	0.54 (0.49,0.59)	1.78 (1.40,2.26)

Table 2 Legend: Primary care physician is the reference group; adjusted for race, gender, region, and insurance type. PT: physical therapy; PCP: primary care physician; DC: chiropractor; Ortho: orthopedic surgeon; Emerg Med: emergency medicine physician; Neurosgn: neurosurgeon; MD other: other physician; Rehab: rehab physician.

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Figure 1 Legend: Initially, 8,797,787 patients with low back pain (LBP) were identified. Patients with an insufficient clean period (opioid use within the last 1 year), patients with a diagnosis of LBP that was not in the first position of their diagnosis, and LBP in only inpatient settings were excluded, reducing the number of patients to 3,840,842. Patients were excluded if they were not continuously enrolled in their insurance for 24 months before and after the initial LBP visit and if they were <18 years old, reducing the number of patients to 3,840,842. Patients with exclusionary conditions, LBP that was not limited to the low back, patients with back procedures in the 12 months prior to the index LBP visit, and patients with any opioid use in the 12 months before the index visit were excluded, leaving 216,504 patients in our sample.

Figure 2 Legend: Adjusted for age, gender, race, geographic region, insurance type, physical component of Elixhauser comorbidity index, and mental comorbidities.

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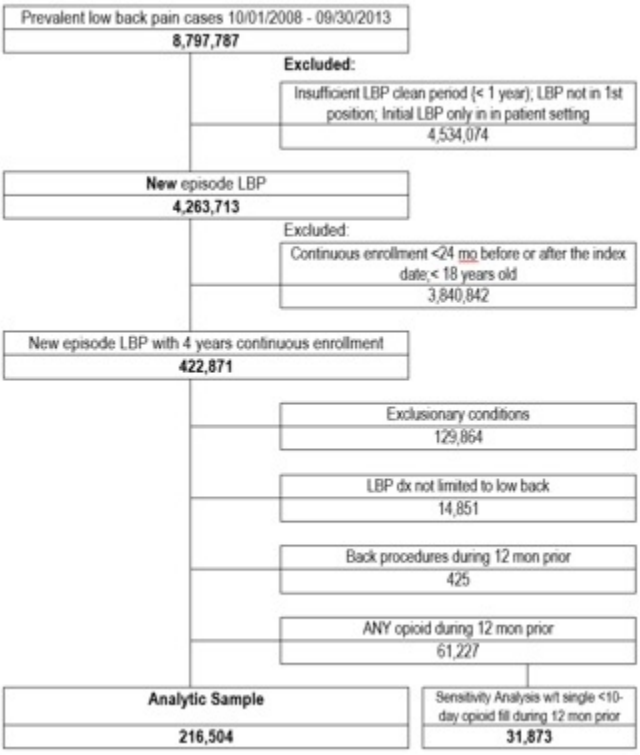

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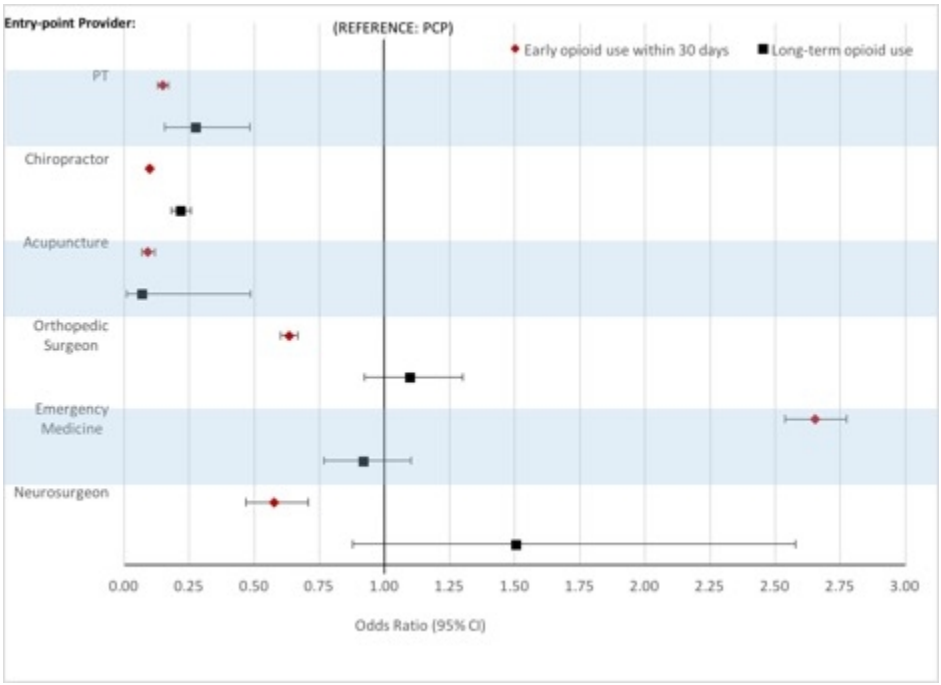
120x134mm (72 x 72 DPI)



Adjusted for age, gender, race, geographic region, insurance type, physical component of Elixhauser comorbidity index, and mental comorbidities.

165x119mm (72 x 72 DPI)

Appendix table 1: Hosmer Lemeshow and c-statistics for all logistic models

Outcome	Hosmer Lemeshow chi-square	p-value	c-statistic
Any opioid use	19.029	0.015	0.631
early opioid use	15.395	0.052	0.704
long-term opioid use	17.181	0.028	0.753

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Appendix Table 2: Bootstrapping, early opioid use

Initial Provider	n	OR (95% CI) bootstrapping	Early use, OR (95% CI)
Physical therapy	200	0.15 (0.13, 0.17)	0.15 (0.13,0.17)
Chiropractor	200	0.10 (0.09, 0.10)	0.10 (0.09,0.10)
Acupuncture	200	0.09 (0.07, 0.12)	0.09 (0.07,0.12)
Orthopedics	200	0.63 (0.60, 0.67)	0.63 (0.60,0.67)
Emergency Medicine	200	2.66 (2.54, 2.78)	2.66 (2.54,2.78)
Neurosurgeon	200	0.57 (0.48, 0.69)	0.58 (0.47,0.71)
MD Other	200	0.50 (0.46, 0.54)	0.50 (0.46,0.54)
Radiology	200	0.70 (0.67, 0.73)	0.70 (0.67,0.73)
Rehab	200	0.54 (0.49, 0.59)	0.54 (0.49,0.59)
Other	200	0.81 (0.76, 0.87)	0.81 (0.76,0.87)

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Appendix Table 3: Bootstrapping, long-term opioid use

Initial Provider	N	OR (95% CI) bootstrapping	Long-term use, OR (95% CI)
Physical therapy	200	0.26 (0.16, 0.50)	0.27 (0.15,0.48)
Chiropractor	200	0.22 (0.18, 0.26)	0.22 (0.18,0.26)
Acupuncture	200		0.07 (0.01,0.48)
Orthopedics	200	1.09 (0.92, 1.31)	1.10 (0.92,1.30)
Emergency Medicine	200	0.92 (0.77, 1.11)	0.92 (0.77,1.10)
Neurosurgeon	200	1.45 (0.88, 2.75)	1.50 (0.88,2.58)
MD Other	200	2.02 (1.71, 2.41)	2.03 (1.70,2.41)
Radiology	200	1.22 (1.08, 1.38)	1.22 (1.08,1.39)
Rehab	200	1.77 (1.42, 2.26)	1.78 (1.40,2.26)
Other	200	0.88 (0.69, 1.14)	0.88 (0.70,1.11)

Appendix Table 3 Legend: Sample size for acupuncture was too small to report for bootstrapping.

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Appendix table 4: Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

		PT	Chiro
Covariate	**Levels**	**OR (95% CI)**	**OR (95% CI)**
AGE	45-65 vs 18-44	1.02 (0.93,1.12)	0.81 (0.78, 0.83) *
	65-74 vs 18-44	1.15 (0.82,1.61)	0.77 (0.69, 0.86) *
GENDER	Female vs Male	1.16 (1.06,1.27)	0.84 (0.82, 0.87) *
RACE	Asian vs White	1.03 (0.86,1.23)	0.68 (0.64, 0.73) *
	Black vs White	0.67 (0.56,0.82) *	0.48 (0.46, 0.51) *
	Hispanic vs White	0.67 (0.57,0.78) *	0.64 (0.62, 0.67) *
	Unknown vs White	0.94 (0.75,1.19)	0.84 (0.77, 0.90) *
REGION	Midwest vs Northeast	2.11 (1.82,2.44) *	0.87 (0.83, 0.91) *
	South vs Northeast	0.88 (0.77,1.00)	0.86 (0.83, 0.89) *
	West vs Northeast	2.11 (1.83,2.42) *	1.00 (0.95, 1.04)
Pregnancy		5.79 (4.92,6.83) *	1.76 (1.62, 1.92) *
Accidents		0.74 (0.56,0.97) *	0.36 (0.32, 0.40) *
Anxiety		0.95 (0.82,1.11)	0.88 (0.84, 0.93) *
Bipolar		0.56 (0.36,0.88) *	0.93 (0.83, 1.05)
Depression		0.92 (0.79,1.08)	0.96 (0.92, 1.01)
Dementia		-	0.72 (0.43, 1.21)
ADHD		1.54 (1.17,2.04) *	0.99 (0.90, 1.09)
Alcohol use disorder		0.95 (0.60,1.49)	0.96 (0.83, 1.10)
Substance use disorder		0.88 (0.47,1.62)	0.82 (0.68, 0.99) *
Chronic Pain, fibromyalgia & Fatigue		1.44 (1.22,1.69) *	0.90 (0.84, 0.95) *
Psychotic Disorder		1.00 (0.40,2.48)	1.14 (0.87, 1.48)
Opioid use 13-24 months back		0.78 (0.69,0.87)	0.84 (0.81, 0.87) *
PT 1-24 months back		5.00 (4.45,5.62) *	1.12 (1.05, 1.20) *
Chiro any 1-24 months back		1.45 (1.17,1.79) *	6.92 (6.52, 7.35) *
Acupuncture any 1-24 months back		1.80 (1.18,2.75) *	1.39 (1.12, 1.73) *
LBP 13-24 months back		1.27 (0.98,1.65)	0.85 (0.77, 0.93) *
Elixhauser physical		0.91 (0.87,0.95) *	0.91 (0.89, 0.92) *
PT State Access	Provisional vs Limited	1.21 (1.05,1.40) *	-
	Unlimited vs Limited	1.67 (1.41,1.98) *	-
Year of index visit		1.06 (1.02,1.09) *	1.02 (1.01, 1.03) *

Appendix Table 4 Legend: Pregnancy: pregnancy in the 12 months prior to the initial LBP visit; Accidents: motor vehicle accidents in the 12 months prior to the initial LBP visit; *p < .01. Reference group for age: ages 18-44; reference group for gender: male; reference group for race: white; reference group for region: Northeast; reference group for PT State Access: limited.

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Appendix table 5: Comorbidities

		Total	Early opioid use	Long-term opioid use
N		216,504	OR (95% CI)	OR (95% CI)
ELIXHAUSER-PHYSICAL	mean (sd)	1.04 (1.35)	1.07 (1.06,1.08)*	1.24 (1.21,1.27)*
Anxiety	%	9.8	1.05 (1.01,1.09)*	1.46 (1.30,1.63)*
Bipolar	%	1.4	1.11 (1.01,1.21)*	1.41 (1.13,1.76)*
Depression/Dep. Disorder	%	10.1	1.11 (1.07,1.15)*	1.55 (1.39,1.73)*
Dementia	%	0.7	0.80 (0.70,0.92)*	0.99 (0.73,1.36)
ADHD	%	1.7	0.87 (0.80,0.95)*	1.00 (0.75,1.32)
Alcohol Use Disorder	%	1.1	1.08 (0.98,1.20)	1.28 (0.98,1.66)
Drug Use Disorders	%	0.6	1.06 (0.93,1.22)	2.34 (1.76,3.10)*
Fibromyalgia, Chronic Pain and Fatigue	%	6.3	0.96 (0.92,1.01)	1.92 (1.71,2.16)*
Post-Traumatic Stress	%	0.3	0.84 (0.69,1.03)	1.16 (0.77,1.77)
Psychotic Disorders	%	0.6	0.86 (0.74,0.99) *	0.76 (0.55,1.05)

Appendix Table 5 Legend: Mental health comorbidities were selected from the Centers for Medicare and Medicaid Services report on prevalence of mental health conditions.[17] *p<0.01;

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Appendix table 6: Propensity matching for initial Physical Therapy (PT) and initial chiropractor vs. initial Primary Care Physician (PCP)

Outcome		**OR (95% CI)**
Early opioid use	Initial PT vs. initial PCP	0.15 (0.12, 0.18)
Long-term opioid use	Initial PT vs. initial PCP	0.29 (0.12, 0.69)
Early opioid use	Initial Chiropractor vs. initial PCP	0.10 (0.09, 0.10)
Long-term opioid use	Initial Chiropractor vs. initial PCP	0.21 (0.16, 0.27)

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	4-7, figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9, table 1
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-9, table 2

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-9, table 2 NA NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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BMJ Open

An Observational Retrospective Study of the Association of Initial Health Care Provider for New-onset Low Back Pain with Early and Long-Term Opioid Use

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Primary Subject Heading:	General practice / Family practice
Secondary Subject Heading:	Addiction
Keywords:	Early and long-term opioid use, Opioid use, Back pain < ORTHOPAEDIC & TRAUMA SURGERY, PAIN MANAGEMENT, opioid

SCHOLARONE™
Manuscripts

An Observational Retrospective Study of the Association of Initial Health Care Provider for New-onset Low Back Pain with Early and Long-Term Opioid Use

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Abstract

Objective: This study examined the association of initial provider treatment with early and long-term opioid use in a national sample of patients with new-onset low back pain (LBP).

Design: A retrospective cohort study of patients with new-onset LBP from 2008-2013.

Setting: The study evaluated outpatient and inpatient claims from patient visits, pharmacy claims, and inpatient and outpatient procedures with initial providers seen for new-onset LBP.

Participants: 216,504 individuals aged 18 or older across the United States who were diagnosed with new-onset LBP and were opioid-naïve were included. Participants had commercial or Medicare Advantage insurance.

Exposures: The primary independent variable is type of initial health care provider including physicians and conservative therapists (physical therapists, chiropractors, acupuncturists).

Main Outcome Measures: Early opioid use (within 30 days of the index visit) following new LBP visit and long-term opioid use (starting within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months).

Results: Early use of opioids was 22%. Patients who received initial treatment from chiropractors or physical therapists had decreased odds of early and long-term opioid use compared to those who received initial treatment from primary care physicians (PCPs) [AOR (95% CI): 0.10 (0.09,0.10) and 0.15 (0.13,0.17) respectively]. Compared to PCP visits, initial chiropractic and physical therapy also were associated with decreased odds of long-term opioid use in a propensity-score matched sample [OR (95% CI): 0.21 (0.16, 0.27) and 0.29 (0.12, 0.69) respectively].

Conclusions: Initial visits to chiropractors or physical therapists is associated with substantially decreased early and long-term use of opioids. Incentivizing use of conservative therapists may be a strategy to reduce risks of short- and long-term opioid use.

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Strengths and Limitations of this Study

- This is a nationwide study comparing short and long term opioid use among patients with low back pain (LBP) who seek initial care from conservative therapists, physician specialists and primary care physicians.
- We go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP.
- We provide a broader depiction of conservative therapy than prior studies, as we included chiropractors and acupuncturists, as well as other MD specialists.
- This study assesses the impact of state regulations of access to physical therapy on choice of initial provider.
- This is a claims based study; therefore, causation cannot be inferred, and different patient characteristics we could assess is limited.

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Introduction

Over the past decade, there has been an increase in opioid use in the United States, with over 12 million Americans reporting long-term opioid use or misuse in 2015.[1-3] The National Survey on Drug Use and Health reported over 42,000 prescription opioid-related deaths in 2016, with total estimated costs of prescription opioid use reaching $78.5 billion.[4,5] One of the most common conditions for which opioids are prescribed is low back pain (LBP).[2-4] Several studies have reported that opioids are the most frequently prescribed medication for treatment of LBP,[4,5] and more than half of opioid users report having a history of back pain.[6] This frequency of opioid prescribing is particularly concerning given that LBP is one of the three most common conditions for which Americans seek medical care.[2,7]

Given the high prevalence of LBP, several treatment guidelines have been issued for treatment, and specifically discourage opioids to treat pain. The American College of Physicians (ACP) and the Centers for Disease Control (CDC) recommend non-pharmacologic treatments including exercise, physical therapy (PT), spinal manipulation, acupuncture, and massage.[2,8] These guidelines indicate that opioids should not be considered as a treatment option for LBP unless recommended treatments fail and if the benefits of their use outweigh the risk for the individual patient.[2,8] Prior to the release of these recommendations, physician vists for new-onset LBP were much more common than non-pharmacologic therapies like chiropractic care, PT, and acupuncture .[8-11]

Several studies have attempted to elucidate the predictors of opioid use among patients with LBP. Comparisons of the treatment patterns of primary care physicians (PCPs) and conservative therapists (defined as chiropractors, physical therapists, acupuncturists) suggest that the use of conservative therapies for LBP may decrease the likelihood of opioid use.[9] Despite

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these findings, there has been little research comparing early and long-term opioid use among patients seeking initial care from various providers, including primary care physicians, chiropractors, physical therapists, and acupuncturists as well as patients seeing orthopedic surgeons, neurosurgeons and emergency physicians.[12-14] The purpose of this study is to examine the association of type of initial provider with subsequent early and long-term opioid use in a national sample of patients with new-onset LBP whose treatment could reasonably be managed by non-pharmacologic therapy.

Methods

Study Sample

We conducted a retrospective study of patients seen by a health care provider for new-onset LBP management and who were opioid-naïve at the time of the initial visit (Boston Medical Center IRB approval number: H-36499). We used de-identified administrative claims data from the OptumLabs Data Warehouse (OLDW), which includes medical and pharmacy claims, laboratory results, and enrollment records for commercial and Medicare Advantage (MA) enrollees. The database contains longitudinal health information on enrollees and patients, representing a diverse mixture of ages, ethnicities and geographical regions across the United States.

The various health plans individuals were enrolled in all provide comprehensive insurance coverage for physician, hospital, and prescription drug services.

The index episode of LBP was identified using claims from 2008-2013 with additional claims data covering 2006-2015 to ascertain pre-index visit opioid use and low back conditions and to allow a follow-up period. Patients needed to be continuously enrolled for at least 24 months both before and following the index date (total 48 months) with both medical and

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pharmacy claims data available during that period. The study sample included adults aged 18 years or older with a new outpatient diagnosis of LBP who had commercial or Medicare Advantage insurance.

To qualify, LBP diagnosis appeared in the first location on a patient's index date insurance claim. New-onset LBP was defined as no diagnosis of LBP or back procedures, including spinal surgery, spinal injections, and spinal nerve stimulators during the 12-month period prior to the index event (Figure 1). Given the heterogeneity of claims data in a commercial insured population, we constructed our inclusion and exclusion criteria with the specific purpose of maximizing the likelihood that our analytic sample comprised our target population.

Exclusion Criteria

Patients were excluded if they had 1) a prescription for opioids in the 12 months prior to the index event (see Appendix 1a for a list of opioids included), 2) a diagnosis of neoplasia in this 12-month period or within a 3-month period after the index LBP event, or 3) a LBP-related diagnoses that would typically not be amenable to conservative therapy in the 3 months on or following the index date (See Appendix 1b-d for ICD-9 and CPT Codes for Inclusion/Exclusion Critiera). Each patient was only included in the study once.

