Archives of Rehabilitation Research and Clinical Translation (2020) 2, 100060

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Rehabilitation Research and Clinical Translation

Archives of Rehabilitation Research and Clinical Translation 2020;2:100060

Available online at www.sciencedirect.com

Original Research

Performance of Pain Interventionalists From Different Specialties in Treating Degenerative Disk Disease-Related Low Back Pain

Weibin Shi, MD, PhD [a,b], Edeanya Agbese, MPH [c], Adnan Z. Solaiman, MD [d], Douglas L. Leslie, PhD [c], David R. Gater, MD, PhD, MS [e]

[a] *Physical Medicine and Rehabilitation, Penn State Health Milton S Hershey Medical Center, Hershey, PA*
[b] *Pennsylvania State Hershey Rehabilitation Hospital, Hummelstown, PA*
[c] *The Center for Applied Studies in Health Economics, Department of Public Health Sciences, Pennsylvania State University College of Medicine, Hershey, PA*
[d] *Northern Light Rehabilitation, Bangor, ME*
[e] *Physical Medicine and Rehabilitation, Miller School of Medicine, University of Miami, Miami, FL*

KEYWORDS
Cost-benefit analysis;
Injections, epidural;
Intervertebral disc degeneration;
Low back pain;
Physical therapy modalities;
Radiculopathy;
Rehabilitation

Abstract *Objectives:* To examine the utilization of current common treatments by providers from different specialties and the effect on delaying spinal surgery in patients with disk degenerative disease (DDD) related low back pain.
Design: Retrospective observational study using data from the MarketScan Commercial Claims and Encounters database (2005-2013).
Setting: Not applicable.
Participants: Patients (N=6229) newly diagnosed with DDD-related low back pain who received interventional treatments from only 1 provider specialty and continuously enrolled in the database for 3 years after diagnosis.
Main Outcome Measures: Measures of treatment utilization and cost were constructed for patients who received spinal surgery within 3 years after diagnosis. Cox proportional hazards models were used to examine time to surgery among provider specialties and generalized linear models were used to examine cost differences among provider specialties.
Results: Of the 6229 patients, 427 (6.86%) underwent spinal surgery with unadjusted mean interventional treatment costs ranging from $555 to $851. Although the differences in mean costs across provider specialties were large, they were not statistically significant. Cox

List of abbreviations: DDD, disk degenerative disease; LBP, low back pain.
Supported by the Office of Faculty and Professional Development of the Pennsylvania State College of Medicine.
Disclosures: none.
Cite this article as: Arch Rehabil Res Clin Transl. 2020;2:100060.

https://doi.org/10.1016/j.arrct.2020.100060

proportional hazards models showed that there was no significant difference between provider specialties in the time from DDD diagnosis to spinal surgery. However, patients diagnosed with DDD at a younger age and receiving physical therapy had significantly delayed time to surgery (hazard ratio, 0.66; 95% confidence interval [CI], 0.54-0.81 and hazard ratio, 0.77; 95% CI, 0.62-0.96, respectively).

Conclusions: Although there were no statistically significant differences among provider specialties for time to surgery and cost, patients receiving physical therapy had significantly delayed time to surgery.

Low back pain (LBP) is one of the leading causes of disability (ie, mobility restrictions) and can affect functional status in the work force.[1] Approximately 80% of the population experiences at least 1 episode of low back pain in their lives,[2] with 5% to 10% of patients developing persistent chronic LBP.[3] The prevalence of LBP is rising and can affect anyone at any time.[4,5] One of the major causes of LBP is intervertebral disk degenerative disease (DDD),[6-9] which is typically the presentation of the natural aging of the intervertebral disks and only progresses to a disease state, or DDD, when it causes pain, radicular symptoms, and weakness.[10] Generally, the prognosis of DDD-related LBP is favorable,[11,12] and treatments for the condition include conservative management (non-interventional and interventional) and spinal surgery. Conversely, patients with persistent DDD symptoms who have not responded to conservative treatments may be likely candidates for spinal surgery. Surgeries such as diskectomy with or without decompression, including minimally invasive microdiskectomy, have shown effectiveness in treating disk herniation with neurological symptoms, but likely lead to either a significant risk of recurrence, spinal instability leading to fusion,[13] or so-called failed back surgery syndrome.[14] Invasive surgeries such as lumbar artificial total disk replacement have yet to provide reliably good results.[15,16] Because of the uncertainty of long-term outcomes, patients with DDD-related LBP often request nonsurgical treatments to prevent or, when possible, delay these spine surgeries.

