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A 2-Year Cost Analysis of Maximum Nonoperative Treatments in Patients With Symptomatic Lumbar Stenosis or Spondylolisthesis That Ultimately Required Surgery

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Abstract

Study Design: Retrospective cohort study.

Objectives: The purpose of this study is to characterize the utilization and costs of maximal nonoperative therapies (MNTs) within 2 years prior to spinal fusion surgery in patients with symptomatic lumbar stenosis or spondylolisthesis.

Methods: A large insurance database was queried for patients with symptomatic lumbar stenosis or spondylolisthesis undergoing index 1-, 2-, or 3-level lumbar decompression and fusion procedures between 2007 and 2016. This database consists of 20.9 million covered lives and includes private/commercially insured and Medicare Advantage beneficiaries. The utilization of MNTs within 2 years prior to index surgery was assessed by cost billed to the patient, prescriptions written, and number of units billed.

Results: A total of 27 877 out of 3 423 114 (0.8%) eligible patients underwent posterior lumbar instrumented fusion. Patient MNT utilization was as follows: 11 383 (40.8%) used nonsteroidal anti-inflammatory drugs (NSAIDs), 19 770 (70.9%) used opioids, 12 414 (44.5%) used muscle relaxants, 14 422 (51.7%) received lumbar epidural steroid injection (LESI), 11 156 (40.0%) attended physical therapy/occupational therapy, 4005 (14.4%) presented to the emergency department, and 4042 (14.5%) received chiropractor treatments. The total direct cost associated with all MNTs prior to index spinal fusion was $28 241 320 ($1013.07 per/patient). LESI comprised the largest portion of the total cost of MNT ($15 296 941, 54.2%), followed by opioids ($3 702 463, 13.1%) and NSAIDs ($3 058 335, 10.8%).

Conclusions: Opioids are the most frequently prescribed and most used therapy in the preoperative period. Assuming minimal improvement in pain and functional disability after maximum nonoperative therapies, the incremental cost effectiveness ratio for MNT could be highly unfavorable.

Keywords

lumbar, stenosis, spondyliosthesis, low back pain, preoperative period, nonoperative therapy

Introduction

Low back pain (LBP) is a leading cause of disability and morbidity in the United States.[1] Common causes of LBP include degenerative lumbar stenosis or spondylolisthesis, which are increasing in prevalence with an aging US population. While the majority of patients with LBP experience a benign clinical course, an estimated 6% to 11% of patients go on to develop chronic LBP, defined as back pain lasting more than 3 months.[2]

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The increased prevalence of chronic LBP comes a considerable cost to both patients and society.[3-5]

In the majority of cases, treatment of chronic LBP begins with nonoperative therapies such as opioid medications, lumbar epidural steroid injections (LESI), muscle relaxants, nonsteroidal anti-inflammatory drugs (NSAIDs), physical therapy/occupational therapy (PT/OT), and chiropractor therapy. For many patients with LBP, these conservative treatments are therapeutically sufficient; however, a subset of patients fail maximum nonoperative therapy (MNT) and require surgery.[6,7] The costs and utilization of MNT can be considerable and are rising. In recent 7-year intervals, there has been an increase in expenditures for opioids and spinal injections in the treatment of chronic back pain of 423% and 629%, respectively.[8] This trend has contributed to the opioid epidemic, with over half of all chronic opioid users having back pain.[9,10] This increased utilization of MNT has not been demonstrated to improve outcomes or decrease disability rates on a population level,[8,11] which indicates that the incremental costs-effectiveness ratio (ICER) after MNT may be highly unfavorable. As the cost-effectiveness of therapy assumes increasing importance in an era of outcomes-based payment strategies such as bundled payments, determining the costs and utilization of nonoperative conservative therapies in patients who eventually end up undergoing surgery is important in determining how health care resources should be allocated.

To this end, the purpose of this current study is to characterize the utilization and costs of MNTs within 2 years prior to spinal fusion surgery in patients with symptomatic lumbar stenosis or spondylolisthesis.

Methods

Data Source

The study sample was derived from a large insurance database. This database consists of 20.9 million covered lives and includes private/commercially insured and Medicare Advantage beneficiaries with an orthopedic diagnosis. Institutional review board approval was obtained prior to initiation of the study. Research files were accessed on a remote server hosted by PearlDiver (PearlDiver Technologies, Inc, Colorado Springs, CO). Research records are searchable by Current Procedural Terminology (CPT), National Drug Code (NDC), International Classification of Diseases (ICD) diagnosis and procedure codes, generic drug codes specific to Humana, prescription name, and laboratory results based on Logical Observation Identifiers Names and Codes (LOINC).

Patient Sample

We included adult patients (≥19 years old) with degenerative conditions of the lumbosacral spine that underwent an index 1-, 2-, or 3-level lumbar decompression and fusion procedure between 2007 and 2016. Patients with the following ICD-9 (721.3, 721.42 722.10 722.52 722.73 722.93 724.02 724.03 724.20 724.40 724.50) and ICD-10 diagnosis codes prior to a spinal fusion operation were included in the study sample. Patients with first occurrence ICD-9 (81.07, 81.08, 81.62) or ICD-10 procedure codes were used to identify all primary 1-, 2-, or 3-level fusions. Patients were excluded if they underwent more than 3-level lumbar fusions (81.63, 81.64), an anterior approach (81.06), or had a history of cervical (81.02, 81.03) or thoracic fusions (81.04, 81.05). Additionally, patients with a concurrent diagnosis of fracture (80.54, 80.55, 80.56, 80.57, 80.58, 80.59) or malignancy (170.2, 170.6) were excluded. For each of the aforementioned ICD-9 codes, the relevant corresponding ICD-10 codes were incorporated into the patient selection/exclusion criteria (Appendix A). Finally, the total number of potential spinal fusion patients was determined by capturing all adult patients (≥19 years old) with an inclusion degenerative spinal diagnosis and did not meet exclusion criteria.