Dependent variables

Early opioid use was defined as an opioid fill within 30 days of the index visit. Long-term use was defined as an initial opioid fill within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months. This definition relied on previous literature.[6,15]

Independent variables

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Patient characteristics

We identified patient characteristics and comorbidities using ICD-9 codes for the claims data in the two years prior to the index event. Characteristics included age, sex, race/ethnicity, insurance (commercial or Medicare Advantage), and state of residence (which was mapped to one of 4 United States census regions: Northeast, South, Midwest and West). Race and ethnicity are defined as Black, Hispanic, Asian, or White (Table 1). Ethnicity was assigned by an external vendor based on a structured, rule-based system that combines analysis of first names, middle names, surnames, and surname prefixes and suffixes, with geographic reference files. Values were then categorized to comply with data de-identification requirements. Physical comorbidities were assessed using a modification of the Elixhauser index[15] in which mental health conditions were excluded. Other comorbidities, listed in Table 2, included 8 mental health conditions and a condition comprising chronic pain, fibromyalgia and fatigue. The latter conditions were included based on prior studies that have reported an association between such conditions and opioid use[16,17] and their specifications were based on the Centers for Medicare and Medicaid Serivces Chronic Conditions Data Warehouse.[18]

Based on the index claim date of patients with an eligible LBP diagnosis, initial providers were characterized as physical therapist, chiropractor, acupuncturist, primary care physician, orthopedic surgeon, emergency medicine physician, neurosurgeon, radiologists, other non-physicians (physician assistant or nurse practitioners), or physical medicine and rehabilitation physician according to provider specialty and procedure codes. If a patient saw both a physician and a conservative therapist on the index date, the initial provider was assumed to be the physician, although this was notably a small number of individuals (n=262).

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Patient access to PT in every state was classified as either 'limited', 'provisional', or 'unrestricted', based on the three levels of patient access outlined by the American Physical Therapy Association.[19] To access PT for their initial LBP visit in limited access states, patients must have a prior relevant medical diagnosis, a recent diagnosis from a physician or other specified clinician, and/or a prior physician referral to PT. States with provisional access permitted patients to see physical therapists with some provisions that vary by state. Restrictions in provisional access states include time and/or visit limits and physician referrals for specific interventions. Patients in unrestricted states do not face these restrictions when seeking initial care from a physical therapist. There were six states with limited access to PT, 26 states with provisional access, and 18 states with unrestricted access to PT.[19]

Statistical Analyses

The main analyses included multivariable logistic regressions with early opioid use and long-term opioid use as outcomes and entry-point provider as the main independent variable. The reference group for these comparisons was patients who visited PCP first for the LBP. All models were adjusted for age, sex, race/ethnicity, geographic region, insurance type, the Elixhauser physical index as a continuous count of physical co-morbidities and, individually, mental health comorbidities.

As a supplemental alternative to adjusting for baseline confounding through regression adjustment, we invoked two-to-one propensity score matching (2 PCP: 1 physical therpist or 2 PCP: 1 chiropractor) without replacement to achieve baseline covariate balance among patients who initially saw chiropractor first, saw a physical therapist first or who saw PCP first.[20,21] The propensity scores were calculated as predicted probabilities of chiropractor first and a physical therapist first as opposed to PCP first as a function of the following matching variables: age, sex,

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race/ethnicity, baseline comorbidities, geographic region, calendar year of the index visit, copay, deductible, plan type, history of pregnancy within 12 months, history of vehicular accidents within 12 months, history of opioid use within the year prior to the opioid free period, LBP diagnoses in the 13-24 months prior to the index visit, and prior PT visits. The propensity score for PT also considered the state PT access category, but the chiropractor propensity score did not. We examined the covariate balance in the matched samples through the standardized mean differences of each covariate. Finally, we applied a logistic model using the matched sample to assess the association between chiropractor compared to PCP as the initial provider seen and PT compared to PCP as the initial provider seen with the outcomes early term opioid use and separately long-term opioid use (binary variables). The caliper for propensity matching was set to 0.001 for both PT and chiropractor models.

In stage one of the propensity analysis, multivariable odds of initial chiropractic care and initial physical therapist versus initial PCP as a function of baseline covariates were measured. Covariates measured include age, gender, race, geographic region, all mental and physical comorbidities included in the previous models, pregnancy and motor vehicle accidents in the 12 months prior to the LBP visit, opioid use in the 13-24 months prior to the LBP index visit, PT, chiropracitic care, and acupuncture in the 24 months prior to the LBP visit, and year of index visit. PT state access was only used for the PT vs PCP propensity analysis.

For all logistic models, we calculated adjusted odds ratios with 95% Wald confidence intervals. We also evaluated overall model fit, model discrimination (C statistic) and calibration (Hosmer Lemeshow test) for all logistic models (Appendix 2). While the Hosmer Lemeshow models were significant, this was likely due to the large sample sizes used for this study. The differences between the observed and expected values within the decile groups was relatively

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small suggesting credible calibration of the models and statistical significance due to the large sample sizes.[22,23] We further validated the covariate-adjusted ORs of early use and long-term use as a function of initial provider using the bootstrap method.[24] The resampling rate was 200 with a two-third/one-third sampling ratio. The bootstrapped estimates were then used to construct means and 95% confidence intervals for the ORs.

Patient and Public Involvement

No patient involvement.

Results

A total of 8,797,787 patients had a visit with a provider for LBP during the study period, and 216,504 met all inclusion/exclusion criteria (Figure 1). More than half the patients initially saw a PCP (n=114,782, 53.0%), and the most frequent initial conservative provider seen was chiropractor (50,041, 23.1%) followed by physical therapist 3,499 (1.6%) and acupuncturist 1,839 (0.8%). Patient demographics by initial provider are shown in Table 1. Most patients had commercial insurance (183,117, 84.7%); the remainder had Medicare Advantage coverage. Of patients with an acupuncturist as the initial provider type, nearly all (99.3%) had commercial insurance. For all other initial provider types, 87-89% of patients had commercial insurance. Approximately 18% of patients received an opioid fill within 3 days of the initial LBP visit, 22% received such a fill within the first 30 days and 1.2% met criteria for long-term use. 18% of patients received fast-acting opioids, while 17.4% received prescription NSAIDs and we postulate that many more likely received non-prescription NSAIDs, as they are available over the counter. The choice of initial provider varied by state PT access category. For example, in limited access states, 55.2% of initial providers were PCP, 0.9% were physical therapists, and 25.7% were chiropractors. In provisional access states, the rates were 51.7% for PCPs, 1.6% for

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physical therapists, and 23.2% for chiropractors, and in unrestricted access states, the rates were 55.8% for PCPs, 2.6% for physical therapists, and 22.6% for chiropractors.

Initial provider was associated with short and long-term opioid use outcomes in the adjusted multivariate models (Table 2). Compared to seeing a PCP as initial provider, patients who first saw conservative therapists (chiropractor, acupuncturists and physical therapists) all had significantly decreased odds of both early and long-term opioid use. For early opioid use, patients initially visiting chiropractors had 90% decreased odds [95% CI: (0.09,0.10)] while those visiting an acupuncturists had 91% decreased odds [95% CI: (0.07,0.12)] and those visiting physical therapists had 85% decreased odds [95% CI: (0.13,0.17)]. Chiropractors, acupuncturists and physical therapists all had major decreased odds of long term opioid use compared to those who initially saw PCPs (0.22, 95% CI: (0.18,0.26); 0.07, 95% CI: (0.01,0.48); 0.27, 95% CI: (0.15,0.48) respectively). Compared to PCPs, orthopedic surgeons, neurosurgeons and rehab physicians as initial providers decreased patients' odds of early opioid use (0.63, 95% CI: (0.60,0.67); 0.58, 95% CI: (0.47,0.71); 0.54, 95% CI: (0.49,0.59), respectively), while patients seeing emergency physicians initially had significantly increased odds of early opioid use (2.66, 95% CI: (2.54,2.78)). However, compared to PCP as first provider, odds for long-term opioid use were no longer significantly different for orthopedic surgeons, neurosurgeons, and emergency physicians (1.10, 95% CI: (0.92,1.30); 1.50, 95% CI: (0.88,2.58); 0.92, 95% CI: (0.77,1.10), respectively), but were significantly increased for rehab physicians (1.78, 95% CI: (1.40,2.26)). (Table 2). The estimates reported using bootstrapping methods indicated little or no differences with the actual results (Appendix 3 and 4).

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Patients with anxiety, bipolar disorder, and depression had significantly increased odds of long-term opioid use, as did those diagnosed with drug use disorders and fibromyalgia/chronic pain/fatigue (Table 2).

Propensity-score matched odds of long-term opioid use were significantly lower for chiropractic care first compared to PCP first and for PT first as compared to PCP first with odds ratios consistent with findings in our primary covariate-adjusted logistic models (detailed results presented in Appendix 5).

Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

Patients in states with provisional access to PT had 1.21 (95% CI: 1.05, 1.40) times the odds of seeing a physical therapist initially while patients in states with unrestricted access to PT had 1.67 (95% CI: 1.40, 1.98) times the odds of seeing a physical therapist initially all compared to patients in states with limited PT access (Appendix 6).

Discussion

Initial treatment from conservative therapists in those with LBP was associated with a marked decrease in the odds of short and long term opioid use. To our knowledge, this is one of the first national studies to compare short and long term opioid use among patients with LBP who receive care from conservative therapists, physician specialists and PCPs. Although the impact of unmeasured confounders cannot be ruled out in this retrospective observational cohort study, the findings warrant careful consideration.

Several factors may help explain the apparent protective effect of conservative therapists. Since non-physicians are unable to prescribe opioids, patients seeking conservative therapy do not receive opioid prescriptions at the index visit, and subsequent visits to an MD would be

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required to obtain such prescriptions. There may be selection bias among patients choosing to seek initial treatment from conservative therapists, and such biases could be related to educational level or preferences which may also result in decreased desire for those patients to use opioids. Additionally, the conservative therapy provided may result in decreased pain and improved back-related function so that patients do not need or seek opioid medications. A growing body of evidence suggest that spinal manipulation, massage, acupuncture, and superficial heat are effective for reducing acute low back pain intensity and improving function.[23,25] The conservative therapists studied in this analysis can incorporate one or more of these approaches: physical therapist (manipulation, massage, heat), chiropractor (manipulation, massage, heat), and acupuncturist (acupuncture, massage).[23] Therefore and importantly, early engagement of conservative therapists may decrease initial opioid prescriptions in association with MD visits by providing the opportunity to incorporate evidence-based non-pharmacological interventions.

Notably, state access to PT had a considerable association with choice of initial provider. Compared to states with limited access to PT, patients in states with unrestricted and provisional access had 67% and 21% higher odds of visiting physical therapists initially, respectively. Given that initial PT is associated with significant reductions in early and long-term opioid use, these observations are potentially important.

The discrepancy between early and long-term use among PCPs and physicians specialists is also interesting. While patients who initially see orthopedic surgeons, neurosurgeons, rehabilitation physicians, and other physicians have significantly lower odds of early opioid use compared to PCPs, patients who initially see these physicians have similar or increased odds of long-term opioid use compared to PCPs. While we do not have a measure of pain severity, we hypothesize that physician specialists are trying to avoid prescribing opioids at the index visit,

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but if patients return at follow-up due to persistent pain, physicians are likely to prescribe opioids.

Comparisons to prior studies

Our results are consistent with prior studies showing high rates of opioid prescription fills for patients with LBP who were seen by emergency department physicians.[3,26] While there are very few studies suggesting that PT and chiropractic care are used in emergency departments in the United States[27], other countries have successfully introduced physical therapists into emergency departments to treat patients with LBP.[28-30]

Certain comorbidities were also associated with increased odds of opioid use. Patients with fibromyalgia, chronic pain, and fatigue and those with certain psychiatric conditions, including anxiety, bipolar disorder, and depression had greater odds of long-term opioid use than patients without these disorders. This is consistent with recent evidence suggesting that adults with mental health conditions account for half of opioid prescriptions in the United States.[31]

A recent study by Frogner et al. also found that LBP patients who saw physical therapists initially had lower opioid use, although this study only focused on six states.[13] Another recent study by Hayward et al. evaluated the use of non-opioid treatments from various providers, including physical therapists and physicians, however this was a descriptive study across only 16 states.[32] Our study examines the association of conservative therapy on opioid use with a sample that is national in scope. We also provide a broader depiction of conservative therapy, as we included chiropractors and acupuncturists in addition to physical therapists, as well as other MD specialists. Importantly, we find that conservative therapists other than physical therapists, including chiropractors and acupuncturists, when seen first after a new episode of LBP are apparently protective of early and long term use of opioids when compared with PCP's. Finally,

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we go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP, using rigorous definitions of recent onset.

Fritz et al. found that early PT was associated with decreased opioid prescriptions[33], and a review by Ojha et al. noted that early PT as treatment for musculoskeletal disorders was associated with decreased frequency of opioid prescriptions, although this was based on a limited number of outcomes.[34] Thackerary et al. also suggested that the odds of receiving an opioid prescription among Medicaid beneficiaries were reduced for those who had a PT consult, as compared to those who did not.[35] While these studies did not measure the odds of opioid use among patients who initially saw physical therapists compared to other initial providers, our results are consistent with previously published reports that PT is associated with lower odds of opioid use.

Limitations

There are several limitations to this study. Analysis was conducted using claims data, limiting our generalizability beyond commercial and Medicare Advantage enrolled patients. However, the sample is national in scope and provides a range of sociodemographic and clinical characteristics. The observational nature of the study and the use of claims data limited our ability to eliminate the influence of unmeasured confounders. In particular, confounding by indication may bias our results. Patients who seek early treatment with non-pharmacologic practitioners may be more likely to have mild back pain that does not require more aggressive treatment such as opioids, compared to individuals with more severe back pain who may be more likely to see practitioners able to prescribe opioids. Studies have suggested that those with more severe LBP are more likely to receive opioids,[36] and if patients with less severe pain were more

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likely to choose conservative therapists rather than physicians, this could contribute to overestimation of the protective effect of conservative therapy on opioid use. Several prior studies have shown comparable baseline pain scores for those who choose conservative therapists compared to those who choose to see physicians initially, however it is important to note that these studies had different patient populations than this study as they were conducted either only in one state or in countries other than the United States.[36-40] Other unmeasured confounders may include patient preferences and behavioral characteristics. For example, those who chose conservative therapists as initial providers for LBP may have preferences to avoidpharmacological and/or opioid therapy. Therefore, while the associations between initial health care providers for LBP and subsequent opioid therapy found in our analyses have potentially important implications, one cannot infer causality due to the observational retrospective nature of the study.

Policy Implications and Future Research

In conclusion, our results suggest that use of conservative therapists as initial providers for new-onset LBP are associated with lower odds of early and long-term use of opioids compared with PCPs. Further research in other settings and prospective pragmatic trials will be useful to confirm our findings and to better understand other factors that influence choice of initial providers for LBP. Future research should include personal factors such as preferences related to opioid use, and medical, non-medical and specialists as initial providers. Factors related to health plan benefit design such as out-of-pocket costs for treatment alternatives (e.g. PT and chiropractor visits, opioids) and impact of gatekeeper requirements on care patterns should be investigated.

Contributorship statement

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Drs. Kazis, Rothendler, Ameli, Cabral, McDonough, Carey, and Saper were responsible for project design and conceptualization. Drs. Ameli and Cabral were responsible for data analysis. Drs. Kazis, Rothendler, Ameli, Cabral, McDonough, Carey, Saper, and Stein and Ms. Garrity were responsible for writing of the manuscript. Drs. Sanghavi, Elton, and Fritz provided critical feedback during the analysis and writing of the manuscript. All authors were involved in the editing and review of the manuscript.

Competing interests

Drs. Ameli, Sanghavi, and Elton work for OptumLabs but do not have any competing interests to report.

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Data sharing statement

Certain data from OptumLabs Data Warehouse may be available upon request.

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Table 1: Patient characteristics

	Entry-point provider									
		Conservative Therapist			Physician					
	Total	Chiropractor	Physical Therapist	Acupuncture	Primary Care	Orthopedic Surgeon	Emergency Medicine	MD Other	Rehab	Neurosurgeon
Full Sample – N (%)	216,504 (100)	50,014 (23.1)	3,499 (1.6)	1,839 (0.8)	114,782 (53.0)	9,335 (4.3)	8,746 (4.0)	4,422 (2.0)	3,246 (1.5)	578 (0.3)
Age, year – mean (STD)	48.1 (15.9)	45.7 (14.9)	47.0 (15.7)	42.4 (10.6)	47.7 (15.4)	50.1 (16.4)	50.1 (18.3)	51.3 (15.3)	46.9 (15.0)	52.2 (14.8)
Gender – N (%)										
Female	108,347 (50.1)	22,808 (45.6)	1,995 (57.1)	972 (52.9)	58,182 (50.7)	4,648 (49.8)	4,560 (52.2)	2,282 (51.6)	1,554 (47.9)	245 (42.4)
Male	107,660 (49.8)	27,193 (54.4)	>1,493 (>42.6) [xx]	>856 (>46.5) [xx]	56,517 (49.2)	4,674 (50.1)	>4,175 (>47.7) [xx]	2,140 (48.4)	>1,681 (>51.8)[xx]	333 (57.6)
Race/ethnicity - N (%)										
Black	18,907 (8.7)	2,190 (4.4)	191 (5.5)	45 (2.4)	11,755 (10.2)	802 (8.6)	1,192 (13.6)	494 (11.2)	208 (6.4)	50 (8.7)
Hispanic	20,936 (9.7)	3,766 (7.5)	263 (7.5)	224 (12.2)	12,212 (10.6)	752 (8.1)	860 (9.8)	541 (12.2)	293 (9.0)	38 (6.6)
Asian	9,344 (4.3)	1,636 (3.3)	224 (6.4)	747 (40.6)	4,885 (4.3)	354 (3.8)	270 (3.1)	194 (4.4)	218 (6.7)	15 (2.6)
White	159,503 (73.7)	40,709 (81.4)	2,666 (76.2)	732 (39.8)	81,971 (71.4)	7,046 (75.5)	6,115 (69.9)	3,013 (68.1)	2,394 (73.8)	449 (77.7)
Unknown (Missing)	7,814 (3.6)	1,713 (3.4)	155 (4.4)	91 (4.9)	3,959 (3.4)	381 (4.1)	309 (3.5)	180 (4.1)	133 (4.1)	26 (4.5)
Insurance - N (%)										
Commercial	183,117 (84.7)	44,520 (89.0)	3,048 (87.1)	1,827 (99.3)	99,842 (87.0)	7,696 (82.5)	6,236 (71.3)	3,601 (81.4)	2,891 (89.1)	472 (81.7)
Medicare Advantage	32,937 (15.2)	5,476 (11.0)	>440 (>12.6)[xx]	12 (0.7)	14,900 (13.0)	> 1628 (>17.4) [xx]	>2,499 (>28.6) [xx]	>810 (>18.3)[xx]	>344 (>10.6)[xx]	>95 (>16.4) [xx]

Table 1 Legend: Age, gender, race/ethnicity, and insurance are all statistically significant at $p<0.0001$. [xx]: Cell suppressed due to small N's with unknown gender or insurance in the corresponding column. Two additional initial type of providers – other non-MD (eg. Physician assistants, advance practice nurses) and radiologist - were included in the analyses but not reported in this table. Outcomes with a sample size <11 are not shown due to small sample size. There were a small number of individuals with unknown gender and insurance type, and if we provided exact n's, readers may be able to infer the unknown n's which would be problematic since we cannot disclose n<11 for purposes of confidentiality of the data. For example, in Table 1 under Male PT, >1493 means that there was an unknown gender row or column with n<11. Therefore, the number of male PT first individuals is between 1,493 and 1,504.