Conservative treatments, including noninterventional modalities, such as medications, exercise, and physical therapy, and interventional procedures, such as epidural injections have proven effective for pain relief, functional improvement, and avoiding or delaying surgery.[17-23] Recommendations and guidelines for interventional pain management physicians have been published by both the American Society of Interventional Pain Physicians[24] and the International Spine Intervention Society.[25,26] However, research has not found a common comprehensive standard or guideline that is strictly followed by physicians.[27,28] Health insurance policies in the United States might also affect treatment outcomes for patients with DDD. For example, Aetna's policy for interlaminar epidural injection states: "Initially, the individual may receive the first three injections at intervals of no sooner than two weeks."[29] Moreover, because of flexibility in the certification requirements for spinal interventional procedures, a variety of providers from different specialties, even without subspecialty board certification, can perform these procedures.[30,31] In fact, non–board-certified practitioners performed 37.7% of these interventional procedures according to a recent study in Florida.[31] Given the various medical backgrounds and paths to becoming an interventional pain specialist, the training and skill level among provider types vary widely and could influence treatment outcomes for patients.

The past few decades have witnessed a tremendous increase in spinal interventional procedure rates and more nonpain specialty providers performing these procedures in the United States,[32,33] although interventional therapies, such as epidural injections, for persistent LBP should be limited to selected patients according to current recommendations.[34] Although possible overutilization of interventional spinal procedures has been observed across all performing specialties,[30] medical professionals have yet to agree on the most cost-effective conservative treatment protocol for DDD-related LBP. It is important to have a model for physicians to follow in terms of judicious use of conservative treatments and cost-effectiveness. Thus, this study aims to address this gap by using private health insurance data to assess conservative treatments provided by various provider specialties, including their outcomes and cost, to inform clinical practice.

Methods

Data retrieval

All data for this study were retrieved from the Truven Health MarketScan Commercial Claims and Encounters Database (2005-2013).[a] MarketScan files contain deidentified medical and health care claim records for the employees and dependents of large and medium firms and health plans. Patients were identified using *International Classification of Diseases—9th Revision* codes along with current procedural terminology codes. The Penn State College of Medicine Institutional Review Board and Human Subjects Protection Office approved this study.

To be included in our study sample, patients had to be diagnosed with lumbar or lumbosacral intervertebral disk disorder (722.52), be continuously enrolled in a health insurance plan for at least 3 years, and receive interventional treatments from only 1 provider specialty within 3 years of diagnosis. We excluded patients with any of the following diagnoses 1 year before their index diagnosis: lumbar or lumbosacral intervertebral disk disorder, displacement of lumbar intervertebral disk without myelopathy (722.10), LBP (724.2), intervertebral disk with myelopathy (722.7), and other diseases of the spine (336).

We focused on intervention treatments provided by 6 provider specialties: anesthesiology, neurosurgery, orthopedics, pain management, physiatry, and radiology. To compare treatment outcomes and intervention treatment costs by provider specialty, we further limited our sample to those who received surgery and studied all outcomes before surgery (see appendix 1 for treatment and surgical codes). Because patients diagnosed with radiculopathy have greater pain and possible chronicity than those with isolated LBP,[35,36] we hypothesized that such patients would have a different treatment plan. Thus, we further subdivided the sample into those with and those without radiculopathy. We identified physical medicine, rehabilitation modalities, and therapeutic procedures (hereafter, physical therapy) separate from other conservative treatments. Our outcome measures included average time to surgery, average number of interventional visits before surgery, total costs of all intervention visits before surgery, use of other conservative treatments, and physical therapy utilization. Our control variables included sex, age at DDD diagnosis, radiculopathy diagnosis, provider specialty, and geographic region.