Medical Therapies

Medical therapy utilization prior to the index surgery was captured. Specifically, nonoperative therapies of interest included NSAID agents, opioid use, muscle relaxants, LESI, PT/OT sessions, and chiropractor sessions. Additionally, emergency department (ED) visits for which an inclusion degenerative spinal condition was listed as the primary active problem were documented. Generic drug codes specific to Humana were used to capture NSAID, opioid, and muscle relaxant prescriptions prior to surgery (Appendix B). With regard to opioid use, we queried the most frequently prescribed opiate formulations including oxycodone hydrochloride, hydrocodone/acetaminophen, and oxycodone/acetaminophen, which were prescribed in the majority (>80%) of patients, with alternative formulations used in the minority of patients. Similarly, relevant CPT codes for LESI, PT/OT, and chiropractor visits were used to gather the number of sessions billed prior to the index operation (Appendix B).

The extent of preoperative medical therapy utilization was characterized by total dollars spent, number of documented prescriptions, and number of units billed for. A "unit" consists of an individual pill, injection, therapy visit, or ED visit. In addition to the absolute totals, the use of each medical therapy was normalized by the number of unique patients utilizing the respective treatment. Annual use of each medical therapy was also documented in order to investigate longitudinal trends in maximal medical therapy.

Baseline Demographics and Comorbidities

Demographics such as age, gender, geographical region, and ethnicity were captured. As a measure for ensuring patient privacy, patient age data is binned into buckets consisting of 5-year intervals. Patient geographic region is separated into 4 regions (Midwest, Northeast, South, and West), consistent with US Census Bureau definitions, and is based on the location in which the insurance claim was made. Additionally, ICD-9 and

ICD-10 diagnosis codes were used to collect preoperative comorbidities known to influence outcomes in spinal surgery, which included obesity (BMI ≥30), type 2 diabetes mellitus, smoking status, atrial fibrillation, myocardial infarction, and chronic obstructive pulmonary disease (Appendix C).

Data Analysis

The primary aim of the study was to characterize the utilization of maximal medical therapies prior to index lumbar decompression and fusion. The secondary aim was to investigate longitudinal trends in the preoperative medical therapy utilization in this population. It should be noted that data input for 2016 was incomplete at the time the of the records query and therefore was omitted from this portion of the analysis. All analysis were carried out in R (The R Project for Statistical Computing) through the PearlDiver database. The terms cost, payment, and reimbursement are used interchangeably to report financial data and represents the actual amount paid by insurers. Where necessary, χ^2 tests were used for categorical variables and Student's *t* tests for continuous variables. All tests were 2-sided, and results were considered statistically significant if the *P* value was less than .05.

Results

A total of 27 877 patients (males: 11 301; females: 16 576) underwent 1-, 2-, or 3-level posterior lumbar instrumented fusion and met the inclusion criteria (Table 1). There were 3 423 114 patients with an inclusion spine diagnosis, who met the age requirements and did not meet exclusion criteria. Consequently, of the 3 423 114 patients eligible for spinal fusion, only 0.8% failed medical management and elected to have an operation.

Demographically, females (59.5%) and Caucasians (70.8%) comprised the majority of the population. The largest portions of insurance claims were made from the South (62.3%) and the Midwest (25.2%) geographic sectors (Table 1). Preoperative comorbidity prevalence was as follows: 17.6% of patients were smokers, 35.1% of patients had type 2 diabetes mellitus, 24.8% were obese, 8.9% of patients had chronic obstructive pulmonary disease, and 7.6% had atrial fibrillation (Table 1).

Table 1. Characteristics of Lumbosacral Fusion Population Who Received Medical Therapy Within 2 Years Prior to Fusion.

Characteristic	N	%
Total	27 877	n/a
Male	11 301	40.5%
Female	16 576	59.5%
Geographical region breakdown		
Midwest	7016	25.2%
Northeast	583	2.1%
South	17 365	62.3%
West	2913	10.4%
Racial breakdown		
Unknown	5685	20.4%
White	19 729	70.8%
Black	1910	6.9%
Other	215	0.8%
Asian	55	0.2%
Hispanic	226	0.8%
North American Native	57	0.2%
Preoperative comorbidities		
Obesity (BMI >30)	6913	24.8%
Type 2 diabetes mellitus	9791	35.1%
Myocardial infarction	575	2.1%
Atrial fibrillation	2123	7.6%
Smoking	4894	17.6%
COPD	2487	8.9%
Narcotics use		
NSAIDs	11 383	40.8%
Opioids	19 770	70.9%
Muscle relaxants	12 414	44.5%
LESI	14 422	51.7%
PT/OT	11 156	40.0%
ED visits	4005	14.4%
Chiropractor visits	4042	14.5%

Abbreviations: BMI, body mass index; COPD, chronic obstructive pulmonary disease; ED, emergency department; LESI, lumbar epidural steroid injections; NSAIDs, nonsteroidal anti-inflammatory drugs; PT/OT, physical therapy/occupational therapy.

Maximal Nonoperative Therapy Utilization

Patient MNT utilization was as follows: 11 383 (40.8%) used NSAIDs, 19 770 (70.9%) used opioids, 12 414 (44.5%) used muscle relaxants, 14 422 (51.7%) received LESI, 11 156 (40.0%) attended PT/OT, 4005 (14.4%) presented to the ED, and 4042 (14.5%) received chiropractor treatments (Table 2).

In our cohort, there were 18 814 PT/OT visits, 35 969 ED visits, and 73 496 chiropractor visits prior to the index surgery. A total of 10 914 851 opioid pills were billed for, which comprises 57.0% of all the medications used for the management of lumbar stenosis and spondylolisthesis (NSAIDs, opioids, and muscle relaxants; Table 3). This figure translates to 552.1 opioid pills per opioid user. Additionally, of all preoperative medical therapies, opioid prescriptions were the predominant treatment, with 139 207 total prescriptions written compared to 46 735 NSAID prescriptions and 58 938 muscle relaxant prescriptions.