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Table 2: Odds of early and long-term opioid use by initial provider

		Early use, OR (95% CI)	Long-term, OR (95% CI)
Initial provider	PT (N=3,499)	0.15 (0.13,0.17)	0.27 (0.15,0.48)
	DC (N=50,014)	0.10 (0.09,0.10)	0.22 (0.18,0.26)
	Acupuncture (N=1,839)	0.09 (0.07,0.12)	0.07 (0.01,0.48)
	Ortho (N=9,335)	0.63 (0.60,0.67)	1.10 (0.92,1.30)
	Emerg Med (N=8,746)	2.66 (2.54,2.78)	0.92 (0.77,1.10)
	Neurosgn (N=578)	0.58 (0.47,0.71)	1.50 (0.88,2.58)
	MD other (N=4,422)	0.50 (0.46,0.54)	2.03 (1.70,2.41)
	Rehab (N=3,246)	0.54 (0.49,0.59)	1.78 (1.40,2.26)
Age	45-64 vs 18-44	1.07 (1.05,1.10)	1.32 (1.19,1.46)
	65-74 vs 18-44	0.89 (0.82,0.97)	0.79 (0.54,1.15)
	75+ vs 18-44	0.80 (0.72,0.89)	0.67 (0.45,1.00)
Sex	Female vs. male	0.83 (0.81,0.85)	0.82 (0.76,0.89)
Race	Asian vs White	0.49 (0.46,0.52)	0.29 (0.20,0.42)
	Black vs White	0.90 (0.87,0.94)	0.87 (0.76,0.99)
	Hispanic vs White	0.79 (0.76,0.82)	0.69 (0.59,0.81)
	Unknown vs White	0.84 (0.79,0.89)	0.65 (0.51,0.83)
Region	Midwest vs Northeast	0.78 (0.75,0.81)	0.74 (0.64,0.87)
	South vs Northeast	1.11 (1.08,1.14)	1.22 (1.11,1.34)
	West vs Northeast	1.01 (0.97,1.04)	1.17 (1.02,1.34)
Insurance type	Medicare <65 y/o vs commercial insurance	0.98 (0.89,1.08)	3.77 (3.19,4.46)
	Medicare ≥65 y/o vs commercial insurance	0.98 (0.89,1.08)	2.24 (1.54,3.26)
Comorbidities	Anxiety	1.05 (1.01,1.09)	1.46 (1.30,1.63)
	Bipolar disorder	1.11 (1.01,1.21)	1.41 (1.13,1.76)
	Depression	1.11 (1.07,1.15)	1.55 (1.39,1.73)
	Dementia	0.80 (0.70,0.92)	0.99 (0.73,1.36)
	ADHD	0.87 (0.80,0.95)	1.00 (0.75,1.32)
	Alcohol use disorder	1.08 (0.98,1.20)	1.28 (0.98,1.66)
	Substance use disorder	1.06 (0.93,1.22)	2.34 (1.76,3.10)
	Fibromyalgia/Chronic Pain/Fatigue	0.96 (0.92,1.01)	1.92 (1.71,2.16)
	PTSD	0.84 (0.69,1.03)	1.16 (0.77,1.77)
	Psychotic disorder	0.86 (0.74,0.99)	0.76 (0.55,1.05)
	Elixhauser physical	1.07 (1.06,1.08)	1.24 (1.21,1.27)

Table 2 Legend: The following variables were all included in the regression: Age, gender, race/ethnicity, insurance, Elixhauser, which includeds physical comorbidities and mental health comorbidities. Primary care physician is the reference group (N=114,782); adjusted for race/ethnicity, gender, region, and insurance type. PT: physical therapy; PCP: primary care physician; DC: chiropractor; Ortho: orthopedic surgeon; Emerg Med: emergency medicine physician; Neurosgn: neurosurgeon; MD other: other physician; Rehab: rehab physician.*p<0.01. Two additional initial providers – other non-MD (eg. Physician assistants, advance practice nurses) and radiologist - were included in the analyses but not reported in this table.

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Figure 1 Legend: Initially, 8,797,787 patients with low back pain (LBP) were identified. Patients with an insufficient clean period (LBP within the last 1 year), patients with a diagnosis of LBP that was not in the first position of their diagnosis, and LBP in only inpatient settings were excluded, reducing the number of patients to 4,263,713. Patients were excluded if they were not continuously enrolled in their insurance for 24 months before and after the initial LBP visit and if they were <18 years old, reducing the number of patients to 422,871. Patients with exclusionary conditions, LBP that was not limited to the low back, patients with back procedures in the 12 months prior to the index LBP visit, and patients with any opioid use in the 12 months before the index visit were excluded, leaving 216,504 patients in our sample.

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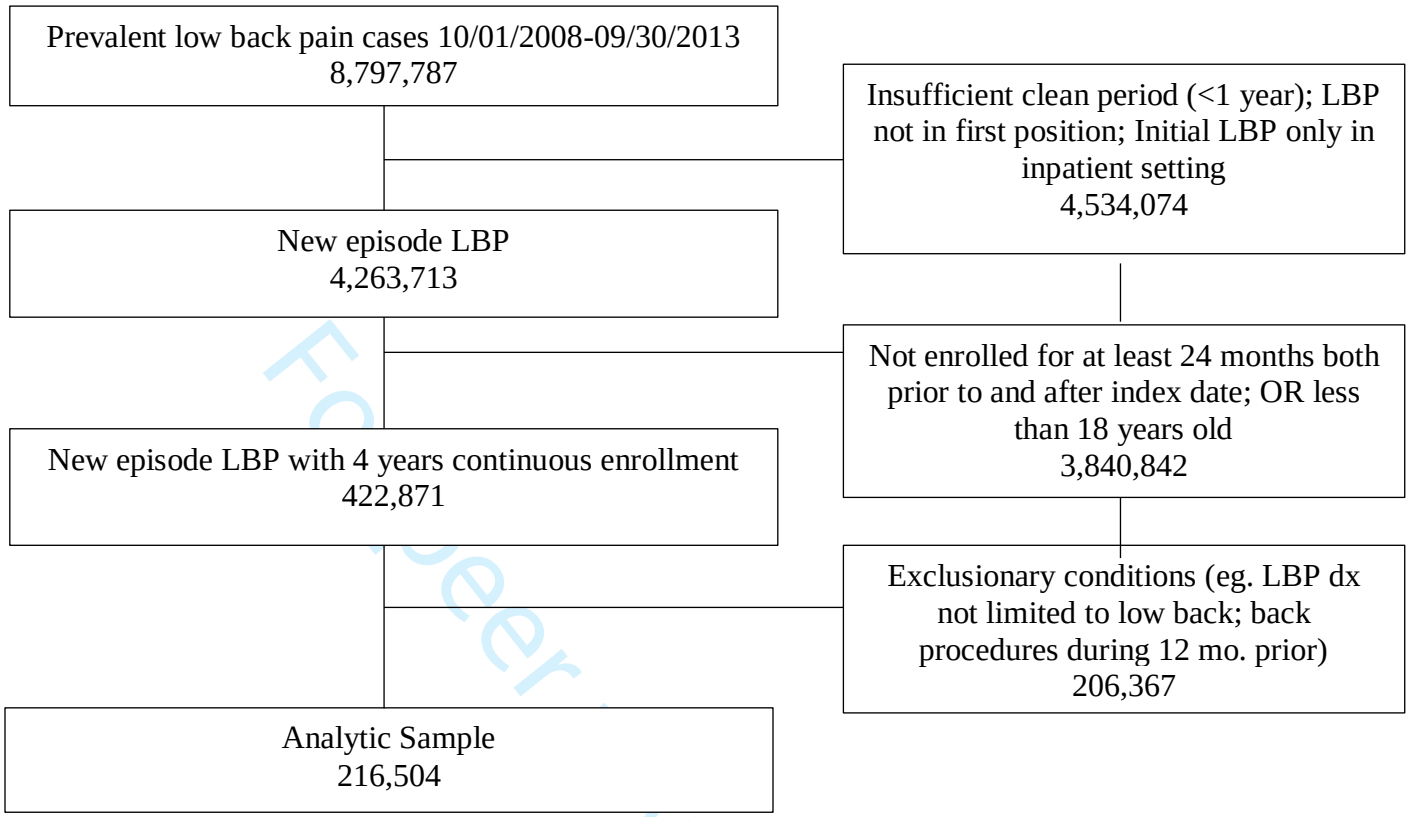
Figure 1: Inclusion and exclusion criteria



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Appendix 1: ICD-9 and CPT Codes for Inclusion/Exclusion Criteria

Appendix 1a: Drugs classified as opioids

The following drugs were identified as opioids with over 10,000 NDC codes: Buprenorphine, Codeine, Dihydrocodeine, Fentanyl LA, Fentanyl SA, Hydrocodone LA, Hydrocodone SA, Hydromorphone LA, Hydromorphone SA, Levomethadyl, Levorphanol, Meperidine, Methadone, Morphine LA, Morphine SA, Naltrexone, Opium, Oxycodone LA, Oxycodone SA, Oxymorphone LA, Oxymorphone SA, Pentazocine, Propoxyphene, Tapentadol LA, Tapentadol SA, Tramadol LA, Tramadol SA.

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Appendix 1b: ICD-9 LBP Diagnoses Inclusion/Exclusion Criteria

ICD-9 code	Description	Include as location-specific LBP index diagnosis	Exclusion if in clean period prior to index diagnosis	Exclusion if on index date or within 3 months afterwards
353.4	Lumbosacral root lesions, not elsewhere classified	x	x	
721.3	Lumbosacral spondylosis without myelopathy	x	x	
721.42	Spondylosis with myelopathy, lumbar region	x	x	
722.1	Displacement of thoracic or lumbar intervertebral disc without myelopathy	x	x	
722.32	Schmorl nodes, lumbar region	x	x	
722.51	Degeneration of thoracic or lumbar intervertebral disc	x	x	
722.52	Degeneration of lumbar or lumbosacral intervertebral disc	x	x	
722.93	Other and unspecified disc disorder of lumbar region	x	x	
724.2	Lumbago	x	x	
724.3	Sciatica	x	x	
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	x	x	
724.5	Unspecified backache	x	x	
724.6	Disorders of sacrum	x	x	
739.3	Non-allopathic lesion of lumbar region, not elsewhere classified	x	x	
739.4	Non-allopathic lesion of sacral region, not elsewhere classified	x	x	
846.0	Sprain and strain of lumbosacral (joint) (ligament)	x	x	
846.1	Sprain and strain of sacroiliac (ligament)	x	x	
846.2	Sprain and strain of sacrospinatus (ligament)	x	x	
846.3	Sprain and strain of sacrotuberous (ligament)	x	x	
846.8	Other specified sites of sacroiliac region sprain and strain	x	x	
846.9	Unspecified site of sacroiliac region sprain and strain	x	x	
847.2	Lumbar sprain and strain	x	x	
847.3	Sprain and strain of sacrum	x	x	
847.4	Sprain and strain of coccyx	x	x	
722.10	Displacement of lumbar intervertebral disc without myelopathy	x	x	
722.73	Intervertebral disc herniation Intervertebral disc disorder with myelopathy lumbar region	x	x	
724.02	Spinal stenosis, lumbar region, without neurogenic claudication	x	x	
724.03	Spinal stenosis, lumbar region, with neurogenic claudication	x	x	
756.11	Spondylolysis, lumbosacral region (congenital)	x	x	
721.5	Kissing spine		x	
721.6	Ankylosing vertebral hyperostosis		x	
721.7	Traumatic spondylopathy		x	
721.8	Other allied disorders of spine		x	

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721.90	Spondylosis of unspecified site without mention of myelopathy		x	
721.91	Spondylosis of unspecified site with myelopathy		x	
722.30	Schmorl nodes, unspecified region		x	
722.90	Other and unspecified disc disorder of unspecified region		x	
724.8	Other symptoms referable to back		x	
724.9	Other unspecified back disorders		x	
847.9	Sprain and strain of unspecified site of back		x	
722.2	Displacement of intervertebral disc, site unspecifi ed, w/o myelopathy		x	
722.6	Degeneration of intervertebral disc site unspecified		x	
724.00	Spinal stenosis of unspecified region		x	
724.09	Spinal stenosis of other region		x	
738.4	Acquired spondylolisthesis		x	
738.5	Other acquired deformity of back or spine		x	
756.12	Spondylolisthesis (congenital)		x	
806.0-806.9	Fracture of vertebral column with spinal cord injury		x	x
805.0-805.9	Fracture of vertebral column without mention of spinal cord injury		x	x
733.1x	Pathologic fractures		x	x
839.00–839.59	Vertebral dislocations		x	x
720.0–720.9	Inflammatory spondyloarthropathies		x	x
324.1	Intraspinal abscess		x	x
140–239.9	Cancer/neoplasms		x	x
730–730.99	Osteomyelitis		x	x
353.2	Cervical root lesions, not elsewhere classified			
353.3	Thoracic root lesions, not elsewhere classified			
721.0	Cervical spondylosis without myelopathy			
721.1	Cervical spondylosis with myelopathy			
721.2	Thoracic spondylosis without myelopathy			
721.41	Spondylosis with myelopathy, thoracic region			
722.0	Displacement of cervical intervertebral disc without myelopathy			
722.11	Displacement of thoracic intervertebral disc without myelopathy			
722.4	Degeneration of cervical intervertebral disc			
722.71	Intervertebral disc disorder with myelopathy, cervical region			
722.72	Intervertebral disc disorder with myelopathy, thoracic region			
722.81	Postlaminectomy syndrome, cervical region			
722.82	Postlaminectomy syndrome, thoracic region			
722.91	Other and unspecified disc disorder, cervical region			
722.92	Other and unspecified disc disorder, thoracic region			
723.0	Spinal stenosis in cervical region			

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723.4	Brachial neuritis or radiculitis NOS			
724.01	Spinal stenosis, thoracic region			

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Appendix 1c: ICD-9 Procedures for Exclusion Critiera

ICD-9 code	Description
03.01	Removal Of Foreign Body From Spinal Canal
03.02	Reopening Of Laminectomy Site
03.09	Other Exploration And Decompression Of Spinal Cana
03.1	Division Of Intraspinal Nerve Root
03.2x	chordotomy
03.4	Excision Or Destruction Of Lesion Of Spinal Cord Or Spinal Meninges
03.5x	Plastic Operations On Spinal Cord Structures (multiple subcat.)
03.6	Lysis Of Adhesions Of Spinal Cord And Nerve Roots
03.7	Shunt Of Spinal Theca
03.8	Injection Of Destructive Agent Into Spinal Canal
03.93	Insert/Replace Spinal Neurostimulator
03.94	Removal Of Spinal Neurostimulator
03.97	Revision Of Spinal Thecal Shunt
03.98	Removal Of Spinal Thecal Shunt
80.50	Excision Or Destruction Of Intervertebral Disc, Unspecified
80.51	Excision Of Intervertebral Disc
80.52	Intervertebral Chemonucleolysis
80.53	Repair Of The Anulus Fibrosus With Graft Or Prosthesis
80.54	Other And Unspecified Repair Of The Anulus Fibrosus
80.59	Other Destruction Of Intervertebral Disc
81.00	Spinal Fusion, Not Otherwise Specified
81.01	Atlas-Axis Spinal Fusion
81.02	Other Cervical Fusion Of The Anterior Column, Anterior Technique
81.03	Other Cervical Fusion Of The Posterior Column, Posterior Technique
81.04	Dorsal And Dorsolumbar Fusion Of The Anterior Column, Anterior Technique
81.05	Dorsal And Dorsolumbar Fusion Of The Posterior Column, Posterior Technique
81.06	Lumbar And Lumbosacral Fusion Of The Anterior Column, Anterior Technique
81.07	Lumbar And Lumbosacral Fusion Of The Posterior Column, Lateral Transverse Process Technique
81.08	Lumbar And Lumbosacral Fusion Of The Anterior Column, Posterior Technique
81.09	Other spinal fusion ? No longer in use?
81.30	Refusion Of Spine, Not Otherwise Specified
81.31	Refusion Of Atlas-Axis Spine
81.32	Refusion Of Other Cervical Spine, Anterior Column, Anterior Technique
81.33	Refusion Of Other Cervical Spine, Posterior Column, Posterior Technique
81.34	Refusion Of Dorsal And Dorsolumbar Spine, Anterior Column, Anterior Technique
81.35	Refusion Of Dorsal And Dorsolumbar Spine, Posterior Column, Posterior Technique
81.36	Refusion Of Lumbar And Lumbosacral Spine, Anterior Column, Anterior Technique
81.37	Refusion Of Lumbar And Lumbosacral Spine, Posterior Column, Lateral Transverse Process Technique
81.38	Refusion Of Lumbar And Lumbosacral Spine, Anterior Column, Posterior Technique

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81.39	Refusion Of Spine, Not Elsewhere Classified
81.63	Fusion Or Refusion Of 4-8 Vertebrae
81.64	Fusion Or Refusion Of 9 Or More Vertebrae
84.51	Insertion Of Interbody Spinal Fusion Device
84.58	Implantation of interspinous process decompression device
84.59	Insert Of Other Spinal Devices
84.60	Insertion Of Spinal Disc Prosthesis; Not Otherwise Specified
84.61	Insertion Of Partial Spinal Disc Prosthesis, Cervical
84.62	Insertion Of Total Spinal Disc Prosthesis, Cervical
84.63	Insertion Of Spinal Disc Prosthesis, Thoracic
84.64	Insertion Of Partial Spinal Disc Prosthesis, Lumbosacral
84.65	Insertion Of Total Spinal Disc Prosthesis, Lumbosacral
84.66	Revision Or Replacement Of Artificial Spinal Disc Prosthesis
84.67	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Thoracic
84.68	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Lumbosacral
84.69	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Not Otherwise Specified
84.80	Insertion Or Replacement Of Interspinous Process Device(s)
84.81	Revision Of Interspinous Process Device(s)
84.82	Insertion Or Replacement Of Pedicle-Based Dynamic Stabilization Device(s)
84.83	Revision Of Pedicle-Based Dynamic Stabilization Device(s)
85.84	Insertion Or Replacement Of Facet Replacement Device(s)
84.85	Revision Of Facet Replacement Device(s)

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Appendix 1d: CPT Codes for Exclusion Criteria

CPT code	Description
00630	anesthesia for procedures in lumbar region; not otherwise specified.
00670	anesthesia for extensive spine and spinal cord procedures.
06300	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, cervical
20250	biopsy, vertebral body, open, thoracic
20930	allograft for spine surgery only; morselized (list separately in addition to code for primary procedure)
20936	autograft for spine surgery only (includes harvesting the graft); local (eg, ribs, spinous process, or laminar fragments) obtained from same incision
20937	autograft for spine surgery only (includes harvesting the graft); morselized (through separate skin or fascial incision) (list separately in addition to code for primary procedure)
20938	autograft for spine surgery only (includes harvesting the graft); structural, bicortical or tricortical (through separate skin or fascial incision) (list separately in addition to code for primary procedure)
22010	incision & drainage: deep abscess: posterior spine; cervical/thoracic/cervicothoracic
22015	incision & drainage: deep abscess: posterior spine; lumbar/sacral/lumbosacral
22100	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; cervical
22101	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; thoracic
22102	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; lumbar
22103	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; each additional segment
22110	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; cervical
22112	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; thoracic
22114	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; lumbar
22116	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; each additional vertebral segment
22206	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); thoracic
22207	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); lumbar
22208	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); each additional vertebral segment
22210	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; cervical
22212	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; thoracic
22214	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; lumbar
22216	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; each additional vertebral segment (list separately in addition to primary procedure)
22220	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; cervical

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22222	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; thoracic
22224	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; lumbar
22226	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; each additional vertebral segment
22305	closed treatment of vertebral process fracture(s)
22310	closed treatment of vertebral body fracture(s), without manipulation, requiring and including casting or bracing
22315	closed treatment of vertebral fracture(s) and/or dislocation(s) requiring casting or bracing, with and including casting and/or bracing, with or without anesthesia, by manipulation or traction
22318	open treatment and/or reduction of odontoid fracture(s) and or dislocation(s) (including os odontoideum), anterior approach, including placement of internal fixation; without grafting
22319	open treatment and/or reduction of odontoid fracture(s) and or dislocation(s) (including os odontoideum), anterior approach, including placement of internal fixation; with grafting
22325	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, 1 fractured vertebra or dislocated segment; lumbar
22326	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; cervical
22327	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; thoracic
22328	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; each additional fractured vertebra or dislocated segment
22505	manipulation of spine requiring anesthesia, any region
22511	percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; lumbosacral
22513	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; thoracic
22514	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; lumbar
22515	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; each additional thoracic or lumbar vertebral body (list separately in addition to code for primary procedure)
22520	percutaneous vertebroplasty, one vertebral body, unilateral or bilateral injection; thoracic
22521	percutaneous vertebroplasty, one vertebral body, unilateral or bilateral injection; lumbar
22522	percutaneous vertebroplasty each additional thoracic or lumbar vertebral body
22523	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); thoracic
22524	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); lumbar