Data analysis

First, we calculated statistics describing sociodemographic, treatment, comorbid diagnoses, and medical provider specialty characteristics for our study population. Next, among those who received spinal surgery, we compared treatment outcomes and costs by provider specialty in the 3 years after DDD diagnosis. We grouped the resultant surgery sample into those with and those without radiculopathy and then compared their treatment costs and outcomes by provider specialty. We then used a generalized linear model with a log link and gamma distribution to test for differences in cost among provider types, controlling for patient clinical and demographic characteristics. A Cox proportional hazards model was then used to identify variables independently associated with time to surgery. Analyses conducted using SAS 9.4[b] and Stata.[c]

Results

A total of 6229 patients with DDD met our inclusion criteria. The average age of the sample was 50.8 years and a majority (56.5%) were women. Comorbid diabetes and radiculopathy (without myelopathy) were present in 20% and 54.8% of our sample, respectively. More than half of our sample received additional conservative treatments for their DDD (physical therapy, 58.3%; other conservative treatments, 21.9%). A little over one-third (39%) received only interventional treatments. Anesthesiologists saw the most patients for interventional treatments (2520; 40.5%) whereas neurosurgeons saw the least (140; 2.3%). During our study period, 427 people (6.86%) underwent surgery (table 1).

Table 1 Baseline characteristics of patients with DDD-related low back pain receiving intervention treatment from 1 type provider within 3 years after diagnosis (N=6229)

Characteristics	Mean ± SD or n (%)
Age at DDD diagnosis, y	50.82±8.90
Sex	
Male	2709 (43.49)
Female	3520 (56.51)
Comorbid conditions	
Diabetes	1243 (19.96)
Radiculopathy, no myelopathy	3414 (54.81)
Conservative treatments	
Physical therapy	3629 (58.26)
Other treatments	1365 (21.91)
None	2430 (39.01)
Surgery	
Yes	427 (6.86)
No	5802 (93.14)
Provider specialties	
Anesthesiology	2520 (40.46)
Neurosurgery	140 (2.25)
Orthopedics	454 (7.29)
Pain management	1231 (19.76)
Physiatry	1306 (20.97)
Radiology	578 (9.28)

The mean unadjusted cost of interventional treatments differed by provider specialty and ranged from $555 (radiology) to $851 (pain management) (table 2). The average time to surgery ranged from 197 days (physiatry) to 325 days (neurosurgery). On average, patients saw their providers for 4 intervention treatments before receiving surgery. When grouped into those with and without radiculopathy, the average time to surgery ranged from 201 days (physiatry) to 354 days (orthopedics) for those with radiculopathy and from 165 days (orthopedics) to 379 days (neurosurgery) for those without radiculopathy (table 3). On average, those with radiculopathy received significantly more intervention treatments before surgery (4.87 vs 3.38; $P<.0001$). The average cost of intervention treatments ranged from $534 (radiology) to $1085 (pain management) for those with radiculopathy and from $561 (pain management) to $732 (orthopedics) for those without radiculopathy (see table 3).

The generalized linear model showed no significant cost differences between provider specialties for interventional treatments. The Cox proportional hazards model showed no significant difference between provider specialties in the time from DDD diagnosis to surgery and in the region in which patients lived (table 4). However, being diagnosed with DDD at a younger age, receiving physical therapy, and having radiculopathy significantly delayed the time to surgery (hazard ratio [HR], 0.66; 95% confidence interval [CI], 0.54-0.81; HR, 0.77; 95% CI, 0.62-0.96; and HR, 0.79; 95% CI, 6.5-9.8, respectively) (see table 4).

Table 2 Characteristics of patients who received surgery after being treated with interventional treatments from one provider specialty (n=427)

Provider Specialty	n	Percentage of Total Provider Specialty	Time to Surgery, d	Number of Visits to Provider	Cost of Intervention Treatment, United States Dollars
			Mean ± SD	Mean ± SD	Mean ± SD
Anesthesiology	148	5.87	224.45 ± 263.43	3.99 ± 3.63	668 ± 829
Neurosurgery	16	11.43	325.38 ± 229.52	4.00 ± 2.39	819 ± 963
Orthopedics	37	8.15	282.76 ± 322.00	4.16 ± 3.93	639 ± 847
Pain management	114	9.26	258.08 ± 281.50	5.17 ± 4.96	851 ± 1074
Physiatry	80	6.13	197.20 ± 225.36	3.74 ± 2.87	698 ± 859
Radiology	32	5.54	250.34 ± 294.55	3.47 ± 3.45	555 ± 762

Discussion

In our sample of patients diagnosed with DDD and treated with interventional treatments, we found that more than half received conservative treatments for their DDD (physical therapy, 58.3%; other treatments, 21.9%) and 427 (6.86%) underwent surgery within 3 years of diagnosis. Among those who underwent surgery, the average cost of their interventional treatment by provider specialty ranged from $555 (radiology) to $851 (pain management), and patients saw their provider for an average of 4 treatments before surgery. Although our regression analysis showed no differences in cost and time to surgery by provider specialty, it did show that receiving physical therapy, being diagnosed with radiculopathy, and being diagnosed with DDD at a younger age significantly delayed the time to surgery.