The total cost associated with all MNT prior to index spinal fusion was $28 241 320 (males: $11 107 614; females: $17 133 706). LESI comprised the largest portion of the total cost of MNT ($15 296 941, 54.1%) followed by opioids ($3 702 463, 13.1%) and NSAIDs ($3 058 335, 10.8%; Table 4). At the patient level, on average $1013.07 was spent on nonoperative treatments prior to index lumbar surgery. When normalized by patients utilizing the respective therapies, patients receiving LESI spent on average $1060.67 prior to spinal fusion.

Longitudinal Trends in Maximal Nonoperative Therapy Utilization

The use of opioids for symptomatic management prior to lumbar fusion in our patient cohort has increased over the last

Table 2. Number of Unique Patients Billed, by Medical Therapy Prior to Index Spinal Fusion.

Characteristic	NSAIDs	Opioids	LESI	PT/OT	ED Visits	Muscle Relaxants	Chiropractor Visits	Total
Total patients	11 383	19 770	14 422	11 156	4005	12 414	4042	77 192
Male	4336	7995	5619	4166	1591	4751	1755	30 213
Female	7047	11 775	8803	6990	2414	7663	2287	46 979
Geographical region breakdown								
Midwest	2446	4426	3829	3159	998	2537	1466	18 861
Northeast	191	385	301	239	105	192	112	1525
South	7557	12 745	8784	6549	2522	8408	2004	48 569
West	1190	2217	1508	1210	380	1278	460	8243
Race breakdown								
Unknown	2223	3615	2893	2294	699	2722	837	15 283
White	7885	14 307	10 309	7886	2750	8490	3049	54 676
Black	980	1468	951	769	447	968	116	5699
Other	104	141	106	86	40	85	13	575
Asian	30	34	29	19	10	16	<11	138[a]
Hispanic	134	164	98	78	48	100	<11	622[a]
North American Native	27	41	36	24	11	33	11	183

Abbreviations: ED, emergency department; LESI, lumbar epidural steroid injections; NSAIDs, nonsteroidal anti-inflammatory drugs; PT/OT, physical therapy/occupational therapy.
[a] Denotes summation value that may be underestimated as one or more of the calculation components were unknown due to confidentiality violations associated with small patient tally (<11) reporting.

Table 3. Total Medical Therapy Units Billed Prior to Index Spinal Fusion.

Characteristic	NSAIDs	Opioids	LESI	PT/OT	ED Visits	Muscle Relaxants	Chiropractor Visits	Unit Totals
Total patients	3 760 038	10 914 851	66 419	18 814	35 969	4 462 055	73 496	19 331 642
Male	1 341 302	4 314 872	25 801	6861	14 874	1 567 006	19 445	7 290 161
Female	2 418 736	6 599 979	40 618	11 953	21 095	2 895 049	54 051	12 041 481
Geographical region breakdown								
Midwest	817 024	2 452 231	16 663	5159	9506	793 534	45 937	4 140 054
Northeast	61 961	271 203	1379	423	840	74 759	1169	411 734
South	2 475 139	6 961 547	41 424	11 102	22 560	3 161 024	21 565	12 694 361
West	405 914	1 229 870	6953	2130	3063	432 738	4825	2 085 493
Race breakdown								
Unknown	554 607	1 625 762	13 659	3820	6767	762 973	9274	2 976 862
White	2 783 023	8 254 222	47 396	13 418	23 861	3 353 033	62 465	14 537 418
Black	319 224	816 160	4098	1227	4354	280 144	1365	1 426 572
Other	38 156	53 260	508	141	380	17 873	148	110 466
Asian	9105	7550	119	28	85	1423	UNK	18 309[a]
Hispanic	46 362	120 165	494	141	442	30 933	UNK	198 536[a]
North American Native	9561	37 732	145	39	80	15 676	112	63 345

Abbreviations: ED, emergency department; LESI, lumbar epidural steroid injections; NSAIDs, nonsteroidal anti-inflammatory drugs; PT/OT, physical therapy/occupational therapy; UNK, unknown.
[a] Denotes summation value that may be underestimated as one or more of the calculation components were unknown due to confidentiality violations associated with small patient tally (<11) reporting.

decade. Specifically, the normalized amount billed for patients using opioids has nearly doubled from $83.15 in 2007 to $142.30 in 2015 (Table 5). Similarly, the normalized number of opioid pills billed for has also increased from 276.2 per opioid user in 2007 to 401.5 per opioid user in 2015 (Table 5).

ED utilization has increased throughout the past decade, where the normalized cost per patient seeking ED treatment has increased from $567.52 in 2007 to $736.66 in 2015. Likewise, similar patterns were observed in the frequency of ED visits, where the normalized visit count has increased from 6.1 visits in 2007 to 8.6 visits in 2015 (Table 5). Trends were also observed in NSAID utilization, where the normalized annual pill count per patient utilizing the therapy increased from 159.4 pills in 2007 to 248.2 pills in 2015 (Table 5). Normalized costs per patient utilizing NSAIDs, LESI, PT/OT, muscle relaxants, and chiropractor visits have stayed approximately the same or even decreased throughout the study window (Table 5).

Discussion

In this retrospective study of 3 423 114 adult patients, we observed that the average cost of long-term MNT was $1013

Table 4. Total Dollars ($US) Spent on Medical Therapies Prior to Index Spinal Fusion.