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22525	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); each additional thoracic or lumbar vertebral body
22526	percutaneous intradiscal electrothermal annuloplasty, unilateral or bilateral including fluoroscopic guidance; single level
22527	percutaneous intradiscal electrothermal annuloplasty, unilateral or bilateral including fluoroscopic guidance; one or more additional levels
22532	arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); thoracic
22533	arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar
22534	add-on code to describe each additional vertebral segment on which the arthrodesis using lateral extracavitary approach is performed, after the first segment. this code should be used in conjunction with cpt code 22532 and 22533.
22548	arthrodesis, anterior transoral or extraoral technique, clivus-c1-c2 (atlas-axis), with or without excision of odontoid process
22551	arthrodesis, anterior interbody, including disc space preparation, discectomy, osteophytectomy and decompression of spinal cord and/or nerve roots; cervical below c2
22554	arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); cervical below c2
22556	arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); thoracic
22558	anterior lumbar interbody fusion, first interspace
22585	anterior lumbar interbody fusion, additional interspace
22586	arthrodesis, pre-sacral interbody technique, including disc space preparation, discectomy, with posterior instrumentation, with image guidance, includes bone graft when performed, l5-s1 interspace
22590	arthrodesis, posterior technique, craniocervical (occiput-c2)
22595	arthrodesis, posterior technique, atlas-axis (c1-c2)
22600	arthrodesis, posterior or posterolateral technique, single level; cervical below c2 segment
22610	arthrodesis, posterior or posterolateral technique, single level; thoracic (with or without lateral transverse technique)
22612	arthrodesis, posterior or posterolateral technique, single level; lumbar (with or without lateral transverse technique)
22614	arthrodesis, posterior or posterolateral technique, single level; each additional vertebral segment
22630	arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar
22632	posterior lumbar interbody fusion, each additional interspace
22633	arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; lumbar
22634	arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; each additional interspace and segment
22800	arthrodesis, posterior, for spinal deformity, with or without cast; up to 6 vertebral segments

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22802	arthrodesis, posterior, for spinal deformity, with or without cast; 7 to 12 vertebral segments
22804	arthrodesis, posterior, for spinal deformity, with or without cast; 13 or more vertebral segments
22808	arthrodesis, anterior, for spinal deformity, with or without cast; 2 to 3 vertebral segments
22810	arthrodesis, anterior, for spinal deformity, with or without cast; 4 to 7 vertebral segments
22812	arthrodesis, anterior, for spinal deformity, with or without cast; 8 or more vertebral segments
22818	kyphectomy, circumferential exposure of spine and resection of vertebral segment(s) (including body and posterior elements); single or 2 segments
22819	kyphectomy, circumferential exposure of spine and resection of vertebral segment(s) (including body and posterior elements); 3 or more segments
22830	exploration of spinal fusion
22840	posterior non-segmental instrumentation (eg, harrington rod technique, pedicle fixation across one interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at c1, facet screw fixation)
22841	internal spinal fixation by wiring of spinous processes
22842	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments
22843	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments
22844	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 13 or more vertebral segments
22845	anterior instrumentation; 2 to 3 vertebral segments
22846	anterior instrumentation; 4 to 7 vertebral segments
22847	anterior instrumentation; 8 or more vertebral segments
22848	pelvic fixation (attachment of caudal end of instrumentation to pelvic bony structures) other than sacrum
22849	reinsertion of spinal fixation device
22850	removal of posterior nonsegmental instrumentation (eg, harrington rod)
22851	application of intervertebral biomechanical device(s) (eg, synthetic cage(s), threaded bone dowel(s), methylmethacrylate) to vertebral defect or interspace
22852	removal of posterior segmental instrumentation
22855	removal of anterior instrumentation
22856	total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophytectomy for nerve root or spinal cord decompression and microdissection), single interspace, cervical
22857	total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), single interspace, lumbar
22861	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22862	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22864	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22865	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; lumbar
27096	injection procedure for si joint, arthrography, and/or anesthetic steroid
62263	percutaneous lysis of epidural adhesions using solution injection or mechanical means, including radiologic localization, multiple adhesiolysis sessions, two or more days

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62264	percutaneous lysis of epidural adhesions using solution injection or mechanical means, including radiologic localization, multiple adhesiolysis sessionsone day
62281	injection/infusion of neurolytic substance (eg, alcohol, phenol, iced saline solutions), with or without other therapeutic substance; epidural, cervical or thoracic
62282	injection/infusion of neurolytic substance (eg, alcohol, phenol, iced saline solutions), with or without other therapeutic substance; epidural, lumbar, sacral (caudal)
62287	aspiration procedure, percutaneous, of nucleus pulposus of intervertebral disk, any method, single or multiple levels, lumbar.
62292	injection procedure for chemonucleolysis, including discography, intervertebral disc, single or multiple levels, lumbar
62310	injection, single (not via indwelling catheter), not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; cervical or thoracic
62311	injection, single (not via indwelling catheter), not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; lumbar, sacral (caudal)
62318	injection, including catheter placement, continuous infusion or intermittent bolus, not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; cervical or thoracic
62319	injection, including catheter placement, continuous infusion or intermittent bolus, not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; lumbar, sacral (caudal)
62322	injection(s), of diagnostic or therapeutic substance(s) (eg, anesthetic, antispasmodic, opioid, steroid, other solution), not including neurolytic substances, including needle or catheter placement, interlaminar epidural or subarachnoid, lumbar or sacral (caudal) section
62323	injection(s), of diagnostic or therapeutic substance(s) (eg, anesthetic, antispasmodic, opioid, steroid, other solution), not including neurolytic substances, including needle or catheter placement, interlaminar epidural or subarachnoid, lumbar or sacral (caudal); with imaging guidance (ie, fluoroscopy or ct)
62350	implantation, revision or repositioning of tunneled intrathecal or epidural catheter, for long-term medication administration via an external pump or implantable reservoir/infusion pump; without laminectomy
62351	implantation, revision or repositioning of tunneled intrathecal or epidural catheter, for long-term medication administration via an external pump or implantable reservoir/infusion pump; with laminectomy
62355	removal of previously implanted intrathecal or epidural catheter.
62360	implantation or replacement of device for intrathecal or epidural drug infusion; subcutaneous reservoir
62361	implantation or replacement of device for intrathecal or epidural drug infusion; nonprogrammable pump
62362	implantation or replacement of device for intrathecal or epidural drug infusion; programmable pump, including preparation of pump, with or without programming
62365	removal of subcutaneous reservoir or pump, previously implanted for intrathecal or epidural infusion
62367	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); without reprogramming or refill

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62368	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming
62369	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming and refill
62370	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming and refill (requiring physician's skill)
63001	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; cervical
63003	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; thoracic
63005	lumbar laminectomy without facetectomy, foraminotomy or discectomy, 1 or 2 segments
63011	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; sacral
63012	lumbar laminectomy for spondylolisthesis with removal of abnormal facet or pars interarticularis)
63015	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), more than 2 vertebral segments; cervical
63016	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), more than 2 vertebral segments; thoracic
63017	more than two segments
63020	laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, including open and endoscopically-assisted approaches; 1 interspace, cervical
63030	lumbar laminotomy including partial facetectomy, foraminotomy,and/or excision of herniated disc
63035	each additional interspace
63040	laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, reexploration, single interspace; cervical
63042	re-exploration lumbar laminotomy, including partial facetectomy, foraminotomy, and/or excision of herniated disc
63043	laminonotomy with decompression of nerve root, each additional cervical interspace
63044	each additional interspace
63045	laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [e.g., spinal or lateral recess stenosis]), single vertebral segment; cervical
63046	laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [e.g., spinal or lateral recess stenosis]), single vertebral segment; thoracic
63047	lumbar laminectomy, facetectomy and foraminotomy, single level)
63048	each additional segment
63050	laminoplasty, cervical, with decompression of the spinal cord, 2 or more vertebral segments
63051	laminoplasty, cervical, with decompression of the spinal cord, 2 or more vertebral segments; with reconstruction of the posterior bony elements (including the application of bridging bone graft and non-segmental fixation devices (e.g., wire, suture, mini-plates), when performed)

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63055	transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (e.g., herniated intervertebral disc), single segment; thoracic
63056	transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (e.g., herniated intervertebral disc), single segment; lumbar (including transfacet, or lateral extraforaminal approach) (e.g., far lateral herniated intervertebral disc)
63057	transpedicular approach with decompression of spinal cord, each additional segmen
63064	costovertebral approach with decompression of spinal cord or nerve root(s) (e.g., herniated intervertebral disc), thoracic; single segment
63066	costrovertebral approach with decompression of spinal cord or nerve roots, thoracic, each additional segment
63075	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, single interspace
63076	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, each additional interspac
63077	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; thoracic, single interspace
63078	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; thoracic, each additional interspace
63081	vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve root(s); cervical, single segment
63082	vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve root(s); cervical, each additional segment
63085	vertebral corpectomy (vertebral body resection), partial or complete, transthoracic approach with decompression of spinal cord and/or nerve root(s); thoracic, single segment
63086	vertebral corpectomy (vertebral body resection), partial or complete, transthoracic approach with decompression of spinal cord and/or nerve root(s); thoracic, each additional segment
63087	vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; single segment
63088	vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; each additional segment
63090	vertebral corpectomy (vertebral body resection), partial or complete, transperitoneal or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; single segment
63091	or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; each additional segment
63102	vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression ofspinal cord and/or nerve root(s) (e.g., for tumor or retropulsed bone fragments); lumbar, single segment
63103	vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression of spinal cord and/or nerve root(s) (e.g., for tumor or retropulsed bone fragments); thoracic or lumbar, each additional segment
63170	laminectomy with myelotomy (e.g., bischof or drez type), cervical, thoracic, or thoracolumbar
63172	laminectomy with drainage of intramedullary cyst/syrinx; to subarachnoid space

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63173	laminectomy with drainage of intramedullary cyst/syrinx; to peritoneal or pleural space
63180	laminectomy and section of dentate ligaments, with or without dural graft, cervical; 1 or 2 segments
63182	laminectomy and section of dentate ligaments, with or without dural graft, cervical; more than 2 segments
63185	laminectomy with rhizotomy; 1 or 2 segments
63190	laminectomy with rhizotomy; more than 2 segments
63191	laminectomy with section of spinal accessory nerve
63194	laminectomy with cordotomy, with section of 1 spinothalamic tract, 1 stage; cervical
63195	laminectomy with cordotomy, with section of 1 spinothalamic tract, 1 stage; thoracic
63196	laminectomy with cordotomy, with section of both spinothalamic tracts, 1 stage; cervical
63197	laminectomy with cordotomy, with section of both spinothalamic tracts, 1 stage; thoracic
63198	laminectomy with cordotomy with section of both spinothalamic tracts, 2 stages within 14 days; cervical
63199	laminectomy with cordotomy with section of both spinothalamic tracts, 2 stages within 14 days; thoracic
63200	laminectomy, with release of tethered spinal cord, lumbar
63250	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; cervical
63251	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; thoracic
63252	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; thoracolumbar
63265	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; cervical
63266	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; thoracic
63267	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; lumbar
63268	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; sacral
63270	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; cervical
63271	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; thoracic
63272	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; lumbar
63273	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; sacral
63275	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, cervical
63276	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, thoracic
63277	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, lumbar
63278	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, sacral
63280	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, cervical
63281	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, thoracic
63282	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, lumbar
63283	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, sacral
63285	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, cervical
63286	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, thoracic
63287	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, thoracolumbar
63290	laminectomy for biopsy/excision of intraspinal neoplasm; combined extradura-intradural lesion, any level
63295	osteoplastic reconstruction of dorsal spinal elements, following primary intraspinal procedure (list separately in addition to code for primary procedure)
63301	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, thoracic by transthoracic approach

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63302	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, thoracic by thoracolumbar approach
63303	vertebral corpectomy (vertebral body resection),partial or complete, for excision of intraspinal lesion, single segment; extradural, lumbar or sacral by transperitoneal or retroperitoneal approach
63304	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, cervical
63305	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, thoracic by transthoracic approach
63306	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, thoracic by thoracolumbar approach
63307	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, lumbar or sacral by transperitoneal or retroperitoneal approach
63308	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; each additional segment
63650	dorsal column stimulator placements
63655	laminectomy for implantation of neurostimulator electrodes, plate/paddle, epidural
63660	revision or removal of spinal neurostimulator electrodes
63661	removal of spinal neurostimulator electrode percutaneous array(s), including fluoroscopy, when performed
63662	removal of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
63663	revision including replacement, when performed, of spinal neurostimulator electrode percutaneous array(s), including fluoroscopy, when performed
63664	revision including replacement, when performed, of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
63685	insertion or replacement of spinal neurostimulator pulse generator or receiver, direct or inductive coupling
63688	revision including replacement, when performed, of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
64470	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; cervical or thoracic, single level
64472	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; cervical or thoracic, each additional level
64475	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; lumbar or sacral, single level
64476	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; lumbar or sacral, each additional level
64479	injection, anesthetic agent and/or steroid, transforaminal epidural; cervical or thoracic, single level
64480	injection, anesthetic agent and/or steroid, transforaminal epidural; cervical or thoracic, each additional level
64483	injection, anesthetic agent and/or steroid, transforaminal epidural; lumbar or sacral, single level
64484	injection, anesthetic agent and/or steroid, transforaminal epidural; lumbar or sacral, each additional level
64490	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal)joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; single level
64491	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; second level

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64492	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; third and any additional level(s)
64493	paravertebral facet joint injection, lumbar or sacral, single level
64494	paravertebral facet joint injection, lumbar or sacral, second level
64495	paravertebral facet joint injection, lumbar or sacral, third and each additional level
64520	Injection, anesthetic agent; lumbar or thoracic (paravertebral sympathetic)
64553	percutaneous implantation of neurostimulator electrode array; cranial nerve
64622	destruction by neurolytic agent, paravertebral facet joint nerve; lumbar or sacral, single level
64623	lumbar or sacral, each additional level
64635	destruction by neurolytic agent, paravertebral facet joint nerve; lumbar or sacral, single level with image guidance
64636	lumbar or sacral, each additional level with image guidance
95991	refilling and maintenance of implantable pump or reservoir for drug delivery, spinal (intrathecal, epidural) or brain (intraventricular), includes electronic analysis of pump, when performed; requiring skill of a physician or other qualified health care professional
0092T	total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophytectomy for nerve root or spinal cord decompression and microdissection), each additional interspace, cervical (list separately in addition to code for primary procedure)
0095T	removal of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, cervical (list separately in addition to code for primary procedure)
0098T	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, cervical (list separately in addition to code for primary procedure)
0163T	total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), each additional interspace, lumbar (list separately in addition to code for primary procedure)
0164T	removal of total disc arthroplasty, (artificial disc), anterior approach, each additional interspace, lumbar (list separately in addition to code for primary procedure)
0165T	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, lumbar (list separately in addition to code for primary procedure)
0171T	insertion of posterior spinous process distraction device (including necessary removal of bone or ligament for insertion and imaging guidance), lumbar; single level
0172T	insertion of posterior spinous process distraction device (including necessary removal of bone or ligament for insertion and imaging guidance), lumbar; each additional level (list separately in addition to code for primary procedure)
0215T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, cervical or thoracic; third and any additional level(s)
0216T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; single level
0217T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; second level
0218T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; third and any additional level(s)
0230T	injection(s), anesthetic agent and/or steroid, transforaminal epidural, with ultrasound guidance, lumbar or sacral; single level

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0231T	injection(s), anesthetic agent and/or steroid, transforaminal epidural, with ultrasound guidance, lumbar or sacral; each additional level
0282T	percutaneous or open implantation of neurostimulator electrode array(s), subcutaneous (peripheral subcutaneous field stimulation), including imaging guidance, when performed, cervical, thoracic or lumbar, for trial, including removal at the conclusion of trial period
0283T	percutaneous or open implantation of neurostimulator electrode array(s), subcutaneous (peripheral subcutaneous field stimulation), including imaging guidance, when performed, cervical, thoracic or lumbar, permanent, with implantation of a pulse generator
0284T	revision or removal of pulse generator or electrodes, including imaging guidance, when performed, including addition of new electrodes, when performed

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Appendix table 2: Hosmer Lemeshow and c-statistics for all logistic models

Outcome	Hosmer Lemeshow chi-square	p-value	c-statistic
Any opioid use	19.029	0.015	0.631
Early opioid use	15.395	0.052	0.704
Long-term opioid use	17.181	0.028	0.753

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Appendix Table 3: Bootstrapping, early opioid use

Initial Provider	n	OR (95% CI) bootstrapping	Early use, OR (95% CI)
Physical therapy	200	0.15 (0.13, 0.17)	0.15 (0.13,0.17)
Chiropractor	200	0.10 (0.09, 0.10)	0.10 (0.09,0.10)
Acupuncture	200	0.09 (0.07, 0.12)	0.09 (0.07,0.12)
Orthopedics	200	0.63 (0.60, 0.67)	0.63 (0.60,0.67)
Emergency Medicine	200	2.66 (2.54, 2.78)	2.66 (2.54,2.78)
Neurosurgeon	200	0.57 (0.48, 0.69)	0.58 (0.47,0.71)
MD Other	200	0.50 (0.46, 0.54)	0.50 (0.46,0.54)
Radiology	200	0.70 (0.67, 0.73)	0.70 (0.67,0.73)
Rehab	200	0.54 (0.49, 0.59)	0.54 (0.49,0.59)
Other	200	0.81 (0.76, 0.87)	0.81 (0.76,0.87)

Appendix Table 3 Legend: Bootstrapping is a resampling technique that allows assigning of accuracy. The estimates reported using bootstrapping methods listed in this table indicate little or no differences with the actual results.

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Appendix Table 4: Bootstrapping, long-term opioid use

Initial Provider	N	OR (95% CI) bootstrapping	Long-term use, OR (95% CI)
Physical therapy	200	0.26 (0.16, 0.50)	0.27 (0.15,0.48)
Chiropractor	200	0.22 (0.18, 0.26)	0.22 (0.18,0.26)
Acupuncture	200		0.07 (0.01,0.48)
Orthopedics	200	1.09 (0.92, 1.31)	1.10 (0.92,1.30)
Emergency Medicine	200	0.92 (0.77, 1.11)	0.92 (0.77,1.10)
Neurosurgeon	200	1.45 (0.88, 2.75)	1.50 (0.88,2.58)
MD Other	200	2.02 (1.71, 2.41)	2.03 (1.70,2.41)
Radiology	200	1.22 (1.08, 1.38)	1.22 (1.08,1.39)
Rehab	200	1.77 (1.42, 2.26)	1.78 (1.40,2.26)
Other	200	0.88 (0.69, 1.14)	0.88 (0.70,1.11)

Appendix Table 4 Legend: Sample size for acupuncture was too small to report for bootstrapping.