Spine health providers perform similarly in treating DDD-related low back pain

The data presented herein demonstrated that there were no differences in cost and performance in treating DDD-related LBP among different provider types (see table 4). In other words, a provider's primary specialty type is not a contributing factor in his or her performance in treating patients with DDD-related LBP. The standard training

Table 3 Characteristics of patients who received surgery after being treated with interventional treatments from one provider specialty by radiculopathy status

Patients With Radiculopathy (n=246)

Provider Specialty	n	Percentage of Total Diagnosed With Radiculopathy	Time to Surgery, d	Number of Visits to Provider	Cost of Intervention Treatment, United States Dollars
			Mean ± SD	Mean ± SD	Mean ± SD
Anesthesiology	86	6.59	241.94 ± 269.82	4.62 ± 3.28	823 ± 860
Neurosurgery	9	11.84	283.56 ± 214.68	4.78 ± 2.28	1073 ± 1202
Orthopedics	23	8.75	354.17 ± 333.52	4.57 ± 2.94	583 ± 433
Pain management	63	9.13	293.76 ± 311.56	6.13 ± 5.43	1085 ± 1182
Physiatry	47	5.70	200.70 ± 201.97	4.26 ± 2.73	719 ± 693
Radiology	18	7.06	269.83 ± 277.96	3.67 ±3.76	534 ± 702

Patients Without Radiculopathy (n=181)

Provider Specialty	n	Percentage of Total Without Radiculopathy	Time to Surgery, d	Number of Visits to Provider	Cost of Intervention Treatment, United States Dollars
			Mean ± SD	Mean ± SD	Mean ± SD
Anesthesiology	62	5.10	200.19 ± 254.48	3.13 ± 3.94	453 ± 738
Neurosurgery	7	10.94	379.14 ± 253.48	3.00 ± 2.31	494 ± 414
Orthopedics	14	7.33	165.43 ± 273.93	3.50 ± 5.24	732 ± 1286
Pain management	51	9.43	214.00 ± 234.80	3.98 ± 4.07	562 ± 848
Physiatry	33	6.86	192.21 ± 258.27	3.00 ± 2.94	668 ± 1064
Radiology	14	4.33	225.29 ± 323.50	3.21 ± 3.14	583 ± 861

Table 4 Survival analysis modelling the time to surgery for patients diagnosed with DDD (n=427)

Parameter	χ^2	*P* value	Hazard Ratio	95% Confidence Limits	
Age at diagnosis	15.85	<.0001	0.66	0.54	0.81
Sex					
Male (reference)					
Female	0.06	.802	0.97	0.79	1.20
Radiculopathy	4.87	.027	0.79	0.65	0.98
Physical therapy	5.31	.021	0.77	0.62	0.96
Other conservative treatments	0.09	.766	0.95	0.69	1.31
Region					
Northeast (reference)					
North central	0.64	.425	0.84	0.54	1.29
South	0.00	.965	1.01	0.67	1.52
West	0.28	.594	1.14	0.71	1.83
Unknown	0.17	.679	1.55	0.20	12.33
Provider Specialty					
Radiology (reference)					
Anesthesiology	0.39	.532	1.15	0.75	1.76
Neurosurgery	1.08	.299	0.70	0.36	1.37
Orthopedics	0.000	.996	1.00	0.59	1.68
Pain management	0.01	.930	1.02	0.66	1.57
Physiatry	1.24	.266	1.29	0.82	2.04

programs along with the efforts that different societies have been made to standardize spinal interventional procedures may have played a significant role.