Characteristic	NSAIDs	Opioids	LESI	PT/OT	ED Visits	Muscle Relaxants	Chiropractor Visits	Cost Totals
Total Patients	$3 058 335	$3 702 463	$15 296 941	$1 145 264	$2 728 706	$1 079 743	$1 229 868	$28 241 320
Male	$988 251	$1 576 259	$6 113 712	$426 230	$1 117 594	$378 131	$507 437	$11 107 614
Female	$2 070 084	$2 126 204	$9 183 229	$719 034	$1 611 112	$701 612	$722 431	$17 133 706
Geographical Region Breakdown								
Midwest	$651 545	$755 127	$4 497 847	$366 023	$709 878	$188 594	$543 412	$7 712 426
Northeast	$37 766	$104 349	$248 784	$22 398	$52 981	$15 412	$29 175	$510 865
South	$2 052 185	$2 404 011	$9 080 902	$636 748	$1 713 126	$776 258	$548 192	$17 211 422
West	$316 839	$438 976	$1 469 408	$120 095	$252 721	$99 479	$109 089	$2 806 607
Race Breakdown								
Unknown	$525 714	$679 823	$4 622 924	$274 081	$805 319	$268 405	$243 964	$7 420 230
White	$2 215 993	$2 661 203	$9 615 489	$785 703	$1 595 918	$734 780	$935 215	$18 544 301
Black	$243 690	$298 316	$826 424	$68 564	$261 007	$64 404	$39 956	$1 802 361
Other	$25 314	$16 373	$93 751	$6 705	$22 391	$2895	$4442	$171 871
Asian	$11 907	$1822	$21 756	$1540	$5970	$235	UNK	$43 230[a]
Hispanic	$30 793	$35 382	$87 208	$6013	$30 925	$6819	UNK	$197 140[a]
North American Native	$4924	$9544	$29 389	$2658	$7176	$2205	$2052	$57 948

Abbreviations: ED, emergency department; LESI, lumbar epidural steroid injections; NSAIDs, nonsteroidal anti-inflammatory drugs; PT/OT, physical therapy/occupational therapy; UNK, unknown.

[a] Denotes summation value that may be underestimated as one or more of the calculation components were unknown due to confidentiality violations associated with small patient tally (<11) reporting.

Table 5. Normalized Total Annual Dollars Spent on Medical Therapy ($US/Patient Utilizing Respective Therapy) and the Corresponding Normalized Annual Medical Therapy Unit Counts (Units/Patient Utilizing Respective Therapy) Prior to Index Spinal Fusion.

Year	NSAIDS	Narcotics	LESI	PT/OT	ED Visits	Muscle Relaxants	Chiropractor Visits
2007	$191.05 (159.4)	$83.15 (276.2)	$956.95 (3.9)	$85.91 (1.4)	$567.52 (6.1)	$71.18 (195.2)	$207.90 (7.9)
2008	$203.26 (171.7)	$78.47 (285.1)	$924.97 (4.0)	$88.56 (1.5)	$485.62 (6.5)	$76.92 (224.2)	$215.65 (8.5)
2009	$167.07 (200.8)	$75.45 (294.4)	$975.05 (4.0)	$83.83 (1.4)	$571.93 (7.6)	$52.94 (245.1)	$201.52 (7.7)
2010	$154.90 (222.5)	$107.70 (317.4)	$876.95 (3.9)	$89.23 (1.4)	$635.66 (8.4)	$42.66 (244.3)	$220.85 (58.2[a])
2011	$157.91 (235.9)	$124.38 (323.8)	$775.78 (3.7)	$91.30 (1.5)	$585.63 (7.8)	$45.18 (250.4)	$204.52 (7.9)
2012	$173.72 (220.6)	$111.03 (330.8)	$821.97 (3.8)	$86.26 (1.4)	$630.16 (8.4)	$68.56 (253.4)	$212.75 (8.4)
2013	$208.33 (240.3)	$113.54 (357.5)	$840.50 (3.7)	$87.56 (1.5)	$531.60 (9.2)	$59.11 (261.0)	$249.31 (9.4)
2014	$225.12 (244.8)	$149.34 (409.0)	$871.00 (3.7)	$88.58 (1.4)	$702.98 (8.7)	$61.37 (262.0)	$236.62 (8.3)
2015	$146.92 (248.2)	$142.30 (384.8)	$802.70 (3.2)	$82.92 (1.3)	$736.66 (8.6)	$67.70 (257.7)	$224.22 (8.2)

Abbreviations: ED, emergency department; LESI, lumbar epidural steroid injections; NSAIDs, nonsteroidal anti-inflammatory drugs; PT/OT, physical therapy/occupational therapy; UNK, unknown.

[a] Denotes Humana Coding Error for this individual therapy.

per patient ($28 241 320 total) over the 2-year period prior to surgery. LESI comprised the largest portion of the total cost of MNT, accounting for 54.2% ($15 296 941). This was followed by opioids, which accounted for 13.1% ($3 702 463), and NSAIDs, which accounted for 10.8% ($3 058 335). These results characterize the utilization and costs of preoperative MNTs, as well as indicate that opioid medications are the most used therapy in the preoperative period.

The modalities and utilization of nonoperative therapy in the treatment of chronic back pain have been previously studied. In a study of 607 patients enrolled in the degenerative spondylolisthesis Spine Patient Outcomes Research Trial (SPORT) between March 2000 and February 2005, Weinstein et al determined that 68% of patients with degenerative spondylolisthesis had received PT prior to enrollment, 63% had used anti-inflammatory medications, 55% had received epidural injections, 30% had used opioid medications, and 25% had utilized chiropractic care.[12] Similarly, in an additional analysis of 1411 patients enrolled within the SPORT between March 2000 and February 2003, Cummins et al observed 29% of patients with lumbar stenosis used opioids, 31% received over-the-counter (OTC) medications, 19% had used muscle relaxants and antidepressants, 33% utilized chiropractic therapy, and 7% presented to the ED. The authors observed a similar distribution in the utilizations of nonoperative therapies for patients with symptomatic degenerative spondylolisthesis.[6] The results from these studies are largely consistent with our findings in patients with symptomatic lumbar stenosis or spondylolisthesis ultimately requiring surgery, with a notable exception being opioid use. The observed rate of opioid use in the current study is 70.9% compared to 30% in the previously mentioned studies. The difference, while significant, is consistent with national opioid prescribing trends and usage that demonstrate an estimated 200% to 400% increase over the past decade.[13-16]