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Appendix table 5: Propensity matching for initial Physical Therapy (PT) and initial chiropractor vs. initial Primary Care Physician (PCP)

Outcome		**OR (95% CI)**
Early opioid use	Initial PT (N=2248) vs. initial PCP (N=4496)	0.15 (0.12, 0.18)
Long-term opioid use	Initial PT (N=2248) vs. initial PCP (N=4496)	0.29 (0.12, 0.69)
Early opioid use	Initial Chiropractor (N=32300) vs. initial PCP (N=32300)	0.10 (0.09, 0.10)
Long-term opioid use	Initial Chiropractor (N=32300) vs. initial PCP (N=32300)	0.21 (0.16, 0.27)

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Appendix table 6: Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

		PT	Chiro
Covariate	**Levels**	**OR (95% CI)**	**OR (95% CI)**
AGE	45-65 vs 18-44	1.02 (0.93,1.12)	0.81 (0.78, 0.83) *
	65-74 vs 18-44	1.15 (0.82,1.61)	0.77 (0.69, 0.86) *
GENDER	Female vs Male	1.16 (1.06,1.27)*	0.84 (0.82, 0.87) *
RACE	Asian vs White	1.03 (0.86,1.23)	0.68 (0.64, 0.73) *
	Black vs White	0.67 (0.56,0.82) *	0.48 (0.46, 0.51) *
	Hispanic vs White	0.67 (0.57,0.78) *	0.64 (0.62, 0.67) *
	Unknown vs White	0.94 (0.75,1.19)	0.84 (0.77, 0.90) *
REGION	Midwest vs Northeast	2.11 (1.82,2.44) *	0.87 (0.83, 0.91) *
	South vs Northeast	0.88 (0.77,1.00)	0.86 (0.83, 0.89) *
	West vs Northeast	2.11 (1.83,2.42) *	1.00 (0.95, 1.04)
Pregnancy		5.79 (4.92,6.83) *	1.76 (1.62, 1.92) *
Accidents		0.74 (0.56,0.97) *	0.36 (0.32, 0.40) *
Anxiety		0.95 (0.82,1.11)	0.88 (0.84, 0.93) *
Bipolar		0.56 (0.36,0.88) *	0.93 (0.83, 1.05)
Depression		0.92 (0.79,1.08)	0.96 (0.92, 1.01)
Dementia		-	0.72 (0.43, 1.21)
ADHD		1.54 (1.17,2.04) *	0.99 (0.90, 1.09)
Alcohol use disorder		0.95 (0.60,1.49)	0.96 (0.83, 1.10)
Substance use disorder		0.88 (0.47,1.62)	0.82 (0.68, 0.99) *
Chronic Pain, fibromyalgia & Fatigue		1.44 (1.22,1.69) *	0.90 (0.84, 0.95) *
Psychotic Disorder		1.00 (0.40,2.48)	1.14 (0.87, 1.48)
Opioid use 13-24 months back		0.78 (0.69,0.87)	0.84 (0.81, 0.87) *
PT 1-24 months back		5.00 (4.45,5.62) *	1.12 (1.05, 1.20) *
Chiro any 1-24 months back		1.45 (1.17,1.79) *	6.92 (6.52, 7.35) *
Acupuncture any 1-24 months back		1.80 (1.18,2.75) *	1.39 (1.12, 1.73) *
LBP 13-24 months back		1.27 (0.98,1.65)	0.85 (0.77, 0.93) *
Elixhauser physical		0.91 (0.87,0.95) *	0.91 (0.89, 0.92) *
PT State Access	Provisional vs Limited	1.21 (1.05,1.40) *	-
	Unrestricted vs Limited	1.67 (1.41,1.98) *	-
Year of index visit		1.06 (1.02,1.09) *	1.02 (1.01, 1.03) *

Appendix Table 6 Legend: Pregnancy: pregnancy in the 12 months prior to the initial LBP visit; Accidents: motor vehicle accidents in the 12 months prior to the initial LBP visit; *p < .01. Reference group for age: ages 18-44; reference group for gender: male; reference group for race: white; reference group for region: Northeast; reference group for PT State Access: limited.

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	4-7, figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9, table 1
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-9, table 2

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-9, table 2 NA NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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An Observational Retrospective Study of the Association of Initial Health Care Provider for New-onset Low Back Pain with Early and Long-Term Opioid Use

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Manuscripts

An Observational Retrospective Study of the Association of Initial Health Care Provider for New-onset Low Back Pain with Early and Long-Term Opioid Use

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Abstract

Objective: This study examined the association of initial provider treatment with early and long-term opioid use in a national sample of patients with new-onset low back pain (LBP).

Design: A retrospective cohort study of patients with new-onset LBP from 2008-2013.

Setting: The study evaluated outpatient and inpatient claims from patient visits, pharmacy claims, and inpatient and outpatient procedures with initial providers seen for new-onset LBP.

Participants: 216,504 individuals aged 18 or older across the United States who were diagnosed with new-onset LBP and were opioid-naïve were included. Participants had commercial or Medicare Advantage insurance.

Exposures: The primary independent variable is type of initial health care provider including physicians and conservative therapists (physical therapists, chiropractors, acupuncturists).

Main Outcome Measures: Short-term opioid use (within 30 days of the index visit) following new LBP visit and long-term opioid use (starting within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months).

Results: Short-term use of opioids was 22%. Patients who received initial treatment from chiropractors or physical therapists had decreased odds of short and long-term opioid use compared to those who received initial treatment from primary care physicians (PCPs) [AOR (95% CI): 0.10 (0.09,0.10) and 0.15 (0.13,0.17) respectively]. Compared to PCP visits, initial chiropractic and physical therapy also were associated with decreased odds of long-term opioid use in a propensity-score matched sample [OR (95% CI): 0.21 (0.16, 0.27) and 0.29 (0.12, 0.69) respectively].

Conclusions: Initial visits to chiropractors or physical therapists is associated with substantially decreased early and long-term use of opioids. Incentivizing use of conservative therapists may be a strategy to reduce risks of early- and long-term opioid use.

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Strengths and Limitations of this Study

- This is a nationwide study comparing early and long term opioid use among patients with low back pain (LBP) who seek initial care from conservative therapists, physician specialists and primary care physicians.
- We go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP.
- We provide a broader depiction of conservative therapy than prior studies, as we included chiropractors and acupuncturists, as well as other MD specialists.
- This study assesses the impact of state regulations of access to physical therapy on choice of initial provider.
- This is a claims based study; therefore, causation cannot be inferred, and different patient characteristics we could assess is limited.

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Introduction

Over the past decade, there has been an increase in opioid use in the United States, with over 12 million Americans reporting long-term opioid use or misuse in 2015.[1-3] The National Survey on Drug Use and Health reported over 42,000 prescription opioid-related deaths in 2016, with total estimated costs of prescription opioid use reaching $78.5 billion.[4,5] One of the most common conditions for which opioids are prescribed is low back pain (LBP).[2-4] Several studies have reported that opioids are the most frequently prescribed medication for treatment of LBP,[4,5] and more than half of opioid users report having a history of back pain.[6] This frequency of opioid prescribing is particularly concerning given that LBP is one of the three most common conditions for which Americans seek medical care.[2,7]

Given the high prevalence of LBP, several treatment guidelines have been issued for treatment, and specifically discourage opioids to treat pain. The American College of Physicians (ACP) and the Centers for Disease Control (CDC) recommend non-pharmacologic treatments including exercise, physical therapy (PT), spinal manipulation, acupuncture, and massage.[2,8] These guidelines indicate that opioids should not be considered as a treatment option for LBP unless recommended treatments fail and if the benefits of their use outweigh the risk for the individual patient.[2,8] Prior to the release of these recommendations, physician vists for new-onset LBP were much more common than non-pharmacologic therapies like chiropractic care, PT, and acupuncture .[8-11]

Several studies have attempted to elucidate the predictors of opioid use among patients with LBP. Comparisons of the treatment patterns of primary care physicians (PCPs) and conservative therapists (defined as chiropractors, physical therapists, acupuncturists) suggest that the use of conservative therapies for LBP may decrease the likelihood of opioid use.[9] Despite

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these findings, there has been little research comparing early and long-term opioid use among patients seeking initial care from various providers, including primary care physicians, chiropractors, physical therapists, and acupuncturists as well as patients seeing orthopedic surgeons, neurosurgeons and emergency physicians.[12-14] The purpose of this study is to examine the association of type of initial provider with subsequent early and long-term opioid use in a national sample of patients with new-onset LBP whose treatment could reasonably be managed by non-pharmacologic therapy.

Methods

Study Sample

We conducted a retrospective study of patients seen by a health care provider for new-onset LBP management and who were opioid-naïve at the time of the initial visit (Boston Medical Center IRB approval number: H-36499). We used de-identified administrative claims data from the OptumLabs Data Warehouse (OLDW), which includes medical and pharmacy claims, laboratory results, and enrollment records for commercial and Medicare Advantage (MA) enrollees. The database contains longitudinal health information on enrollees and patients, representing a diverse mixture of ages, ethnicities and geographical regions across the United States.

The various health plans individuals were enrolled in all provide comprehensive insurance coverage for physician, hospital, and prescription drug services.

The index episode of LBP was identified using claims from 2008-2013 with additional claims data covering 2006-2015 to ascertain pre-index visit opioid use and low back conditions and to allow a follow-up period. Patients needed to be continuously enrolled for at least 24 months both before and following the index date (total 48 months) with both medical and

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pharmacy claims data available during that period. The study sample included adults aged 18 years or older with a new outpatient diagnosis of LBP who had commercial or Medicare Advantage insurance.

To qualify, LBP diagnosis appeared in the first location on a patient's index date insurance claim. New-onset LBP was defined as no diagnosis of LBP or back procedures, including spinal surgery, spinal injections, and spinal nerve stimulators during the 12-month period prior to the index event (Figure 1). Given the heterogeneity of claims data in a commercial insured population, we constructed our inclusion and exclusion criteria with the specific purpose of maximizing the likelihood that our analytic sample comprised our target population.

Exclusion Criteria

Patients were excluded if they had 1) a prescription for opioids in the 12 months prior to the index event (see Appendix 1a for a list of opioids included), 2) a diagnosis of neoplasia in this 12-month period or within a 3-month period after the index LBP event, or 3) a LBP-related diagnoses that would typically not be amenable to conservative therapy in the 3 months on or following the index date (See Appendix 1b-d for ICD-9 and CPT Codes for Inclusion/Exclusion Critiera). Each patient was only included in the study once.

Dependent variables

Early opioid use was defined as an opioid fill within 30 days of the index visit. Long-term use was defined as an initial opioid fill within 60 days of the index date and either 120 or more days' supply of opioids over 12 months, or 90 days or more supply of opioids and 10 or more opioid prescriptions over 12 months. This definition relied on previous literature.[6,15]

Independent variables

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Patient characteristics

We identified patient characteristics and comorbidities using ICD-9 codes for the claims data in the two years prior to the index event. Characteristics included age, sex/gender, race/ethnicity, insurance (commercial or Medicare Advantage), and state of residence (which was mapped to one of 4 United States census regions: Northeast, South, Midwest and West). Race and ethnicity are defined as Black, Hispanic, Asian, or White (Table 1). Sex/gender is determined based on enrollment records. Ethnicity was assigned by an external vendor based on a structured, rule-based system that combines analysis of first names, middle names, surnames, and surname prefixes and suffixes, with geographic reference files. Values were then categorized to comply with data de-identification requirements. Physical comorbidities were assessed using a modification of the Elixhauser index[15] in which mental health conditions were excluded. Other comorbidities, listed in Table 2, included 8 mental health conditions and a condition comprising chronic pain, fibromyalgia and fatigue. The latter conditions were included based on prior studies that have reported an association between such conditions and opioid use[16,17] and their specifications were based on the Centers for Medicare and Medicaid Serivces Chronic Conditions Data Warehouse.[18]

Based on the index claim date of patients with an eligible LBP diagnosis, initial providers were characterized as physical therapist, chiropractor, acupuncturist, primary care physician, orthopedic surgeon, emergency medicine physician, neurosurgeon, radiologists, other non-physicians (physician assistant or nurse practitioners), or physical medicine and rehabilitation physician according to provider specialty and procedure codes. If a patient saw both a physician and a conservative therapist on the index date, the initial provider was assumed to be the physician, although this was notably a small number of individuals (n=262).

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Patient access to PT in every state was classified as either 'limited', 'provisional', or 'unrestricted', based on the three levels of patient access outlined by the American Physical Therapy Association.[19] To access PT for their initial LBP visit in limited access states, patients must have a prior relevant medical diagnosis, a recent diagnosis from a physician or other specified clinician, and/or a prior physician referral to PT. States with provisional access permitted patients to see physical therapists with some provisions that vary by state. Restrictions in provisional access states include time and/or visit limits and physician referrals for specific interventions. Patients in unrestricted states do not face these restrictions when seeking initial care from a physical therapist. There were six states with limited access to PT, 26 states with provisional access, and 18 states with unrestricted access to PT.[19]

Statistical Analyses

The main analyses included multivariable logistic regressions with early opioid use and long-term opioid use as outcomes and entry-point provider as the main independent variable. The reference group for these comparisons was patients who visited PCP first for the LBP. All models were adjusted for age, sex/gender, race/ethnicity, geographic region, insurance type, the Elixhauser physical index as a continuous count of physical co-morbidities and, individually, mental health comorbidities.

As a supplemental alternative to adjusting for baseline confounding through regression adjustment, we invoked two-to-one propensity score matching (2 PCP: 1 physical therpist or 2 PCP: 1 chiropractor) without replacement to achieve baseline covariate balance among patients who initially saw chiropractor first, saw a physical therapist first or who saw PCP first.[20,21] The propensity scores were calculated as predicted probabilities of chiropractor first and a physical therapist first as opposed to PCP first as a function of the following matching variables: age,

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sex/gender, race/ethnicity, baseline comorbidities, geographic region, calendar year of the index visit, copay, deductible, plan type, history of pregnancy within 12 months, history of vehicular accidents within 12 months, history of opioid use within the year prior to the opioid free period, LBP diagnoses in the 13-24 months prior to the index visit, and prior PT visits. The propensity score for PT also considered the state PT access category, but the chiropractor propensity score did not. We examined the covariate balance in the matched samples through the standardized mean differences of each covariate. Finally, we applied a logistic model using the matched sample to assess the association between chiropractor compared to PCP as the initial provider seen and PT compared to PCP as the initial provider seen with the outcomes early term opioid use and separately long-term opioid use (binary variables). The caliper for propensity matching was set to 0.001 for both PT and chiropractor models.

In stage one of the propensity analysis, multivariable odds of initial chiropractic care and initial physical therapist versus initial PCP as a function of baseline covariates were measured. Covariates measured include age, sex/gender, race, geographic region, all mental and physical comorbidities included in the previous models, pregnancy and motor vehicle accidents in the 12 months prior to the LBP visit, opioid use in the 13-24 months prior to the LBP index visit, PT, chiropracitic care, and acupuncture in the 24 months prior to the LBP visit, and year of index visit. PT state access was only used for the PT vs PCP propensity analysis.

For all logistic models, we calculated adjusted odds ratios with 95% Wald confidence intervals. We also evaluated overall model fit, model discrimination (C statistic) and calibration (Hosmer Lemeshow test) for all logistic models (Appendix 2). While the Hosmer Lemeshow models were significant, this was likely due to the large sample sizes used for this study. The differences between the observed and expected values within the decile groups was relatively

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small suggesting credible calibration of the models and statistical significance due to the large sample sizes.[22,23] We further validated the covariate-adjusted ORs of early use and long-term use as a function of initial provider using the bootstrap method.[24] The resampling rate was 200 with a two-third/one-third sampling ratio. The bootstrapped estimates were then used to construct means and 95% confidence intervals for the ORs.

Patient and Public Involvement

No patient involvement.

Results

A total of 8,797,787 patients had a visit with a provider for LBP during the study period, and 216,504 met all inclusion/exclusion criteria (Figure 1). More than half the patients initially saw a PCP (n=114,782, 53.0%), and the most frequent initial conservative provider seen was chiropractor (50,041, 23.1%) followed by physical therapist 3,499 (1.6%) and acupuncturist 1,839 (0.8%). Patient demographics by initial provider are shown in Table 1. Most patients had commercial insurance (183,117, 84.7%); the remainder had Medicare Advantage coverage. Of patients with an acupuncturist as the initial provider type, nearly all (99.3%) had commercial insurance. For all other initial provider types, 87-89% of patients had commercial insurance. Approximately 18% of patients received an opioid fill within 3 days of the initial LBP visit, 22% received such a fill within the first 30 days and 1.2% met criteria for long-term use. 18% of patients received short-acting opioids (e.g., oxycodone, hydrocodone, codeine). 17.4% received prescriptions for NSAIDs." The choice of initial provider varied by state PT access category. For example, in limited access states, 55.2% of initial providers were PCP, 0.9% were physical therapists, and 25.7% were chiropractors. In provisional access states, the rates were 51.7% for

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PCPs, 1.6% for physical therapists, and 23.2% for chiropractors, and in unrestricted access states, the rates were 55.8% for PCPs, 2.6% for physical therapists, and 22.6% for chiropractors.

Initial provider was associated with early and long-term opioid use outcomes in the adjusted multivariate models (Table 2). Compared to seeing a PCP as initial provider, patients who first saw conservative therapists (chiropractor, acupuncturists and physical therapists) all had significantly decreased odds of both early and long-term opioid use. For early opioid use, patients initially visiting chiropractors had 90% decreased odds [95% CI: (0.09,0.10)] while those visiting an acupuncturists had 91% decreased odds [95% CI: (0.07,0.12)] and those visiting physical therapists had 85% decreased odds [95% CI: (0.13,0.17)]. Chiropractors, acupuncturists and physical therapists all had major decreased odds of long term opioid use compared to those who initially saw PCPs (0.22, 95% CI: (0.18,0.26); 0.07, 95% CI: (0.01,0.48); 0.27, 95% CI: (0.15,0.48) respectively). Compared to PCPs, orthopedic surgeons, neurosurgeons and rehab physicians as initial providers decreased patients' odds of early opioid use (0.63, 95% CI: (0.60,0.67); 0.58, 95% CI: (0.47,0.71); 0.54, 95% CI: (0.49,0.59), respectively), while patients seeing emergency physicians initially had significantly increased odds of early opioid use (2.66, 95% CI: (2.54,2.78)). However, compared to PCP as first provider, odds for long-term opioid use were no longer significantly different for orthopedic surgeons, neurosurgeons, and emergency physicians (1.10, 95% CI: (0.92,1.30); 1.50, 95% CI: (0.88,2.58); 0.92, 95% CI: (0.77,1.10), respectively), but were significantly increased for rehab physicians (1.78, 95% CI: (1.40,2.26)). (Table 2). The estimates reported using bootstrapping methods indicated little or no differences with the actual results (Appendix 3 and 4).

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Patients with anxiety, bipolar disorder, and depression had significantly increased odds of long-term opioid use, as did those diagnosed with drug use disorders and fibromyalgia/chronic pain/fatigue (Table 2).

Propensity-score matched odds of long-term opioid use were significantly lower for chiropractic care first compared to PCP first and for PT first as compared to PCP first with odds ratios consistent with findings in our primary covariate-adjusted logistic models (detailed results presented in Appendix 5).

Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

Patients in states with provisional access to PT had 1.21 (95% CI: 1.05, 1.40) times the odds of seeing a physical therapist initially while patients in states with unrestricted access to PT had 1.67 (95% CI: 1.40, 1.98) times the odds of seeing a physical therapist initially all compared to patients in states with limited PT access (Appendix 6).

Discussion

Initial treatment from conservative therapists in those with LBP was associated with a marked decrease in the odds of early and long term opioid use. To our knowledge, this is one of the first national studies to compare early and long term opioid use among patients with LBP who receive care from conservative therapists, physician specialists and PCPs. Although the impact of unmeasured confounders cannot be ruled out in this retrospective observational cohort study, the findings warrant careful consideration.

Several factors may help explain the apparent protective effect of conservative therapists. Since non-physicians are unable to prescribe opioids, patients seeking conservative therapy do not receive opioid prescriptions at the index visit, and subsequent visits to an MD would be

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required to obtain such prescriptions. There may be selection bias among patients choosing to seek initial treatment from conservative therapists, and such biases could be related to educational level or preferences which may also result in decreased desire for those patients to use opioids. Additionally, the conservative therapy provided may result in decreased pain and improved back-related function so that patients do not need or seek opioid medications. A growing body of evidence suggest that spinal manipulation, massage, acupuncture, and superficial heat are effective for reducing acute low back pain intensity and improving function.[23,25] The conservative therapists studied in this analysis can incorporate one or more of these approaches: physical therapist (manipulation, massage, heat), chiropractor (manipulation, massage, heat), and acupuncturist (acupuncture, massage).[23] Therefore and importantly, early engagement of conservative therapists may decrease initial opioid prescriptions in association with MD visits by providing the opportunity to incorporate evidence-based non-pharmacological interventions.

Notably, state access to PT had a considerable association with choice of initial provider. Compared to states with limited access to PT, patients in states with unrestricted and provisional access had 67% and 21% higher odds of visiting physical therapists initially, respectively. Given that initial PT is associated with significant reductions in early and long-term opioid use, these observations are potentially important.

The discrepancy between early and long-term use among PCPs and physicians specialists is also interesting. While patients who initially see orthopedic surgeons, neurosurgeons, rehabilitation physicians, and other physicians have significantly lower odds of early opioid use compared to PCPs, patients who initially see these physicians have similar or increased odds of long-term opioid use compared to PCPs. While we do not have a measure of pain severity, we hypothesize that physician specialists are trying to avoid prescribing opioids at the index visit,

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but if patients return at follow-up due to persistent pain, physicians are likely to prescribe opioids.