Conservative noninterventional treatments delay spine surgery

Physical therapy utilization in this study is considerably higher (41.69%) than that observed in a Medicare population (16.2%)[37] but close to that observed in a German cohort of primary care physicians (49%).[38] Physical therapy is a widely accepted and powerful tool in the treatment of chronic LBP of a variety of pathologies,[39-42] yet it is nationally underutilized for LBP[43-45] and guidelines advise delaying physical therapy referrals to allow for spontaneous recovery.[46] Using the National Ambulatory and National Hospital Ambulatory Medical Care Surveys between 1997 and 2010, Zheng et al found that, on average, only 10% of primary care visits for LBP were associated with physical therapy referrals.[45] Other studies have found physical therapy referrals made in 21% to 38% of their samples.[43,44,47]

Among patients who received spinal surgery, our results also showed that patients with physical therapy had a significantly delayed time to surgery. There are numerous benefits of patients diagnosed with LBP engaging in physical therapy. Using commercial health insurance data for 6 states, Frogner et al compared differences in opioid prescription, health care utilization, and costs among patients with LBP who saw a physical therapist. They found that when LBP patients saw a physical therapist first, they had lower opioid use and lower utilization of high-cost medical services.[48] In addition, Fritz et al also found engagement in physical therapy to be associated with a decreased risk of using opioid medications, as well as a decreased risk of surgery, additional physician visits, and reduced medical costs.[49]

Given the many benefits of physical therapy, our finding that physical therapy was beneficial even among those patients who did receive spinal surgery supports an increased engagement of physical therapy. However, we did not quantify the number of conservative treatments patients received before surgery. Typically, these treatments continue until their benefits plateau, patients are unable to tolerate further treatments, or patients have reached the maximum number allowable by their insurance companies.

Patients with radiculopathy had delayed time to spine surgery

In our study, we found that patients with radiculopathy had their spinal surgeries later than those without radiculopathy ($P=.027$). As demonstrated by our results, patients with radiculopathy also received more interventional procedures than those not diagnosed with radiculopathy. This could be due to the fact that the distribution pattern of the involved nerve root and the utilization of electromyogram makes the LBP relatively easy to localize in patients with radiculopathy, and thus, targeted steroid injections usually work effectively.[21] In contrast, patients without radiculopathy likely have vague LBP, so-called diskogenic pain, confounded by some sacral and facetogenic pain, which is usually refractory to conservative treatments, including interventional procedures. Therefore, it seems logical to conclude that the next best treatment option will be spine surgery, even though the surgical outcome may not be as effective as expected. In more than 85% of the patients with chronic LBP, a pathoanatomical diagnosis cannot be made, which makes effective treatment difficult.[50] Thus, in reality, these patients receive surgeries even earlier than patients with a specific pathoanatomical diagnosis (such as defined radiculopathy), largely because of the fact that conservative treatment options are limited for non-specific LBP.

Study limitations

Although the MarketScan database provides a large, nationwide patient cohort enabling high statistical power, as with any data source, there are limitations, largely owing to the nature of claims data. Because the data are from private insurance, our results may not be generalizable to Medicare, Medicaid, and uninsured populations. Second, because therapeutic transforaminal epidural steroid injections and diagnostic selective nerve root blocks share the same current procedural terminology code, we could not distinguish between these procedures.[30] However, selective nerve root block is likely a preoperative diagnostic procedure requested by the spine surgeon to test whether a patient's pain is neural in origin and whether a specific nerve root is pain producing in patients with equivocal clinical and imaging studies. Therefore, we believe this comprised only a small portion of all lumbar epidural steroid injections, if any.

Conclusions

In summary, our findings suggest that, although the costs of interventional procedures differ by medical provider specialty, the cost differences are not significantly different, and no specialty performed better in delaying surgery for patients with chronic back pain. Additionally, receiving physical therapy significantly delayed time to spinal surgery among patients diagnosed with DDD at a younger age and those with radiculopathy. Therefore, more should be done to increase the utilization of physical medicine and rehabilitation modalities and therapeutic procedures for patients diagnosed with chronic back pain.

Suppliers

a. MarketScan Commercial Claims and Encounters Database; Truven Health Analytics.
b. SAS 9.4; SAS Institute, Inc.
c. Stata; StataCorp.

Corresponding author

Weibin Shi, MD, PhD, Physical Medicine and Rehabilitation, Penn State Health Milton S Hershey Medical Center, 1135 Old West Chocolate Ave, Suite 101, Hummelstown, PA 17036. *E-mail address:* wshi@pennstatehealth.psu.edu.