The costs of MNTs observed in our current study are within the previously reported range. In a retrospective study of 30 709 patients who underwent conservative management for lumbar disk herniation before eventually requiring discectomy, Daffner et al found that the average cost of nonoperative therapy in the 90 days prior to surgery was $3445 per patient ($105 799 925 in total). Consistent with our study, the largest contributor to overall cost was found to be injections at 32% ($16 211 246). Other contributors included diagnostic imaging (31%), outpatient visits (13%), PT visits (11%), chiropractic therapy (2.3%), preoperative studies (0.8%), medications (0.5%), and miscellaneous (2.3%).[17] As this study showed an almost even distribution between diagnostic and treatment-related charges, this indicates that our study of maximum nonoperative treatments likely underestimates the total cost of nonoperative care. Similarly, in a 2-year analysis of 1235 patients enrolled in SPORT, Tosteson et al determined the cost of therapeutic as well as diagnostic nonoperative management in patients with spinal stenosis with and without degenerative spondylolisthesis. In patients with spinal stenosis the total 2-year direct costs of conservative management were on average $7161/patient, with $2273 coming from medication expenses, $2176 for health care visits, $1376 for diagnostic tests, and $1416 for other services. Total direct costs over 2 years of nonoperative management in patients with degenerative spondylolisthesis with spinal stenosis was on average $6906/patient, with $2503 coming from medications, $2169 for health care visits, $975 for diagnostic tests, and $1057 from other services.[18] Our observed costs estimates are lower than those reported in previous studies because the costs of diagnostic tests(ie, magnetic resonance imaging, X-ray, computed tomography) were not available and therefore not included in the final analysis.

It is important to note that while the direct costs of MNT for LBP can be substantial, they alone do not represent the total costs involved in the preoperative conservative management of LBP. Indirect costs actually represent the majority of the total costs; in fact, an estimated two thirds of the 100 to 200 billion annual costs associated with LBP in the United States can be attributed to lost wages and decreased productivity (ie, indirect costs).[19] In the 2-year study of SPORT by Tosteson et al, the indirect costs related to nonoperative treatment of spinal stenosis and degenerative spondylolisthesis, which were determined by missed work days, missed homemaking activities, and unpaid caregivers, were found to greater than the direct costs ($7401/patient vs $7161/patient for spinal stenosis, and $8942 vs $6906 for degenerative spondylolisthesis).[18] Similarly, in a follow-up study of 2427 patients enrolled in the SPORT trial, Tosteson et al determined the 4-year average total direct plus indirect costs of conservative treatment in patients with spinal stenosis to be $24 611, $31 095 for degenerative spondylolisthesis, and $22 067 for intervertebral disc herniation.[20] As our present study specifically assesses direct costs of MNT prior to undergoing surgery, it likely significantly underestimates the total costs associated with nonoperative management of symptomatic lumbar stenosis or spondylolisthesis. With our study cohort comprised mainly of persons' covered by employer-based plans, there is increased importance to determine the costs and utilization of MNTs in this young working population who are building careers and supporting families.

Clinical Implications

The clinical implications of prolonged conservative management are not trivial. First, the goal of any intervention in spine care should be the restoration of function. The current paradigms of prolonged nonoperative management for treatment of symptomatic lumbar stenosis or spondylolisthesis despite lack of clinical effectiveness prolong patient suffering and may be inappropriate. Second, lack of consensus among spine care providers on the most efficacious nonoperative treatments or optimal duration for trial of nonoperative treatments results in individual prescribers setting their own practice patterns that reflects their own personal attitudes, knowledge, values, and other interests. Finally, assuming that maximum medical therapies are associated with a small improvement in pain and functional disability, the incremental costs effectiveness ratio (ICER) associated with these types of therapies could be highly unfavorable. ICER is used in cost-effectiveness analysis to assess the costs effectiveness of treatment interventions. In the most basic terms, it is defined as the costs difference between 2 possible interventions, divided by the difference in their effect (ie, ICER = (cost of MNT − costs of no intervention)/(effect of MNT − effect without any treatment). Accordingly, increasing costs of an intervention or a decrease in treatment effect or both is associated with a higher ICER. While the average direct costs of MNTs in our study is $1013 per patient, assuming a treatment effect of 5% (0.05), the calculated ICER is over $20 000/QALY (quality-adjusted life year). Using the total costs of nonoperative treatments from the SPORT trial, the 4-year ICER for lumbar stenosis and degenerative spondylolisthesis are estimated to be $492 220/QALY and $621 900/QALY, respectively. Considering that our observed costs estimates significantly underestimates the total costs of MNTs, it is possible that the ICER associated with MNTs is much higher, suggesting that MNTs, when deployed inappropriately, could be highly unfavorable.

Limitations

While this study has many strengths, there are some limitations and with them implications for its interpretation. The database is only comprised of private/commercially insured patients or Medicare Advantage beneficiaries. As such, Medicaid patients were not included in this analysis. Medicaid patients have been shown to use significantly more opioids and have more ED visits than other insurance types,[6] so this likely indicates our study underestimates MNT costs in the general population. To facilitate statistical analysis, we assumed no improvement to be less than 5% incremental gain in health status with nonoperative therapies. We felt that this was a reasonable assumption. Additionally, many patients utilize OTC NSAIDs, which was not captured in our analysis. Furthermore, when constructing the inclusion criteria, both ICD-9 and ICD-10 procedural codes were utilized. The ICD-9 procedural coding system is far broader than ICD-10 and encompasses procedural codes that are irrelevant to the intended study design (eg, sacroiliac joint fixation). Despite efforts to remove these procedure codes, the authors estimate a residual <1% of the sample size is included within the study population. Despite these limitations, this study demonstrated that over 2 years, total direct health care expenditure for nonoperative management of spinal stenosis and spondylolisthesis was over 28 million dollars or $1013 per patient, with opioids being the most frequently prescribed and most used therapy in the preoperative period.

Conclusions

Opioids are the most frequently prescribed and most used therapy in the preoperative period. Assuming minimal improvement in pain and functional disability after maximum nonoperative therapies, the ICER for MNT could be highly unfavorable.