Comparisons to prior studies

Our results are consistent with prior studies showing high rates of opioid prescription fills for patients with LBP who were seen by emergency department physicians.[3,26] While there are very few studies suggesting that PT and chiropractic care are used in emergency departments in the United States[27], other countries have successfully introduced physical therapists into emergency departments to treat patients with LBP.[28-30]

Certain comorbidities were also associated with increased odds of opioid use. Patients with fibromyalgia, chronic pain, and fatigue and those with certain psychiatric conditions, including anxiety, bipolar disorder, and depression had greater odds of long-term opioid use than patients without these disorders. This is consistent with recent evidence suggesting that adults with mental health conditions account for half of opioid prescriptions in the United States.[31]

A recent study by Frogner et al. also found that LBP patients who saw physical therapists initially had lower opioid use, although this study only focused on six states.[13] Another recent study by Hayward et al. evaluated the use of non-opioid treatments from various providers, including physical therapists and physicians, however this was a descriptive study across only 16 states.[32] Our study examines the association of conservative therapy on opioid use with a sample that is national in scope. We also provide a broader depiction of conservative therapy, as we included chiropractors and acupuncturists in addition to physical therapists, as well as other MD specialists. Importantly, we find that conservative therapists other than physical therapists, including chiropractors and acupuncturists, when seen first after a new episode of LBP are apparently protective of early and long term use of opioids when compared with PCP's. Finally,

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we go beyond investigating the odds of opioid use for a one-time LBP event, by examining associations with both early and long-term opioid use among patients with new-onset LBP, using rigorous definitions of recent onset.

Fritz et al. found that early PT was associated with decreased opioid prescriptions[33], and a review by Ojha et al. noted that early PT as treatment for musculoskeletal disorders was associated with decreased frequency of opioid prescriptions, although this was based on a limited number of outcomes.[34] Thackerary et al. also suggested that the odds of receiving an opioid prescription among Medicaid beneficiaries were reduced for those who had a PT consult, as compared to those who did not.[35] While these studies did not measure the odds of opioid use among patients who initially saw physical therapists compared to other initial providers, our results are consistent with previously published reports that PT is associated with lower odds of opioid use.

Limitations

There are several limitations to this study. Analysis was conducted using claims data, limiting our generalizability beyond commercial and Medicare Advantage enrolled patients. However, the sample is national in scope and provides a range of sociodemographic and clinical characteristics. The observational nature of the study and the use of claims data limited our ability to eliminate the influence of unmeasured confounders. In particular, confounding by indication may bias our results. Patients who seek early treatment with non-pharmacologic practitioners may be more likely to have mild back pain that does not require more aggressive treatment such as opioids, compared to individuals with more severe back pain who may be more likely to see practitioners able to prescribe opioids. Studies have suggested that those with more severe LBP are more likely to receive opioids,[36] and if patients with less severe pain were more

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likely to choose conservative therapists rather than physicians, this could contribute to overestimation of the protective effect of conservative therapy on opioid use. Several prior studies have shown comparable baseline pain scores for those who choose conservative therapists compared to those who choose to see physicians initially, however it is important to note that these studies had different patient populations than this study as they were conducted either only in one state or in countries other than the United States.[36-40] Other unmeasured confounders may include patient preferences and behavioral characteristics. For example, those who chose conservative therapists as initial providers for LBP may have preferences to avoidpharmacological and/or opioid therapy. Therefore, while the associations between initial health care providers for LBP and subsequent opioid therapy found in our analyses have potentially important implications, one cannot infer causality due to the observational retrospective nature of the study.

Policy Implications and Future Research

In conclusion, our results suggest that use of conservative therapists as initial providers for new-onset LBP are associated with lower odds of early and long-term use of opioids compared with PCPs. Further research in other settings and prospective pragmatic trials will be useful to confirm our findings and to better understand other factors that influence choice of initial providers for LBP. Future research should include personal factors such as preferences related to opioid use, and medical, non-medical and specialists as initial providers. Factors related to health plan benefit design such as out-of-pocket costs for treatment alternatives (e.g. PT and chiropractor visits, opioids) and impact of gatekeeper requirements on care patterns should be investigated.

Contributorship statement

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Drs. Kazis, Rothendler, Ameli, Cabral, McDonough, Carey, and Saper were responsible for project design and conceptualization. Drs. Ameli and Cabral were responsible for data analysis. Drs. Kazis, Rothendler, Ameli, Cabral, McDonough, Carey, Saper, and Stein and Ms. Garrity were responsible for writing of the manuscript. Drs. Sanghavi, Elton, and Fritz provided critical feedback during the analysis and writing of the manuscript. All authors were involved in the editing and review of the manuscript.

Competing interests

Drs. Ameli, Sanghavi, and Elton work for OptumLabs but do not have any competing interests to report. This study was commissioned by Optum Labs and the American Physical Therapy Association (APTA). The funders provided comments on the production of the manuscript. The primary author, Dr. Kazis Professor at Boston University, had final editorial comment on the manuscript.

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Data sharing statement

Certain data from OptumLabs Data Warehouse may be available upon request.

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Table 1: Patient characteristics

	Entry-point provider									
		Conservative Therapist			Physician					
	Total	Chiropractor	Physical Therapist	Acupuncture	Primary Care	Orthopedic Surgeon	Emergency Medicine	MD Other	Rehab	Neurosurgeon
Full Sample – N (%)	216,504 (100)	50,014 (23.1)	3,499 (1.6)	1,839 (0.8)	114,782 (53.0)	9,335 (4.3)	8,746 (4.0)	4,422 (2.0)	3,246 (1.5)	578 (0.3)
Age, year – mean (STD)	48.1 (15.9)	45.7 (14.9)	47.0 (15.7)	42.4 (10.6)	47.7 (15.4)	50.1 (16.4)	50.1 (18.3)	51.3 (15.3)	46.9 (15.0)	52.2 (14.8)
Sex/Gender – N (%)										
Female	108,347 (50.1)	22,808 (45.6)	1,995 (57.1)	972 (52.9)	58,182 (50.7)	4,648 (49.8)	4,560 (52.2)	2,282 (51.6)	1,554 (47.9)	245 (42.4)
Male	107,660 (49.8)	27,193 (54.4)	>1,493 (>42.6) [xx]	>856 (>46.5) [xx]	56,517 (49.2)	4,674 (50.1)	>4,175 (>47.7) [xx]	2,140 (48.4)	>1,681 (>51.8)[xx]	333 (57.6)
Race/ethnicity - N (%)										
Black	18,907 (8.7)	2,190 (4.4)	191 (5.5)	45 (2.4)	11,755 (10.2)	802 (8.6)	1,192 (13.6)	494 (11.2)	208 (6.4)	50 (8.7)
Hispanic	20,936 (9.7)	3,766 (7.5)	263 (7.5)	224 (12.2)	12,212 (10.6)	752 (8.1)	860 (9.8)	541 (12.2)	293 (9.0)	38 (6.6)
Asian	9,344 (4.3)	1,636 (3.3)	224 (6.4)	747 (40.6)	4,885 (4.3)	354 (3.8)	270 (3.1)	194 (4.4)	218 (6.7)	15 (2.6)
White	159,503 (73.7)	40,709 (81.4)	2,666 (76.2)	732 (39.8)	81,971 (71.4)	7,046 (75.5)	6,115 (69.9)	3,013 (68.1)	2,394 (73.8)	449 (77.7)
Unknown (Missing)	7,814 (3.6)	1,713 (3.4)	155 (4.4)	91 (4.9)	3,959 (3.4)	381 (4.1)	309 (3.5)	180 (4.1)	133 (4.1)	26 (4.5)
Insurance - N (%)										
Commercial	183,117 (84.7)	44,520 (89.0)	3,048 (87.1)	1,827 (99.3)	99,842 (87.0)	7,696 (82.5)	6,236 (71.3)	3,601 (81.4)	2,891 (89.1)	472 (81.7)
Medicare Advantage	32,937 (15.2)	5,476 (11.0)	>440 (>12.6)[xx]	12 (0.7)	14,900 (13.0)	> 1628 (>17.4) [xx]	>2,499 (>28.6) [xx]	>810 (>18.3)[xx]	>344 (>10.6)[xx]	>95 (>16.4) [xx]

Table 1 Legend: Age, sex/gender, race/ethnicity, and insurance are all statistically significant at p<0.0001. [XX]: Cell suppressed due to small N's with unknown sex/gender or insurance in the corresponding column. Two additional initial type of providers – other non-MD (eg. Physician assistants, advance practice nurses) and radiologist - were included in the analyses but not reported in this table. Outcomes with a sample size <11 are not shown due to small sample size. There were a small number of individuals with unknown sex/gender and insurance type, and if we provided exact n's, readers may be able to infer the unknown n's which would be problematic since we cannot disclose n<11 for purposes of confidentiality of the data. For example, in Table 1 under Male PT, >1493 means that there was an unknown sex/gender row or column with n<11. Therefore, the number of male PT first individuals is between 1,493 and 1,504.

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Table 2: Odds of early and long-term opioid use by initial provider

		Early use, OR (95% CI)	Long-term, OR (95% CI)
Initial provider	PT (N=3,499)	0.15 (0.13,0.17)	0.27 (0.15,0.48)
	DC (N=50,014)	0.10 (0.09,0.10)	0.22 (0.18,0.26)
	Acupuncture (N=1,839)	0.09 (0.07,0.12)	0.07 (0.01,0.48)
	Ortho (N=9,335)	0.63 (0.60,0.67)	1.10 (0.92,1.30)
	Emerg Med (N=8,746)	2.66 (2.54,2.78)	0.92 (0.77,1.10)
	Neurosgn (N=578)	0.58 (0.47,0.71)	1.50 (0.88,2.58)
	MD other (N=4,422)	0.50 (0.46,0.54)	2.03 (1.70,2.41)
	Rehab (N=3,246)	0.54 (0.49,0.59)	1.78 (1.40,2.26)
Age	45-64 vs 18-44	1.07 (1.05,1.10)	1.32 (1.19,1.46)
	65-74 vs 18-44	0.89 (0.82,0.97)	0.79 (0.54,1.15)
	75+ vs 18-44	0.80 (0.72,0.89)	0.67 (0.45,1.00)
Sex/Gender	Female vs. male	0.83 (0.81,0.85)	0.82 (0.76,0.89)
Race	Asian vs White	0.49 (0.46,0.52)	0.29 (0.20,0.42)
	Black vs White	0.90 (0.87,0.94)	0.87 (0.76,0.99)
	Hispanic vs White	0.79 (0.76,0.82)	0.69 (0.59,0.81)
	Unknown vs White	0.84 (0.79,0.89)	0.65 (0.51,0.83)
Region	Midwest vs Northeast	0.78 (0.75,0.81)	0.74 (0.64,0.87)
	South vs Northeast	1.11 (1.08,1.14)	1.22 (1.11,1.34)
	West vs Northeast	1.01 (0.97,1.04)	1.17 (1.02,1.34)
Insurance type	Medicare <65 y/o vs commercial insurance	0.98 (0.89,1.08)	3.77 (3.19,4.46)
	Medicare ≥65 y/o vs commercial insurance	0.98 (0.89,1.08)	2.24 (1.54,3.26)
Comorbidities	Anxiety	1.05 (1.01,1.09)	1.46 (1.30,1.63)
	Bipolar disorder	1.11 (1.01,1.21)	1.41 (1.13,1.76)
	Depression	1.11 (1.07,1.15)	1.55 (1.39,1.73)
	Dementia	0.80 (0.70,0.92)	0.99 (0.73,1.36)
	ADHD	0.87 (0.80,0.95)	1.00 (0.75,1.32)
	Alcohol use disorder	1.08 (0.98,1.20)	1.28 (0.98,1.66)
	Substance use disorder	1.06 (0.93,1.22)	2.34 (1.76,3.10)
	Fibromyalgia/Chronic Pain/Fatigue	0.96 (0.92,1.01)	1.92 (1.71,2.16)
	PTSD	0.84 (0.69,1.03)	1.16 (0.77,1.77)
	Psychotic disorder	0.86 (0.74,0.99)	0.76 (0.55,1.05)
	Elixhauser physical	1.07 (1.06,1.08)	1.24 (1.21,1.27)

Table 2 Legend: The following variables were all included in the regression: Age, sex/gender, race/ethnicity, insurance, Elixhauser, which includeds physical comorbidities and mental health comorbidities. Primary care physician is the reference group (N=114,782); adjusted for race/ethnicity, sex/gender, region, and insurance type. PT: physical therapy; PCP: primary care physician; DC: chiropractor; Ortho: orthopedic surgeon; Emerg Med: emergency medicine physician; Neurosgn: neurosurgeon; MD other: other physician; Rehab: rehab physician.*p<0.01. Two additional initial providers – other non-MD (eg. Physician assistants, advance practice nurses) and radiologist - were included in the analyses but not reported in this table.

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Figure 1 Legend: Initially, 8,797,787 patients with low back pain (LBP) were identified. Patients with an insufficient clean period (LBP within the last 1 year), patients with a diagnosis of LBP that was not in the first position of their diagnosis, and LBP in only inpatient settings were excluded, reducing the number of patients to 4,263,713. Patients were excluded if they were not continuously enrolled in their insurance for 24 months before and after the initial LBP visit and if they were <18 years old, reducing the number of patients to 422,871. Patients with exclusionary conditions, LBP that was not limited to the low back, patients with back procedures in the 12 months prior to the index LBP visit, and patients with any opioid use in the 12 months before the index visit were excluded, leaving 216,504 patients in our sample.

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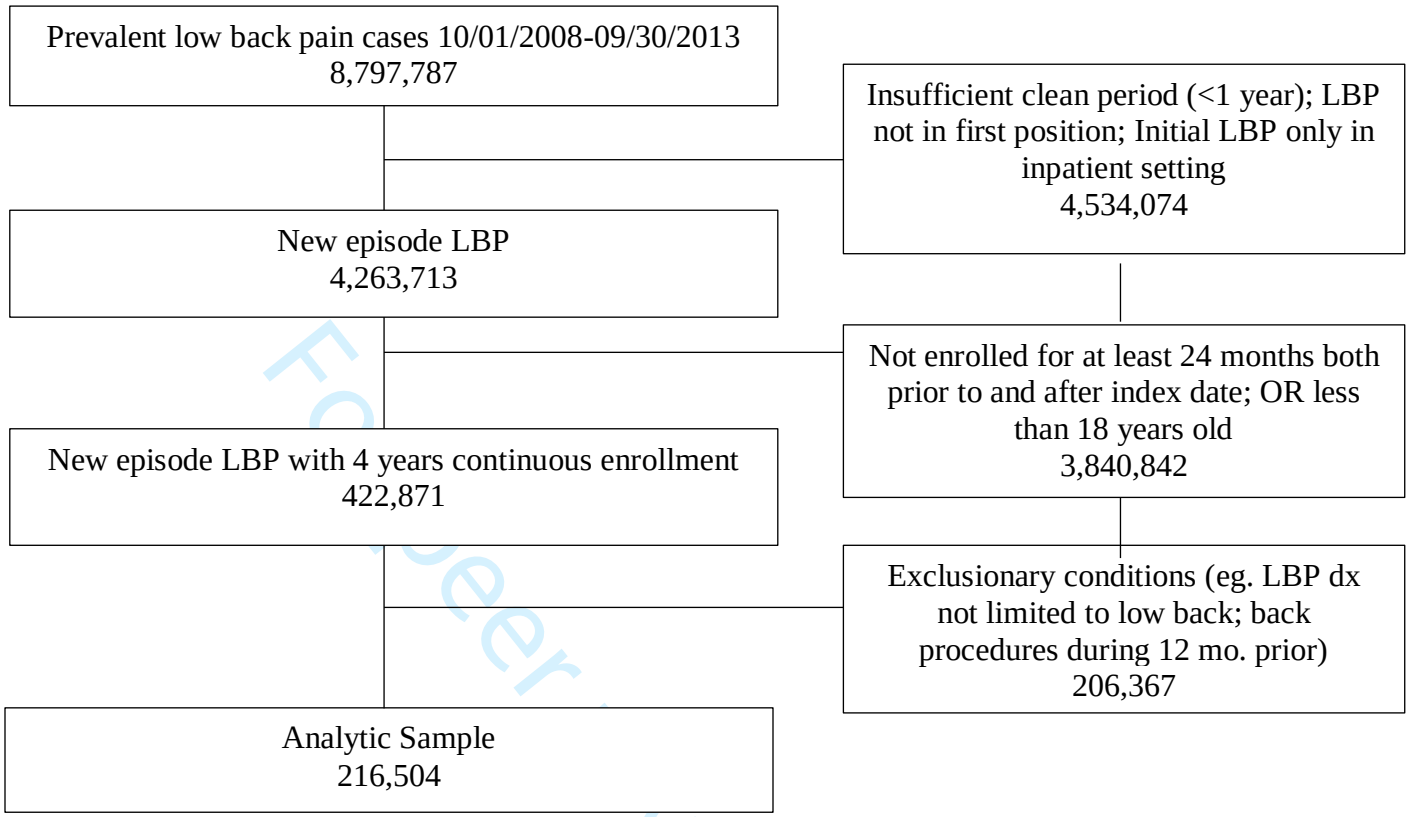
Figure 1: Inclusion and exclusion criteria



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Appendix 1: ICD-9 and CPT Codes for Inclusion/Exclusion Criteria

Appendix 1a: Drugs classified as opioids

The following drugs were identified as opioids with over 10,000 NDC codes: Buprenorphine, Codeine, Dihydrocodeine, Fentanyl LA, Fentanyl SA, Hydrocodone LA, Hydrocodone SA, Hydromorphone LA, Hydromorphone SA, Levomethadyl, Levorphanol, Meperidine, Methadone, Morphine LA, Morphine SA, Naltrexone, Opium, Oxycodone LA, Oxycodone SA, Oxymorphone LA, Oxymorphone SA, Pentazocine, Propoxyphene, Tapentadol LA, Tapentadol SA, Tramadol LA, Tramadol SA.