Appendix

Appendix 1 Current Procedural Terminology Codes Used to Identify Treatments and Surgical Procedures

Treatments and Procedures	CPT Codes
Interventional Procedures	
Injection/infusion of neurolytic substance (eg, alcohol, phenol, iced saline solutions), with or without other therapeutic substance; subarachnoid ultrasonic guidance for needle placement (eg, biopsy, aspiration, injection, localization device), imaging supervision and interpretation (not covered for chemical ablation [including but not limited to alcohol, phenol, or sodium morrhuate] of facet joints)	62280
Nucleoplasty/percutaneous	62287
Injection procedure for chemonucleolysis, including diskography, intervertebral disk, single or multiple levels, lumbar	62292
Chemonucleolysis	62293
Injection, anesthetic agent and/or steroid, interlaminar epidural, lumbar/sacral	62311
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	62319
Injection, anesthetic agent and/or steroid, transforaminal epidural, lumbar	64483
Multiple level transforaminal epidural injections	64484
Lumbar or sacral ultrasonic guidance for needle placement (eg, biopsy, aspiration, injection, localization device), imaging supervision and interpretation	64636
Fluoroscopic guidance for needle placement	77003
Surgeries and Procedures	
Percutaneous laminotomy/laminectomy (intralaminar approach) for decompression of neural elements, (with or without ligamentous resection, diskectomy, facetectomy and/or foraminotomy) any method under indirect image guidance (eg, fluoroscopic, CT), with or without the use of an endoscope, single or multiple levels, unilateral or bilateral; lumbar	0275T
Anterior interbody fusion, lumbar	22558
Posterolateral fusion, lumbar	22612
Posterior interbody fusion, lumbar	22630

(*continued on next page*)

Appendix 1 (*continued*)

Combined fusion, posterolateral fusion, with posterior interbody fusion	22633
Posterior instrumentation	22840-22844
Application of biomechanical device (cages, etc)	22851
Total disk arthroplasty (artificial disk), anterior approach, (other than for decompression)	22857
Revision including replacement of total disk arthroplasty (artificial disk), anterior approach	22862
Percutaneous lysis of epidural adhesions using solution injection (eg, hypertonic saline, enzyme) or mechanical means (eg, catheter) including radiologic localization (includes contrast when administered), multiple adhesiolysis sessions	62263
Percutaneous lysis of epidural adhesions using solution injection (eg, hypertonic saline, enzyme) or mechanical means (eg, catheter) including radiologic localization (includes contrast when administered), multiple adhesiolysis sessions	62264
Percutaneous aspiration within the nucleus pulposus, intervertebral disk, or paravertebral tissue for diagnostic purposes	62267
Epidural, lumbar, sacral (caudal) (not covered for chemical ablation [including but not limited to alcohol, phenol or sodium morrhuate] of facet joints)	62282
Decompression procedure, percutaneous, of nucleus pulposus of intervertebral disk, any method, single or multiple levels, lumbar (eg, manual or automated percutaneous diskectomy, percutaneous laser diskectomy)	62287
Laminectomy, diskectomy and related procedures (eg, decompression of spinal cord)	63001-63091
Laminectomy with rhizotomy	63185-63190
Epidurography, radiological supervision, and interpretation	72275
Allograft (morselized)*	20930
Allograft (structural)*	20931
Autograft (rib/lamina/spinous process, same incision)*	20936
Autograft (morselized, separate incision)*	20937
Autograft (structural, separate incision)*	20938
Removal of total disk arthroplasty (artificial disk), anterior approach, each additional interspace, lumbar*	+0164T
Conservative Treatments	
Physical medicine and rehabilitation modalities and therapeutic procedures (physical therapy)	97001-97140
Other conservative treatments	90832, 90834, 90837, 96116, 97810, 98940-98943

* Add-on code.