Appendix A

ICD-9 and ICD-10 Diagnosis Codes for Inclusion and Exclusion Criteria

Inclusion/Exclusion Criteria	ICD-9/ICD-10 Codes
Inclusion diagnosis codes	*ICD-9-D:* ICD-9-D-7213, ICD-9-D-72 142, ICD-9-D-72 210, ICD-9-D-72 252, ICD-9-D-72 273, ICD-9-D-72 293, ICD-9-D-72 402, ICD-9-D-72 403, ICD-9-D-7242, ICD-9-D-7243, ICD-9-D-7244, ICD-9-D-7245
	ICD-10-D: ICD-10-D-M47817, ICD-10-D-M4716, ICD-10-D-M5126, ICD-10-D-M5127, ICD-10-D-M5136, ICD-10-D-M5137, ICD-10-D-M5106, ICD-10-D-M4647, ICD-10-D-M5186, ICD-10-D-M5187, ICD-10-D-M4806, ICD-10-D-M4806, ICD-10-D-M545, ICD-10-D-M5430, ICD-10-D-M5414, ICD-10-D-M5415, ICD-10-D-M5416, ICD-10-D-M5417, ICD-10-D-M5489, ICD-10-D-M549
Inclusion procedure codes	*ICD-9-P:* ICD-9-P-8107, ICD-9-P-8108, ICD-9-P-8162
	ICD-10-P: ICD-9-P-8107, ICD-10-P-0SG0071, ICD-10-P-0SG00J1, ICD-10-P-0SG00K1, ICD-10-P-0SG00Z1, ICD-10-P-0SG0371, ICD-10-P-0SG03J1, ICD-10-P-0SG03K1, ICD-10-P-0SG03Z1, ICD-10-P-0SG0471, ICD-10-P-0SG04K1, ICD-10-P-0SG04Z1, ICD-10-P-0SG3071, ICD-10-P-0SG30J1, ICD-10-P-0SG30K1, ICD-10-P-0SG30Z1, ICD-10-P-0SG3371, ICD-10-P-0SG33J1, ICD-10-P-0SG33K1, ICD-10-P-0SG33Z1, ICD-10-P-0SG3471, ICD-10-P-0SG34K1, ICD-10-P-0SG34Z1, ICD-9-P-8108, ICD-10-P-0SG007J, ICD-10-P-0SG00JJ, ICD-10-P-0SG00KJ, ICD-10-P-0SG00ZJ, ICD-10-P-0SG03JJ, ICD-10-P-0SG03KJ, ICD-10-P-0SG047J, ICD-10-P-0SG307J, ICD-10-P-0SG30JJ, ICD-10-P-0SG30KJ, ICD-10-P-0SG30ZJ, ICD-10-P-0SG337J, ICD-10-P-0SG347J
Exclusion diagnosis codes	*ICD-9-D:* ICD-9-D-8055, ICD-9-D-8056, ICD-9-D-8057, ICD-9-D-8058, ICD-9-D-8059, ICD-9-D-1702, ICD-9-D-1706
	ICD-10-D: ICD-10-D-S32009B, ICD-10-D-S3210XA, ICD-10-D-S322XXA, ICD-10-D-S3210XB, ICD-10-D-S322XXB, ICD-10-D-S129XXA, ICD-10-D-S22009A, ICD-10-D-S32009A, ICD-10-D-S3210XA, ICD-10-D-S322XXA, ICD-10-D-S129XXA, ICD-10-D-S22009B, ICD-10-D-S32009B, ICD-10-D-S3210XB, ICD-10-D-S322XXB, ICD-10-D-C412, ICD-10-D-C414
Exclusion procedure codes	*ICD-9-P:* ICD-9-P-8163, ICD-9-P-8164, ICD-9-P-8106, ICD-9-P-8102, ICD-9-P-8103, ICD-9-P-8104, ICD-9-P-8105, ICD-9-P-8054
	ICD-10-P: ICD-10-P-0SG0070, ICD-10-P-0SG00J0, ICD-10-P-0SG00K0, ICD-10-P-0SG00Z0, ICD-10-P-0SG0370, ICD-10-P-0SG03Z0, ICD-10-P-0SG3070, ICD-10-P-0SG30J0, ICD-10-P-0SG30K0, ICD-10-P-0SG30Z0, ICD-10-P-0SG33J0, ICD-10-P-0RG1070, ICD-10-P-0RG10J0, ICD-10-P-0RG10K0, ICD-10-P-0RG10Z0, ICD-10-P-0RG13K0, ICD-10-P-0RG13Z0, ICD-10-P-0RG4070, ICD-10-P-0RG40J0, ICD-10-P-0RG40K0, ICD-10-P-0RG40Z0, ICD-10-P-0RG1071, ICD-10-P-0RG10J1, ICD-10-P-0RG10K1, ICD-10-P-0RG10Z1, ICD-10-P-0RG1371, ICD-10-P-0RG4071, ICD-10-P-0RG40J1, ICD-10-P-0RG40K1, ICD-10-P-0RG40Z1, ICD-10-P-0RG6070, ICD-10-P-0RG60Z0, ICD-10-P-0RGA070, ICD-10-P-0RGA0K0, ICD-10-P-0RG6071, ICD-10-P-0RG60J1, ICD-10-P-0RG60K1, ICD-10-P-0RG60Z1, ICD-10-P-0RG63K1, ICD-10-P-0RG64Z1, ICD-10-P-0RGA071, ICD-10-P-0RGA0J1, ICD-10-P-0RGA0K1, ICD-10-P-0RGA0Z1, ICD-10-P-0RGA371, ICD-10-P-0RGA3K1, ICD-10-P-0RGA3Z1, ICD-10-P-0RGA471, ICD-10-P-0RGA4Z1, ICD-10-P-0RQ30ZZ, ICD-10-P-0SQ20ZZ, ICD-10-P-0SQ40ZZ

Abbreviation: ICD, International Classification of Diseases.