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Appendix 1b: ICD-9 LBP Diagnoses Inclusion/Exclusion Criteria

ICD-9 code	Description	Include as location-specific LBP index diagnosis	Exclusion if in clean period prior to index diagnosis	Exclusion if on index date or within 3 months afterwards
353.4	Lumbosacral root lesions, not elsewhere classified	x	x	
721.3	Lumbosacral spondylosis without myelopathy	x	x	
721.42	Spondylosis with myelopathy, lumbar region	x	x	
722.1	Displacement of thoracic or lumbar intervertebral disc without myelopathy	x	x	
722.32	Schmorl nodes, lumbar region	x	x	
722.51	Degeneration of thoracic or lumbar intervertebral disc	x	x	
722.52	Degeneration of lumbar or lumbosacral intervertebral disc	x	x	
722.93	Other and unspecified disc disorder of lumbar region	x	x	
724.2	Lumbago	x	x	
724.3	Sciatica	x	x	
724.4	Thoracic or lumbosacral neuritis or radiculitis, unspecified	x	x	
724.5	Unspecified backache	x	x	
724.6	Disorders of sacrum	x	x	
739.3	Non-allopathic lesion of lumbar region, not elsewhere classified	x	x	
739.4	Non-allopathic lesion of sacral region, not elsewhere classified	x	x	
846.0	Sprain and strain of lumbosacral (joint) (ligament)	x	x	
846.1	Sprain and strain of sacroiliac (ligament)	x	x	
846.2	Sprain and strain of sacrospinatus (ligament)	x	x	
846.3	Sprain and strain of sacrotuberous (ligament)	x	x	
846.8	Other specified sites of sacroiliac region sprain and strain	x	x	
846.9	Unspecified site of sacroiliac region sprain and strain	x	x	
847.2	Lumbar sprain and strain	x	x	
847.3	Sprain and strain of sacrum	x	x	
847.4	Sprain and strain of coccyx	x	x	
722.10	Displacement of lumbar intervertebral disc without myelopathy	x	x	
722.73	Intervertebral disc herniation Intervertebral disc disorder with myelopathy lumbar region	x	x	
724.02	Spinal stenosis, lumbar region, without neurogenic claudication	x	x	
724.03	Spinal stenosis, lumbar region, with neurogenic claudication	x	x	
756.11	Spondylolysis, lumbosacral region (congenital)	x	x	
721.5	Kissing spine		x	
721.6	Ankylosing vertebral hyperostosis		x	
721.7	Traumatic spondylopathy		x	
721.8	Other allied disorders of spine		x	

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721.90	Spondylosis of unspecified site without mention of myelopathy		x	
721.91	Spondylosis of unspecified site with myelopathy		x	
722.30	Schmorl nodes, unspecified region		x	
722.90	Other and unspecified disc disorder of unspecified region		x	
724.8	Other symptoms referable to back		x	
724.9	Other unspecified back disorders		x	
847.9	Sprain and strain of unspecified site of back		x	
722.2	Displacement of intervertebral disc, site unspecifi ed, w/o myelopathy		x	
722.6	Degeneration of intervertebral disc site unspecified		x	
724.00	Spinal stenosis of unspecified region		x	
724.09	Spinal stenosis of other region		x	
738.4	Acquired spondylolisthesis		x	
738.5	Other acquired deformity of back or spine		x	
756.12	Spondylolisthesis (congenital)		x	
806.0-806.9	Fracture of vertebral column with spinal cord injury		x	x
805.0-805.9	Fracture of vertebral column without mention of spinal cord injury		x	x
733.1x	Pathologic fractures		x	x
839.00–839.59	Vertebral dislocations		x	x
720.0–720.9	Inflammatory spondyloarthropathies		x	x
324.1	Intraspinal abscess		x	x
140–239.9	Cancer/neoplasms		x	x
730–730.99	Osteomyelitis		x	x
353.2	Cervical root lesions, not elsewhere classified			
353.3	Thoracic root lesions, not elsewhere classified			
721.0	Cervical spondylosis without myelopathy			
721.1	Cervical spondylosis with myelopathy			
721.2	Thoracic spondylosis without myelopathy			
721.41	Spondylosis with myelopathy, thoracic region			
722.0	Displacement of cervical intervertebral disc without myelopathy			
722.11	Displacement of thoracic intervertebral disc without myelopathy			
722.4	Degeneration of cervical intervertebral disc			
722.71	Intervertebral disc disorder with myelopathy, cervical region			
722.72	Intervertebral disc disorder with myelopathy, thoracic region			
722.81	Postlaminectomy syndrome, cervical region			
722.82	Postlaminectomy syndrome, thoracic region			
722.91	Other and unspecified disc disorder, cervical region			
722.92	Other and unspecified disc disorder, thoracic region			
723.0	Spinal stenosis in cervical region			

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723.4	Brachial neuritis or radiculitis NOS			
724.01	Spinal stenosis, thoracic region			

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Appendix 1c: ICD-9 Procedures for Exclusion Critiera

ICD-9 code	Description
03.01	Removal Of Foreign Body From Spinal Canal
03.02	Reopening Of Laminectomy Site
03.09	Other Exploration And Decompression Of Spinal Cana
03.1	Division Of Intraspinal Nerve Root
03.2x	chordotomy
03.4	Excision Or Destruction Of Lesion Of Spinal Cord Or Spinal Meninges
03.5x	Plastic Operations On Spinal Cord Structures (multiple subcat.)
03.6	Lysis Of Adhesions Of Spinal Cord And Nerve Roots
03.7	Shunt Of Spinal Theca
03.8	Injection Of Destructive Agent Into Spinal Canal
03.93	Insert/Replace Spinal Neurostimulator
03.94	Removal Of Spinal Neurostimulator
03.97	Revision Of Spinal Thecal Shunt
03.98	Removal Of Spinal Thecal Shunt
80.50	Excision Or Destruction Of Intervertebral Disc, Unspecified
80.51	Excision Of Intervertebral Disc
80.52	Intervertebral Chemonucleolysis
80.53	Repair Of The Anulus Fibrosus With Graft Or Prosthesis
80.54	Other And Unspecified Repair Of The Anulus Fibrosus
80.59	Other Destruction Of Intervertebral Disc
81.00	Spinal Fusion, Not Otherwise Specified
81.01	Atlas-Axis Spinal Fusion
81.02	Other Cervical Fusion Of The Anterior Column, Anterior Technique
81.03	Other Cervical Fusion Of The Posterior Column, Posterior Technique
81.04	Dorsal And Dorsolumbar Fusion Of The Anterior Column, Anterior Technique
81.05	Dorsal And Dorsolumbar Fusion Of The Posterior Column, Posterior Technique
81.06	Lumbar And Lumbosacral Fusion Of The Anterior Column, Anterior Technique
81.07	Lumbar And Lumbosacral Fusion Of The Posterior Column, Lateral Transverse Process Technique
81.08	Lumbar And Lumbosacral Fusion Of The Anterior Column, Posterior Technique
81.09	Other spinal fusion ? No longer in use?
81.30	Refusion Of Spine, Not Otherwise Specified
81.31	Refusion Of Atlas-Axis Spine
81.32	Refusion Of Other Cervical Spine, Anterior Column, Anterior Technique
81.33	Refusion Of Other Cervical Spine, Posterior Column, Posterior Technique
81.34	Refusion Of Dorsal And Dorsolumbar Spine, Anterior Column, Anterior Technique
81.35	Refusion Of Dorsal And Dorsolumbar Spine, Posterior Column, Posterior Technique
81.36	Refusion Of Lumbar And Lumbosacral Spine, Anterior Column, Anterior Technique
81.37	Refusion Of Lumbar And Lumbosacral Spine, Posterior Column, Lateral Transverse Process Technique
81.38	Refusion Of Lumbar And Lumbosacral Spine, Anterior Column, Posterior Technique

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81.39	Refusion Of Spine, Not Elsewhere Classified
81.63	Fusion Or Refusion Of 4-8 Vertebrae
81.64	Fusion Or Refusion Of 9 Or More Vertebrae
84.51	Insertion Of Interbody Spinal Fusion Device
84.58	Implantation of interspinous process decompression device
84.59	Insert Of Other Spinal Devices
84.60	Insertion Of Spinal Disc Prosthesis; Not Otherwise Specified
84.61	Insertion Of Partial Spinal Disc Prosthesis, Cervical
84.62	Insertion Of Total Spinal Disc Prosthesis, Cervical
84.63	Insertion Of Spinal Disc Prosthesis, Thoracic
84.64	Insertion Of Partial Spinal Disc Prosthesis, Lumbosacral
84.65	Insertion Of Total Spinal Disc Prosthesis, Lumbosacral
84.66	Revision Or Replacement Of Artificial Spinal Disc Prosthesis
84.67	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Thoracic
84.68	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Lumbosacral
84.69	Revision Or Replacement Of Artificial Spinal Disc Prosthesis, Not Otherwise Specified
84.80	Insertion Or Replacement Of Interspinous Process Device(s)
84.81	Revision Of Interspinous Process Device(s)
84.82	Insertion Or Replacement Of Pedicle-Based Dynamic Stabilization Device(s)
84.83	Revision Of Pedicle-Based Dynamic Stabilization Device(s)
85.84	Insertion Or Replacement Of Facet Replacement Device(s)
84.85	Revision Of Facet Replacement Device(s)

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Appendix 1d: CPT Codes for Exclusion Criteria

CPT code	Description
00630	anesthesia for procedures in lumbar region; not otherwise specified.
00670	anesthesia for extensive spine and spinal cord procedures.
06300	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, cervical
20250	biopsy, vertebral body, open, thoracic
20930	allograft for spine surgery only; morselized (list separately in addition to code for primary procedure)
20936	autograft for spine surgery only (includes harvesting the graft); local (eg, ribs, spinous process, or laminar fragments) obtained from same incision
20937	autograft for spine surgery only (includes harvesting the graft); morselized (through separate skin or fascial incision) (list separately in addition to code for primary procedure)
20938	autograft for spine surgery only (includes harvesting the graft); structural, bicortical or tricortical (through separate skin or fascial incision) (list separately in addition to code for primary procedure)
22010	incision & drainage: deep abscess: posterior spine; cervical/thoracic/cervicothoracic
22015	incision & drainage: deep abscess: posterior spine; lumbar/sacral/lumbosacral
22100	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; cervical
22101	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; thoracic
22102	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; lumbar
22103	partial excision of posterior vertebral component (eg, spinous process, lamina or facet) for intrinsic bony lesion, single vertebral segment; each additional segment
22110	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; cervical
22112	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; thoracic
22114	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; lumbar
22116	partial excision of vertebral body, for intrinsic bony lesion, without decompression of spinal cord or nerve root(s), single vertebral segment; each additional vertebral segment
22206	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); thoracic
22207	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); lumbar
22208	osteotomy of spine, posterior or posterolateral approach, three columns, one vertebral segment (eg, pedicle/vertebral body subtraction); each additional vertebral segment
22210	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; cervical
22212	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; thoracic
22214	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; lumbar
22216	osteotomy of spine, posterior or posterolateral approach, one vertebral segment; each additional vertebral segment (list separately in addition to primary procedure)
22220	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; cervical

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22222	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; thoracic
22224	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; lumbar
22226	osteotomy of spine, including discectomy, anterior approach, single vertebral segment; each additional vertebral segment
22305	closed treatment of vertebral process fracture(s)
22310	closed treatment of vertebral body fracture(s), without manipulation, requiring and including casting or bracing
22315	closed treatment of vertebral fracture(s) and/or dislocation(s) requiring casting or bracing, with and including casting and/or bracing, with or without anesthesia, by manipulation or traction
22318	open treatment and/or reduction of odontoid fracture(s) and or dislocation(s) (including os odontoideum), anterior approach, including placement of internal fixation; without grafting
22319	open treatment and/or reduction of odontoid fracture(s) and or dislocation(s) (including os odontoideum), anterior approach, including placement of internal fixation; with grafting
22325	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, 1 fractured vertebra or dislocated segment; lumbar
22326	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; cervical
22327	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; thoracic
22328	open treatment and/or reduction of vertebral fracture(s) and/or dislocation(s), posterior approach, one fractured vertebra or dislocated segment; each additional fractured vertebra or dislocated segment
22505	manipulation of spine requiring anesthesia, any region
22511	percutaneous vertebroplasty (bone biopsy included when performed), 1 vertebral body, unilateral or bilateral injection, inclusive of all imaging guidance; lumbosacral
22513	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; thoracic
22514	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; lumbar
22515	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device (eg, kyphoplasty), 1 vertebral body, unilateral or bilateral cannulation, inclusive of all imaging guidance; each additional thoracic or lumbar vertebral body (list separately in addition to code for primary procedure)
22520	percutaneous vertebroplasty, one vertebral body, unilateral or bilateral injection; thoracic
22521	percutaneous vertebroplasty, one vertebral body, unilateral or bilateral injection; lumbar
22522	percutaneous vertebroplasty each additional thoracic or lumbar vertebral body
22523	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); thoracic
22524	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); lumbar

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22525	percutaneous vertebral augmentation, including cavity creation (fracture reduction and bone biopsy included when performed) using mechanical device, one vertebral body, unilateral or bilateral cannulation (eg, kyphoplasty); each additional thoracic or lumbar vertebral body
22526	percutaneous intradiscal electrothermal annuloplasty, unilateral or bilateral including fluoroscopic guidance; single level
22527	percutaneous intradiscal electrothermal annuloplasty, unilateral or bilateral including fluoroscopic guidance; one or more additional levels
22532	arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); thoracic
22533	arthrodesis, lateral extracavitary technique, including minimal discectomy to prepare interspace (other than for decompression); lumbar
22534	add-on code to describe each additional vertebral segment on which the arthrodesis using lateral extracavitary approach is performed, after the first segment. this code should be used in conjunction with cpt code 22532 and 22533.
22548	arthrodesis, anterior transoral or extraoral technique, clivus-c1-c2 (atlas-axis), with or without excision of odontoid process
22551	arthrodesis, anterior interbody, including disc space preparation, discectomy, osteophytectomy and decompression of spinal cord and/or nerve roots; cervical below c2
22554	arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); cervical below c2
22556	arthrodesis, anterior interbody technique, including minimal discectomy to prepare interspace (other than for decompression); thoracic
22558	anterior lumbar interbody fusion, first interspace
22585	anterior lumbar interbody fusion, additional interspace
22586	arthrodesis, pre-sacral interbody technique, including disc space preparation, discectomy, with posterior instrumentation, with image guidance, includes bone graft when performed, l5-s1 interspace
22590	arthrodesis, posterior technique, craniocervical (occiput-c2)
22595	arthrodesis, posterior technique, atlas-axis (c1-c2)
22600	arthrodesis, posterior or posterolateral technique, single level; cervical below c2 segment
22610	arthrodesis, posterior or posterolateral technique, single level; thoracic (with or without lateral transverse technique)
22612	arthrodesis, posterior or posterolateral technique, single level; lumbar (with or without lateral transverse technique)
22614	arthrodesis, posterior or posterolateral technique, single level; each additional vertebral segment
22630	arthrodesis, posterior interbody technique, including laminectomy and/or discectomy to prepare interspace (other than for decompression), single interspace; lumbar
22632	posterior lumbar interbody fusion, each additional interspace
22633	arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; lumbar
22634	arthrodesis, combined posterior or posterolateral technique with posterior interbody technique including laminectomy and/or discectomy sufficient to prepare interspace (other than for decompression), single interspace and segment; each additional interspace and segment
22800	arthrodesis, posterior, for spinal deformity, with or without cast; up to 6 vertebral segments

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22802	arthrodesis, posterior, for spinal deformity, with or without cast; 7 to 12 vertebral segments
22804	arthrodesis, posterior, for spinal deformity, with or without cast; 13 or more vertebral segments
22808	arthrodesis, anterior, for spinal deformity, with or without cast; 2 to 3 vertebral segments
22810	arthrodesis, anterior, for spinal deformity, with or without cast; 4 to 7 vertebral segments
22812	arthrodesis, anterior, for spinal deformity, with or without cast; 8 or more vertebral segments
22818	kyphectomy, circumferential exposure of spine and resection of vertebral segment(s) (including body and posterior elements); single or 2 segments
22819	kyphectomy, circumferential exposure of spine and resection of vertebral segment(s) (including body and posterior elements); 3 or more segments
22830	exploration of spinal fusion
22840	posterior non-segmental instrumentation (eg, harrington rod technique, pedicle fixation across one interspace, atlantoaxial transarticular screw fixation, sublaminar wiring at c1, facet screw fixation)
22841	internal spinal fixation by wiring of spinous processes
22842	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 3 to 6 vertebral segments
22843	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 7 to 12 vertebral segments
22844	posterior segmental instrumentation (eg, pedicle fixation, dual rods with multiple hooks and sublaminar wires); 13 or more vertebral segments
22845	anterior instrumentation; 2 to 3 vertebral segments
22846	anterior instrumentation; 4 to 7 vertebral segments
22847	anterior instrumentation; 8 or more vertebral segments
22848	pelvic fixation (attachment of caudal end of instrumentation to pelvic bony structures) other than sacrum
22849	reinsertion of spinal fixation device
22850	removal of posterior nonsegmental instrumentation (eg, harrington rod)
22851	application of intervertebral biomechanical device(s) (eg, synthetic cage(s), threaded bone dowel(s), methylmethacrylate) to vertebral defect or interspace
22852	removal of posterior segmental instrumentation
22855	removal of anterior instrumentation
22856	total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophytectomy for nerve root or spinal cord decompression and microdissection), single interspace, cervical
22857	total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), single interspace, lumbar
22861	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22862	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22864	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; cervical
22865	removal of total disc arthroplasty (artificial disc), anterior approach, single interspace; lumbar
27096	injection procedure for si joint, arthrography, and/or anesthetic steroid
62263	percutaneous lysis of epidural adhesions using solution injection or mechanical means, including radiologic localization, multiple adhesiolysis sessions, two or more days

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62264	percutaneous lysis of epidural adhesions using solution injection or mechanical means, including radiologic localization, multiple adhesiolysis sessionsone day
62281	injection/infusion of neurolytic substance (eg, alcohol, phenol, iced saline solutions), with or without other therapeutic substance; epidural, cervical or thoracic
62282	injection/infusion of neurolytic substance (eg, alcohol, phenol, iced saline solutions), with or without other therapeutic substance; epidural, lumbar, sacral (caudal)
62287	aspiration procedure, percutaneous, of nucleus pulposus of intervertebral disk, any method, single or multiple levels, lumbar.
62292	injection procedure for chemonucleolysis, including discography, intervertebral disc, single or multiple levels, lumbar
62310	injection, single (not via indwelling catheter), not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; cervical or thoracic
62311	injection, single (not via indwelling catheter), not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; lumbar, sacral (caudal)
62318	injection, including catheter placement, continuous infusion or intermittent bolus, not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; cervical or thoracic
62319	injection, including catheter placement, continuous infusion or intermittent bolus, not including neurolytic substances, with or without contrast (for either localization or epidurography), of diagnostic or therapeutic substance(s) (including anesthetic, antispasmodic, opioid, steroid, other solution), epidural or subarachnoid; lumbar, sacral (caudal)
62322	injection(s), of diagnostic or therapeutic substance(s) (eg, anesthetic, antispasmodic, opioid, steroid, other solution), not including neurolytic substances, including needle or catheter placement, interlaminar epidural or subarachnoid, lumbar or sacral (caudal) section
62323	injection(s), of diagnostic or therapeutic substance(s) (eg, anesthetic, antispasmodic, opioid, steroid, other solution), not including neurolytic substances, including needle or catheter placement, interlaminar epidural or subarachnoid, lumbar or sacral (caudal); with imaging guidance (ie, fluoroscopy or ct)
62350	implantation, revision or repositioning of tunneled intrathecal or epidural catheter, for long-term medication administration via an external pump or implantable reservoir/infusion pump; without laminectomy
62351	implantation, revision or repositioning of tunneled intrathecal or epidural catheter, for long-term medication administration via an external pump or implantable reservoir/infusion pump; with laminectomy
62355	removal of previously implanted intrathecal or epidural catheter.
62360	implantation or replacement of device for intrathecal or epidural drug infusion; subcutaneous reservoir
62361	implantation or replacement of device for intrathecal or epidural drug infusion; nonprogrammable pump
62362	implantation or replacement of device for intrathecal or epidural drug infusion; programmable pump, including preparation of pump, with or without programming
62365	removal of subcutaneous reservoir or pump, previously implanted for intrathecal or epidural infusion
62367	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); without reprogramming or refill

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62368	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming
62369	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming and refill
62370	electronic analysis of programmable, implanted pump for intrathecal or epidural drug infusion (includes evaluation of reservoir status, alarm status, drug prescription status); with reprogramming and refill (requiring physician's skill)
63001	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; cervical
63003	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; thoracic
63005	lumbar laminectomy without facetectomy, foraminotomy or discectomy, 1 or 2 segments
63011	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), 1 or 2 vertebral segments; sacral
63012	lumbar laminectomy for spondylolisthesis with removal of abnormal facet or pars interarticularis)
63015	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), more than 2 vertebral segments; cervical
63016	laminectomy with exploration and/or decompression of spinal cord and/or cauda equina, without facetectomy, foraminotomy or discectomy (e.g., spinal stenosis), more than 2 vertebral segments; thoracic
63017	more than two segments
63020	laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, including open and endoscopically-assisted approaches; 1 interspace, cervical
63030	lumbar laminotomy including partial facetectomy, foraminotomy,and/or excision of herniated disc
63035	each additional interspace
63040	laminotomy (hemilaminectomy), with decompression of nerve root(s), including partial facetectomy, foraminotomy and/or excision of herniated intervertebral disc, reexploration, single interspace; cervical
63042	re-exploration lumbar laminotomy, including partial facetectomy, foraminotomy, and/or excision of herniated disc
63043	laminonotomy with decompression of nerve root, each additional cervical interspace
63044	each additional interspace
63045	laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [e.g., spinal or lateral recess stenosis]), single vertebral segment; cervical
63046	laminectomy, facetectomy and foraminotomy (unilateral or bilateral with decompression of spinal cord, cauda equina and/or nerve root[s], [e.g., spinal or lateral recess stenosis]), single vertebral segment; thoracic
63047	lumbar laminectomy, facetectomy and foraminotomy, single level)
63048	each additional segment
63050	laminoplasty, cervical, with decompression of the spinal cord, 2 or more vertebral segments
63051	laminoplasty, cervical, with decompression of the spinal cord, 2 or more vertebral segments; with reconstruction of the posterior bony elements (including the application of bridging bone graft and non-segmental fixation devices (e.g., wire, suture, mini-plates), when performed)