References

1. GBD 2017 Disease and Injury Incidence and Prevalence Collaborators. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392:1789-858.
2. Waddell G. 1987 Volvo award in clinical sciences. A new clinical model for the treatment of low-back pain. Spine (Phila Pa 1976) 1987;12:632-44.
3. Lawrence RC, Helmick CG, Arnett FC, et al. Estimates of the prevalence of arthritis and selected musculoskeletal disorders in the United States. Arthritis Rheum 1998;41:778-99.
4. Freburger JK, Holmes GM, Agans RP, et al. The rising prevalence of chronic low back pain. Arch Intern Med 2009;169:251-8.
5. Hoy D, Bain C, Williams G, et al. A systematic review of the global prevalence of low back pain. Arthritis Rheum 2012;64:2028-37.
6. Luoma K, Riihimaki H, Luukkonen R, et al. Low back pain in relation to lumbar disc degeneration. Spine (Phila Pa 1976) 2000;25:487-92.
7. Fujii K, Yamazaki M, Kang JD, et al. Discogenic back pain: literature review of definition, diagnosis, and treatment. JBMR Plus 2019;3:e10180.
8. Schwarzer AC, Aprill CN, Derby R, et al. The prevalence and clinical features of internal disc disruption in patients with chronic low back pain. Spine (Phila Pa 1976) 1995;20:1878-83.
9. Molinos M, Almeida CR, Caldeira J, et al. Inflammation in intervertebral disc degeneration and regeneration. J R Soc Interface 2015;12:20150429.
10. Adams MA, Roughley PJ. What is intervertebral disc degeneration, and what causes it? Spine (Phila Pa 1976) 2006;31:2151-61.