Appendix B

Humana Generic Drug Codes for Preoperative Medical Therapies of Interest.

Inclusion Medications	Humana Generic Drug Code
Narcotics	*GENERIC_DRUG:* GENERIC_DRUG-100 055, GENERIC_DRUG-101 802, GENERIC_DRUG-106 030, GENERIC_DRUG-106 414, GENERIC_DRUG-100 504, GENERIC_DRUG-101 215, GENERIC_DRUG-100 548, GENERIC_DRUG-101 126
NSAIDs	*GENERIC_DRUG:* GENERIC_DRUG-100 494, GENERIC_DRUG-100 050, GENERIC_DRUG-100 195, GENERIC_DRUG-100 435, GENERIC_DRUG-100 882, GENERIC_DRUG-108 744, GENERIC_DRUG-100 109, GENERIC_DRUG-100 453, GENERIC_DRUG-100 558, GENERIC_DRUG-100 034, GENERIC_DRUG-100 893, GENERIC_DRUG-101 005, GENERIC_DRUG-108 896, GENERIC_DRUG-104 073, GENERIC_DRUG-100 440, GENERIC_DRUG-101 093, GENERIC_DRUG-100 707, GENERIC_DRUG-104 484, GENERIC_DRUG-101 721, GENERIC_DRUG-100 293, GENERIC_DRUG-100 764, GENERIC_DRUG-100 928, GENERIC_DRUG-105 205
Muscle relaxants	*GENERIC_DRUG:* GENERIC_DRUG-100 716, GENERIC_DRUG-100 541, GENERIC_DRUG-100 347, GENERIC_DRUG-102 033, GENERIC_DRUG-100 028, GENERIC_DRUG-101 474, GENERIC_DRUG-100 183, GENERIC_DRUG-110 360, GENERIC_DRUG-100 892, GENERIC_DRUG-100 944, GENERIC_DRUG-100 785, GENERIC_DRUG-100 417
Lumbar epidural spinal injections	*CPT:* CPT-62 311, CPT-62 319, CPT-64 483, CPT-64 484
Physical therapy/ occupational therapy	*CPT:* CPT-4018F, CPT-97 003, CPT-97 004, CPT-G0129, CPT-G8990, CPT-G8991, CPT-G8992, CPT-G8993, CPT-G8994, CPT-G8995, CPT-S9129, CPT-97 001, CPT-97 002, CPT-S8990, CPT-S9131
Chiropractor	*CPT:* CPT-98 940, CPT-98 941, CPT-98 942

Abbreviations: NSAIDs, nonsteroidal anti-inflammatory drugs; CPT, Current Procedural Terminology.

Appendix C

ICD-9 and ICD-10 Diagnosis Codes for Baseline Comorbidities.

Comorbidity	Diagnosis Codes
Obesity (BMI ≥30)	*ICD-9-D:* ICD-9-D-V8530, ICD-9-D-V8531, ICD-9-D-V8532, ICD-9-D-V8533, ICD-9-D-V8534, ICD-9-D-V8535, ICD-9-D-V8536, ICD-9-D-V8537, ICD-9-D-V8538, ICD-9-D-V8539, ICD-9-D-V8541, ICD-9-D-V8542, ICD-9-D-V8543, ICD-9-D-V8544, ICD-9-D-V8545, ICD-9-D-27 800, ICD-9-D-27 801 *ICD-10-D:* ICD-10-D-Z6830, ICD-10-D-Z6831, ICD-10-D-Z6832, ICD-10-D-Z6833, ICD-10-D-Z6834, ICD-10-D-Z6835, ICD-10-D-Z6836, ICD-10-D-Z6837, ICD-10-D-Z6838, ICD-10-D-Z6839, ICD-10-D-Z6841, ICD-10-D-Z6842, ICD-10-D-Z6843, ICD-10-D-Z6844, ICD-10-D-Z6845, ICD-10-D-E6601, ICD-10-D-E6609, ICD-10-D-E668, ICD-10-D-E669
Type 2 diabetes mellitus	*ICD-9-D:* ICD-9-D-24 900, ICD-9-D-24 901, ICD-9-D-24 910, ICD-9-D-24 911, ICD-9-D-24 920, ICD-9-D-24 921, ICD-9-D-24 930, ICD-9-D-24 931, ICD-9-D-24 940, ICD-9-D-24 941, ICD-9-D-24 950, ICD-9-D-24 951, ICD-9-D-24 960, ICD-9-D-24 961, ICD-9-D-24 970, ICD-9-D-24 971, ICD-9-D-24 980, ICD-9-D-24 981, ICD-9-D-24 990, ICD-9-D-24 991, ICD-9-D-25 000, ICD-9-D-25 001, ICD-9-D-25 002, ICD-9-D-25 003, ICD-9-D-25 010, ICD-9-D-25 011, ICD-9-D-25 012, ICD-9-D-25 013, ICD-9-D-25 020, ICD-9-D-25 021, ICD-9-D-25 022, ICD-9-D-25 023, ICD-9-D-25 030, ICD-9-D-25 031, ICD-9-D-25 032, ICD-9-D-25 033, ICD-9-D-25 040, ICD-9-D-25 041, ICD-9-D-25 042, ICD-9-D-25 043, ICD-9-D-25 050, ICD-9-D-25 051, ICD-9-D-25 052, ICD-9-D-25 053, ICD-9-D-25 060, ICD-9-D-25 061, ICD-9-D-25 062, ICD-9-D-25 063, ICD-9-D-25 070, ICD-9-D-25 071, ICD-9-D-25 072, ICD-9-D-25 073, ICD-9-D-25 080, ICD-9-D-25 081, ICD-9-D-25 082, ICD-9-D-25 083, ICD-9-D-25 090, ICD-9-D-25 091, ICD-9-D-25 092, ICD-9-D-25 093, ICD-9-D-3572 *ICD-10-D:* ICD-10-D-E0800, ICD-10-D-E0801, ICD-10-D-E0810, ICD-10-D-E0811, ICD-10-D-E0821, ICD-10-D-E0822, ICD-10-D-E0829, ICD-10-D-E08311, ICD-10-D-E08319, ICD-10-D-E08321, ICD-10-D-E08329, ICD-10-D-E08331, ICD-10-D-E08339, ICD-10-D-E08341, ICD-10-D-E08349, ICD-10-D-E08351, ICD-10-D-E08359, ICD-10-D-E0836, ICD-10-D-E0839, ICD-10-D-E0840, ICD-10-D-E0841, ICD-10-D-E0842, ICD-10-D-E0843, ICD-10-D-E0844, ICD-10-D-E0849, ICD-10-D-E0851, ICD-10-D-E0852, ICD-10-D-E0859, ICD-10-D-E08610, ICD-10-D-E08618, ICD-10-D-E08620, ICD-10-D-E08621, ICD-10-D-E08622, ICD-10-D-E08628, ICD-10-D-E08630, ICD-10-D-E08638,