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63055	transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (e.g., herniated intervertebral disc), single segment; thoracic
63056	transpedicular approach with decompression of spinal cord, equina and/or nerve root(s) (e.g., herniated intervertebral disc), single segment; lumbar (including transfacet, or lateral extraforaminal approach) (e.g., far lateral herniated intervertebral disc)
63057	transpedicular approach with decompression of spinal cord, each additional segmen
63064	costovertebral approach with decompression of spinal cord or nerve root(s) (e.g., herniated intervertebral disc), thoracic; single segment
63066	costrovertebral approach with decompression of spinal cord or nerve roots, thoracic, each additional segment
63075	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, single interspace
63076	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; cervical, each additional interspac
63077	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; thoracic, single interspace
63078	discectomy, anterior, with decompression of spinal cord and/or nerve root(s), including osteophytectomy; thoracic, each additional interspace
63081	vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve root(s); cervical, single segment
63082	vertebral corpectomy (vertebral body resection), partial or complete, anterior approach with decompression of spinal cord and/or nerve root(s); cervical, each additional segment
63085	vertebral corpectomy (vertebral body resection), partial or complete, transthoracic approach with decompression of spinal cord and/or nerve root(s); thoracic, single segment
63086	vertebral corpectomy (vertebral body resection), partial or complete, transthoracic approach with decompression of spinal cord and/or nerve root(s); thoracic, each additional segment
63087	vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; single segment
63088	vertebral corpectomy (vertebral body resection), partial or complete, combined thoracolumbar approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic or lumbar; each additional segment
63090	vertebral corpectomy (vertebral body resection), partial or complete, transperitoneal or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; single segment
63091	or retroperitoneal approach with decompression of spinal cord, cauda equina or nerve root(s), lower thoracic, lumbar, or sacral; each additional segment
63102	vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression ofspinal cord and/or nerve root(s) (e.g., for tumor or retropulsed bone fragments); lumbar, single segment
63103	vertebral corpectomy (vertebral body resection), partial or complete, lateral extracavitary approach with decompression of spinal cord and/or nerve root(s) (e.g., for tumor or retropulsed bone fragments); thoracic or lumbar, each additional segment
63170	laminectomy with myelotomy (e.g., bischof or drez type), cervical, thoracic, or thoracolumbar
63172	laminectomy with drainage of intramedullary cyst/syrinx; to subarachnoid space

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63173	laminectomy with drainage of intramedullary cyst/syrinx; to peritoneal or pleural space
63180	laminectomy and section of dentate ligaments, with or without dural graft, cervical; 1 or 2 segments
63182	laminectomy and section of dentate ligaments, with or without dural graft, cervical; more than 2 segments
63185	laminectomy with rhizotomy; 1 or 2 segments
63190	laminectomy with rhizotomy; more than 2 segments
63191	laminectomy with section of spinal accessory nerve
63194	laminectomy with cordotomy, with section of 1 spinothalamic tract, 1 stage; cervical
63195	laminectomy with cordotomy, with section of 1 spinothalamic tract, 1 stage; thoracic
63196	laminectomy with cordotomy, with section of both spinothalamic tracts, 1 stage; cervical
63197	laminectomy with cordotomy, with section of both spinothalamic tracts, 1 stage; thoracic
63198	laminectomy with cordotomy with section of both spinothalamic tracts, 2 stages within 14 days; cervical
63199	laminectomy with cordotomy with section of both spinothalamic tracts, 2 stages within 14 days; thoracic
63200	laminectomy, with release of tethered spinal cord, lumbar
63250	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; cervical
63251	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; thoracic
63252	laminectomy for excision or occlusion of arteriovenous malformation of spinal cord; thoracolumbar
63265	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; cervical
63266	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; thoracic
63267	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; lumbar
63268	laminectomy for excision or evacuation of intraspinal lesion other than neoplasm, extradural; sacral
63270	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; cervical
63271	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; thoracic
63272	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; lumbar
63273	laminectomy for excision of intraspinal lesion other than neoplasm, intradural; sacral
63275	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, cervical
63276	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, thoracic
63277	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, lumbar
63278	laminectomy for biopsy/excision of intraspinal neoplasm; extradural, sacral
63280	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, cervical
63281	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, thoracic
63282	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, extramedullary, lumbar
63283	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, sacral
63285	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, cervical
63286	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, thoracic
63287	laminectomy for biopsy/excision of intraspinal neoplasm; intradural, intramedullary, thoracolumbar
63290	laminectomy for biopsy/excision of intraspinal neoplasm; combined extradura-intradural lesion, any level
63295	osteoplastic reconstruction of dorsal spinal elements, following primary intraspinal procedure (list separately in addition to code for primary procedure)
63301	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, thoracic by transthoracic approach

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63302	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; extradural, thoracic by thoracolumbar approach
63303	vertebral corpectomy (vertebral body resection),partial or complete, for excision of intraspinal lesion, single segment; extradural, lumbar or sacral by transperitoneal or retroperitoneal approach
63304	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, cervical
63305	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, thoracic by transthoracic approach
63306	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, thoracic by thoracolumbar approach
63307	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; intradural, lumbar or sacral by transperitoneal or retroperitoneal approach
63308	vertebral corpectomy (vertebral body resection), partial or complete, for excision of intraspinal lesion, single segment; each additional segment
63650	dorsal column stimulator placements
63655	laminectomy for implantation of neurostimulator electrodes, plate/paddle, epidural
63660	revision or removal of spinal neurostimulator electrodes
63661	removal of spinal neurostimulator electrode percutaneous array(s), including fluoroscopy, when performed
63662	removal of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
63663	revision including replacement, when performed, of spinal neurostimulator electrode percutaneous array(s), including fluoroscopy, when performed
63664	revision including replacement, when performed, of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
63685	insertion or replacement of spinal neurostimulator pulse generator or receiver, direct or inductive coupling
63688	revision including replacement, when performed, of spinal neurostimulator electrode plate/paddle(s) placed via laminotomy or laminectomy, including fluoroscopy, when performed
64470	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; cervical or thoracic, single level
64472	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; cervical or thoracic, each additional level
64475	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; lumbar or sacral, single level
64476	injection, anesthetic agent and/or steroid, paravertebral facet joint or facet joint nerve; lumbar or sacral, each additional level
64479	injection, anesthetic agent and/or steroid, transforaminal epidural; cervical or thoracic, single level
64480	injection, anesthetic agent and/or steroid, transforaminal epidural; cervical or thoracic, each additional level
64483	injection, anesthetic agent and/or steroid, transforaminal epidural; lumbar or sacral, single level
64484	injection, anesthetic agent and/or steroid, transforaminal epidural; lumbar or sacral, each additional level
64490	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal)joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; single level
64491	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; second level

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64492	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with image guidance (fluoroscopy or ct), cervical or thoracic; third and any additional level(s)
64493	paravertebral facet joint injection, lumbar or sacral, single level
64494	paravertebral facet joint injection, lumbar or sacral, second level
64495	paravertebral facet joint injection, lumbar or sacral, third and each additional level
64520	Injection, anesthetic agent; lumbar or thoracic (paravertebral sympathetic)
64553	percutaneous implantation of neurostimulator electrode array; cranial nerve
64622	destruction by neurolytic agent, paravertebral facet joint nerve; lumbar or sacral, single level
64623	lumbar or sacral, each additional level
64635	destruction by neurolytic agent, paravertebral facet joint nerve; lumbar or sacral, single level with image guidance
64636	lumbar or sacral, each additional level with image guidance
95991	refilling and maintenance of implantable pump or reservoir for drug delivery, spinal (intrathecal, epidural) or brain (intraventricular), includes electronic analysis of pump, when performed; requiring skill of a physician or other qualified health care professional
0092T	total disc arthroplasty (artificial disc), anterior approach, including discectomy with end plate preparation (includes osteophytectomy for nerve root or spinal cord decompression and microdissection), each additional interspace, cervical (list separately in addition to code for primary procedure)
0095T	removal of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, cervical (list separately in addition to code for primary procedure)
0098T	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, cervical (list separately in addition to code for primary procedure)
0163T	total disc arthroplasty (artificial disc), anterior approach, including discectomy to prepare interspace (other than for decompression), each additional interspace, lumbar (list separately in addition to code for primary procedure)
0164T	removal of total disc arthroplasty, (artificial disc), anterior approach, each additional interspace, lumbar (list separately in addition to code for primary procedure)
0165T	revision including replacement of total disc arthroplasty (artificial disc), anterior approach, each additional interspace, lumbar (list separately in addition to code for primary procedure)
0171T	insertion of posterior spinous process distraction device (including necessary removal of bone or ligament for insertion and imaging guidance), lumbar; single level
0172T	insertion of posterior spinous process distraction device (including necessary removal of bone or ligament for insertion and imaging guidance), lumbar; each additional level (list separately in addition to code for primary procedure)
0215T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, cervical or thoracic; third and any additional level(s)
0216T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; single level
0217T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; second level
0218T	injection(s), diagnostic or therapeutic agent, paravertebral facet (zygapophyseal) joint (or nerves innervating that joint) with ultrasound guidance, lumbar or sacral; third and any additional level(s)
0230T	injection(s), anesthetic agent and/or steroid, transforaminal epidural, with ultrasound guidance, lumbar or sacral; single level

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0231T	injection(s), anesthetic agent and/or steroid, transforaminal epidural, with ultrasound guidance, lumbar or sacral; each additional level
0282T	percutaneous or open implantation of neurostimulator electrode array(s), subcutaneous (peripheral subcutaneous field stimulation), including imaging guidance, when performed, cervical, thoracic or lumbar, for trial, including removal at the conclusion of trial period
0283T	percutaneous or open implantation of neurostimulator electrode array(s), subcutaneous (peripheral subcutaneous field stimulation), including imaging guidance, when performed, cervical, thoracic or lumbar, permanent, with implantation of a pulse generator
0284T	revision or removal of pulse generator or electrodes, including imaging guidance, when performed, including addition of new electrodes, when performed

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Appendix table 2: Hosmer Lemeshow and c-statistics for all logistic models

Outcome	Hosmer Lemeshow chi-square	p-value	c-statistic
Any opioid use	19.029	0.015	0.631
Early opioid use	15.395	0.052	0.704
Long-term opioid use	17.181	0.028	0.753

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Appendix Table 3: Bootstrapping, early opioid use

Initial Provider	n	OR (95% CI) bootstrapping	Early use, OR (95% CI)
Physical therapy	200	0.15 (0.13, 0.17)	0.15 (0.13,0.17)
Chiropractor	200	0.10 (0.09, 0.10)	0.10 (0.09,0.10)
Acupuncture	200	0.09 (0.07, 0.12)	0.09 (0.07,0.12)
Orthopedics	200	0.63 (0.60, 0.67)	0.63 (0.60,0.67)
Emergency Medicine	200	2.66 (2.54, 2.78)	2.66 (2.54,2.78)
Neurosurgeon	200	0.57 (0.48, 0.69)	0.58 (0.47,0.71)
MD Other	200	0.50 (0.46, 0.54)	0.50 (0.46,0.54)
Radiology	200	0.70 (0.67, 0.73)	0.70 (0.67,0.73)
Rehab	200	0.54 (0.49, 0.59)	0.54 (0.49,0.59)
Other	200	0.81 (0.76, 0.87)	0.81 (0.76,0.87)

Appendix Table 3 Legend: Bootstrapping is a resampling technique that allows assigning of accuracy. The estimates reported using bootstrapping methods listed in this table indicate little or no differences with the actual results.

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Appendix table 4: Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

		PT	Chiro
Covariate	**Levels**	**OR (95% CI)**	**OR (95% CI)**
AGE	45-65 vs 18-44	1.02 (0.93,1.12)	0.81 (0.78, 0.83) *
	65-74 vs 18-44	1.15 (0.82,1.61)	0.77 (0.69, 0.86) *
GENDER	Female vs Male	1.16 (1.06,1.27)	0.84 (0.82, 0.87) *
RACE	Asian vs White	1.03 (0.86,1.23)	0.68 (0.64, 0.73) *
	Black vs White	0.67 (0.56,0.82) *	0.48 (0.46, 0.51) *
	Hispanic vs White	0.67 (0.57,0.78) *	0.64 (0.62, 0.67) *
	Unknown vs White	0.94 (0.75,1.19)	0.84 (0.77, 0.90) *
REGION	Midwest vs Northeast	2.11 (1.82,2.44) *	0.87 (0.83, 0.91) *
	South vs Northeast	0.88 (0.77,1.00)	0.86 (0.83, 0.89) *
	West vs Northeast	2.11 (1.83,2.42) *	1.00 (0.95, 1.04)
Pregnancy		5.79 (4.92,6.83) *	1.76 (1.62, 1.92) *
Accidents		0.74 (0.56,0.97) *	0.36 (0.32, 0.40) *
Anxiety		0.95 (0.82,1.11)	0.88 (0.84, 0.93) *
Bipolar		0.56 (0.36,0.88) *	0.93 (0.83, 1.05)
Depression		0.92 (0.79,1.08)	0.96 (0.92, 1.01)
Dementia		-	0.72 (0.43, 1.21)
ADHD		1.54 (1.17,2.04) *	0.99 (0.90, 1.09)
Alcohol use disorder		0.95 (0.60,1.49)	0.96 (0.83, 1.10)
Substance use disorder		0.88 (0.47,1.62)	0.82 (0.68, 0.99) *
Chronic Pain, fibromyalgia & Fatigue		1.44 (1.22,1.69) *	0.90 (0.84, 0.95) *
Psychotic Disorder		1.00 (0.40,2.48)	1.14 (0.87, 1.48)
Opioid use 13-24 months back		0.78 (0.69,0.87)*	0.84 (0.81, 0.87) *
PT 1-24 months back		5.00 (4.45,5.62) *	1.12 (1.05, 1.20) *
Chiro any 1-24 months back		1.45 (1.17,1.79) *	6.92 (6.52, 7.35) *
Acupuncture any 1-24 months back		1.80 (1.18,2.75) *	1.39 (1.12, 1.73) *
LBP 13-24 months back		1.27 (0.98,1.65)	0.85 (0.77, 0.93) *
Elixhauser physical		0.91 (0.87,0.95) *	0.91 (0.89, 0.92) *
PT State Access	Provisional vs Limited	1.21 (1.05,1.40) *	-
	Unlimited vs Limited	1.67 (1.41,1.98) *	-
Year of index visit		1.06 (1.02,1.09) *	1.02 (1.01, 1.03) *

Appendix Table 4 Legend: Pregnancy: pregnancy in the 12 months prior to the initial LBP visit; Accidents: motor vehicle accidents in the 12 months prior to the initial LBP visit; *p < .01. Reference group for age: ages 18-44; reference group for gender: male; reference group for race: white; reference group for region: Northeast; reference group for PT State Access: limited.

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Appendix table 5: Propensity matching for initial Physical Therapy (PT) and initial chiropractor vs. initial Primary Care Physician (PCP)

Outcome		**OR (95% CI)**
Early opioid use	Initial PT (N=2248) vs. initial PCP (N=4496)	0.15 (0.12, 0.18)
Long-term opioid use	Initial PT (N=2248) vs. initial PCP (N=4496)	0.29 (0.12, 0.69)
Early opioid use	Initial Chiropractor (N=32300) vs. initial PCP (N=32300)	0.10 (0.09, 0.10)
Long-term opioid use	Initial Chiropractor (N=32300) vs. initial PCP (N=32300)	0.21 (0.16, 0.27)

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Appendix table 6: Multivariable odds of initial chiropractic care and initial PT versus initial PCP as a function of baseline covariates

		PT	Chiro
Covariate	**Levels**	**OR (95% CI)**	**OR (95% CI)**
AGE	45-65 vs 18-44	1.02 (0.93,1.12)	0.81 (0.78, 0.83) *
	65-74 vs 18-44	1.15 (0.82,1.61)	0.77 (0.69, 0.86) *
GENDER	Female vs Male	1.16 (1.06,1.27)*	0.84 (0.82, 0.87) *
RACE	Asian vs White	1.03 (0.86,1.23)	0.68 (0.64, 0.73) *
	Black vs White	0.67 (0.56,0.82) *	0.48 (0.46, 0.51) *
	Hispanic vs White	0.67 (0.57,0.78) *	0.64 (0.62, 0.67) *
	Unknown vs White	0.94 (0.75,1.19)	0.84 (0.77, 0.90) *
REGION	Midwest vs Northeast	2.11 (1.82,2.44) *	0.87 (0.83, 0.91) *
	South vs Northeast	0.88 (0.77,1.00)	0.86 (0.83, 0.89) *
	West vs Northeast	2.11 (1.83,2.42) *	1.00 (0.95, 1.04)
Pregnancy		5.79 (4.92,6.83) *	1.76 (1.62, 1.92) *
Accidents		0.74 (0.56,0.97) *	0.36 (0.32, 0.40) *
Anxiety		0.95 (0.82,1.11)	0.88 (0.84, 0.93) *
Bipolar		0.56 (0.36,0.88) *	0.93 (0.83, 1.05)
Depression		0.92 (0.79,1.08)	0.96 (0.92, 1.01)
Dementia		-	0.72 (0.43, 1.21)
ADHD		1.54 (1.17,2.04) *	0.99 (0.90, 1.09)
Alcohol use disorder		0.95 (0.60,1.49)	0.96 (0.83, 1.10)
Substance use disorder		0.88 (0.47,1.62)	0.82 (0.68, 0.99) *
Chronic Pain, fibromyalgia & Fatigue		1.44 (1.22,1.69) *	0.90 (0.84, 0.95) *
Psychotic Disorder		1.00 (0.40,2.48)	1.14 (0.87, 1.48)
Opioid use 13-24 months back		0.78 (0.69,0.87)	0.84 (0.81, 0.87) *
PT 1-24 months back		5.00 (4.45,5.62) *	1.12 (1.05, 1.20) *
Chiro any 1-24 months back		1.45 (1.17,1.79) *	6.92 (6.52, 7.35) *
Acupuncture any 1-24 months back		1.80 (1.18,2.75) *	1.39 (1.12, 1.73) *
LBP 13-24 months back		1.27 (0.98,1.65)	0.85 (0.77, 0.93) *
Elixhauser physical		0.91 (0.87,0.95) *	0.91 (0.89, 0.92) *
PT State Access	Provisional vs Limited	1.21 (1.05,1.40) *	-
	Unrestricted vs Limited	1.67 (1.41,1.98) *	-
Year of index visit		1.06 (1.02,1.09) *	1.02 (1.01, 1.03) *

Appendix Table 6 Legend: Pregnancy: pregnancy in the 12 months prior to the initial LBP visit; Accidents: motor vehicle accidents in the 12 months prior to the initial LBP visit; *p < .01. Reference group for age: ages 18-44; reference group for gender: male; reference group for race: white; reference group for region: Northeast; reference group for PT State Access: limited.

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STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	3
Objectives	3	State specific objectives, including any prespecified hypotheses	4
Methods			
Study design	4	Present key elements of study design early in the paper	4-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	4-6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	4-6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4-7
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	4-7, figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	4-7
		(*b*) Describe any methods used to examine subgroups and interactions	NA
		(*c*) Explain how missing data were addressed	NA
		(*d*) If applicable, explain how loss to follow-up was addressed	NA
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7, figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	7-9, table 1
		(b) Indicate number of participants with missing data for each variable of interest	NA
		(c) Summarise follow-up time (eg, average and total amount)	NA
Outcome data	15*	Report numbers of outcome events or summary measures over time	7-9, table 2

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Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	7-9, table 2 NA NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	9-10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	12
Generalisability	21	Discuss the generalisability (external validity) of the study results	9-11
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	13

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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