11. Coste J, Delecoeuillerie G, Cohen de Lara A, et al. Clinical course and prognostic factors in acute low back pain: an inception cohort study in primary care practice. BMJ 1994;308:577-80.
12. Croft PR, Macfarlane GJ, Papageorgiou AC, et al. Outcome of low back pain in general practice: a prospective study. BMJ 1998;316:1356-9.
13. Yorimitsu E, Chiba K, Toyama Y, et al. Long-term outcomes of standard discectomy for lumbar disc herniation: a follow-up study of more than 10 years. Spine (Phila Pa 1976) 2001;26:652-7.
14. DePalma MJ, Ketchum JM, Saullo TR, et al. Is the history of a surgical discectomy related to the source of chronic low back pain? Pain Physician 2012;15:E53-8.
15. Jacobs WC, van der Gaag NA, Kruyt MC, et al. Total disc replacement for chronic discogenic low back pain: a Cochrane review. Spine (Phila Pa 1976) 2013;38:24-36.
16. Wei J, Song Y, Sun L, et al. Comparison of artificial total disc replacement versus fusion for lumbar degenerative disc disease: a meta-analysis of randomized controlled trials. Int Orthop 2013;37:1315-25.
17. Machado LA, Kamper SJ, Herbert RD, et al. Analgesic effects of treatments for non-specific low back pain: a meta-analysis of placebo-controlled randomized trials. Rheumatology (Oxford) 2009;48:520-7.
18. van Middelkoop M, Rubinstein SM, Verhagen AP, et al. Exercise therapy for chronic nonspecific low-back pain. Best Pract Res Clin Rheumatol 2010;24:193-204.
19. Rainville J, Nguyen R, Suri P. Effective conservative treatment for chronic low back pain. Semin Spine Surg 2009;21:257-63.
20. Chou R, Atlas SJ, Stanos SP, et al. Nonsurgical interventional therapies for low back pain: a review of the evidence for an American Pain Society clinical practice guideline. Spine (Phila Pa 1976) 2009;34:1078-93.
21. Manchikanti L, Buenaventura RM, Manchikanti KN, et al. Effectiveness of therapeutic lumbar transforaminal epidural steroid injections in managing lumbar spinal pain. Pain Physician 2012;15:E199-245.
22. MacVicar J, King W, Landers MH, et al. The effectiveness of lumbar transforaminal injection of steroids: a comprehensive review with systematic analysis of the published data. Pain Med 2013;14:14-28.
23. Rivera CE. Lumbar epidural steroid injections. Phys Med Rehabil Clin N Am 2018;29:73-92.
24. Manchikanti L, Singh V, Kloth D, et al. Interventional techniques in the management of chronic pain: Part 2.0. Pain Physician 2001;4:24-96.
25. Bogduk N; International Spine Intervention Society. Standards Committee. Practice guidelines for spinal diagnostic and treatment procedures. 1st ed. San Francisco: International Spine Intervention Society; 2004.
26. Bogduk N; International Spine Intervention Society. Practice guidelines for spinal diagnostic and treatment procedures. 2nd edition. San Francisco: International Spine Intervention Society; 2013.
27. Lebude B, Wang D, Harrop JS, et al. Clinical survey: patterns of utilization of lumbar epidural steroid injections by a cohort of spinal surgeons. PM R 2009;1:329-34.
28. Malik KM, Cohen SP, Walega DR, et al. Diagnostic criteria and treatment of discogenic pain: a systematic review of recent clinical literature. Spine J 2013;13:1675-89.
29. Aetna. Back Pain - Invasive Procedures. Clinical Policy Bulletins. Available at: http://www.aetna.com/cpb/medical/data/1_99/0016.html. Accessed February 25, 2020.
30. Abbott ZI, Nair KV, Allen RR, et al. Utilization characteristics of spinal interventions. Spine J 2012;12:35-43.
31. Epstein RH, Dexter F, Pearson ACS. Pain medicine board certification status among physicians performing interventional pain procedures in the state of Florida between 2010 and 2016. Pain Physician 2020;23:E7-18.
32. Friedly J, Chan L, Deyo R. Increases in lumbosacral injections in the Medicare population: 1994 to 2001. Spine (Phila Pa 1976) 2007;32:1754-60.
33. Manchikanti L, Pampati V, Hirsch JA. Retrospective cohort study of usage patterns of epidural injections for spinal pain in the US fee-for-service Medicare population from 2000 to 2014. BMJ Open 2016;6:e013042.
34. Foster NE, Anema JR, Cherkin D, et al. Prevention and treatment of low back pain: evidence, challenges, and promising directions. Lancet 2018;391:2368-83.
35. Selim AJ, Ren XS, Fincke G, et al. The importance of radiating leg pain in assessing health outcomes among patients with low back pain - results from the Veterans Health Study. Spine 1998;23:470-4.
36. Chou R, Shekelle P. Will this patient develop persistent disabling low back pain? JAMA 2010;303:1295-302.
37. Gellhorn AC, Chan L, Martin B, et al. Management patterns in acute low back pain: the role of physical therapy. Spine (Phila Pa 1976) 2012;37:775-82.
38. Chenot JF, Leonhardt C, Keller S, et al. The impact of specialist care for low back pain on health service utilization in primary care patients: a prospective cohort study. Eur J Pain 2008;12:275-83.
39. Delitto A, Piva SR, Moore CG, et al. Surgery versus nonsurgical treatment of lumbar spinal stenosis: a randomized trial. Ann Intern Med 2015;162:465-73.
40. Blum K, Chen AL, Chen TJ, et al. The H-Wave device is an effective and safe non-pharmacological analgesic for chronic pain: a meta-analysis. Adv Ther 2008;25:644-57.
41. Cai C, Pua YH, Lim KC. A clinical prediction rule for classifying patients with low back pain who demonstrate short-term improvement with mechanical lumbar traction. Eur Spine J 2009;18:554-61.
42. Qaseem A, Wilt TJ, McLean RM, et al. Noninvasive treatments for acute, subacute, and chronic low back pain: a clinical practice guideline from the American College of Physicians. Ann Intern Med 2017;166:514-30.
43. Freburger JK, Carey TS, Holmes GM. Physician referrals to physical therapists for the treatment of spine disorders. Spine J 2005;5:530-41.
44. Jackson JL, Browning R. Impact of national low back pain guidelines on clinical practice. South Med J 2005;98:139-43.
45. Zheng P, Kao MC, Karayannis NV, et al. Stagnant physical therapy referral rates alongside rising opioid prescription rates in patients with low back pain in the United States 1997-2010. Spine (Phila Pa 1976) 2017;42:670-4.
46. Chou R, Huffman LH, American Pain S, et al. Nonpharmacologic therapies for acute and chronic low back pain: a review of the evidence for an American Pain Society/American College of Physicians clinical practice guideline. Ann Intern Med 2007;147:492-504.
47. Hart LG, Deyo RA, Cherkin DC. Physician office visits for low back pain. Frequency, clinical evaluation, and treatment patterns from a U.S. national survey. Spine (Phila Pa 1976) 1995;20:11-9.
48. Frogner BK, Harwood K, Andrilla CHA, et al. Physical therapy as the first point of care to treat low back pain: an instrumental variables approach to estimate impact on opioid prescription, health care utilization, and costs. Health Serv Res 2018;53:4629-46.
49. Fritz JM, Childs JD, Wainner RS, et al. Primary care referral of patients with low back pain to physical therapy: impact on future health care utilization and costs. Spine (Phila Pa 1976) 2012;37:2114-21.
50. Dhillon KS. Spinal fusion for chronic low back pain: a 'magic bullet' or wishful thinking? Malays Orthop J 2016;10:61-8.