(continued)

Appendix C. (continued)

Comorbidity	Diagnosis Codes
	ICD-10-D-E08641, ICD-10-D-E08649, ICD-10-D-E0865, ICD-10-D-E0869, ICD-10-D-E088, ICD-10-D-E089, ICD-10-D-E1010, ICD-10-D-E1011, ICD-10-D-E1021, ICD-10-D-E1022, ICD-10-D-E1029, ICD-10-D-E10311, ICD-10-D-E10319, ICD-10-D-E10321, ICD-10-D-E10329, ICD-10-D-E10331, ICD-10-D-E10339, ICD-10-D-E10341, ICD-10-D-E10349, ICD-10-D-E10351, ICD-10-D-E10359, ICD-10-D-E1036, ICD-10-D-E1039, ICD-10-D-E1040, ICD-10-D-E1041, ICD-10-D-E1042, ICD-10-D-E1043, ICD-10-D-E1044, ICD-10-D-E1049, ICD-10-D-E1051, ICD-10-D-E1052, ICD-10-D-E1059, ICD-10-D-E10610, ICD-10-D-E10618, ICD-10-D-E10620, ICD-10-D-E10621, ICD-10-D-E10622, ICD-10-D-E10628, ICD-10-D-E10630, ICD-10-D-E10638, ICD-10-D-E10641, ICD-10-D-E10649, ICD-10-D-E1065, ICD-10-D-E1069, ICD-10-D-E108, ICD-10-D-E109, ICD-10-D-E1100, ICD-10-D-E1101, ICD-10-D-E1121, ICD-10-D-E1122, ICD-10-D-E1129, ICD-10-D-E11311, ICD-10-D-E11319, ICD-10-D-E11321, ICD-10-D-E11329, ICD-10-D-E11331, ICD-10-D-E11339, ICD-10-D-E11341, ICD-10-D-E11349, ICD-10-D-E11351, ICD-10-D-E11359, ICD-10-D-E1136, ICD-10-D-E1139, ICD-10-D-E1140, ICD-10-D-E1141, ICD-10-D-E1142, ICD-10-D-E1143, ICD-10-D-E1144, ICD-10-D-E1149, ICD-10-D-E1151, ICD-10-D-E1152, ICD-10-D-E1159, ICD-10-D-E11610, ICD-10-D-E11618, ICD-10-D-E11620, ICD-10-D-E11621, ICD-10-D-E11622, ICD-10-D-E11628, ICD-10-D-E11630, ICD-10-D-E11638, ICD-10-D-E11641, ICD-10-D-E11649, ICD-10-D-E1165, ICD-10-D-E1169, ICD-10-D-E118, ICD-10-D-E119, ICD-10-D-E1300, ICD-10-D-E1301, ICD-10-D-E1310, ICD-10-D-E1311, ICD-10-D-E1321, ICD-10-D-E1322, ICD-10-D-E1329, ICD-10-D-E13311, ICD-10-D-E13319, ICD-10-D-E13321, ICD-10-D-E13329, ICD-10-D-E13331, ICD-10-D-E13339, ICD-10-D-E13341, ICD-10-D-E13349, ICD-10-D-E13351, ICD-10-D-E13359, ICD-10-D-E1336, ICD-10-D-E1339, ICD-10-D-E1340, ICD-10-D-E1341, ICD-10-D-E1342, ICD-10-D-E1343, ICD-10-D-E1344, ICD-10-D-E1349, ICD-10-D-E1351, ICD-10-D-E1352, ICD-10-D-E1359, ICD-10-D-E13610, ICD-10-D-E13618, ICD-10-D-E13620, ICD-10-D-E13621, ICD-10-D-E13622, ICD-10-D-E13628, ICD-10-D-E13630, ICD-10-D-E13638, ICD-10-D-E13641, ICD-10-D-E13649, ICD-10-D-E1365, ICD-10-D E1369, ICD-10-D-E138, ICD-10-D-E139
Myocardial infarction	*ICD-9-D:* ICD-9-D-41 000, ICD-9-D-41 001, ICD-9-D-41 002, ICD-9-D-41 010, ICD-9-D-41 011, ICD-9-D-41 012, ICD-9-D-41 020, ICD-9-D-41 021, ICD-9-D-41 022, ICD-9-D-41 030, ICD-9-D-41 031, ICD-9-D-41 032, ICD-9-D-41 040, ICD-9-D-41 041, ICD-9-D-41 042, ICD-9-D-41 050, ICD-9-D-41 051, ICD-9-D-41 052, ICD-9-D-41 080, ICD-9-D-41 081, ICD-9-D-41 082, ICD-9-D-41 090, ICD-9-D-41 091, ICD-9-D-41 092, ICD-9-D-41 181 *ICD-10-D:* ICD-10-D-I2101, ICD-10-D-I2102, ICD-10-D-I2109, ICD-10-D-I2111, ICD-10-D-I2119, ICD-10-D-I2121, ICD-10-D-I2129, ICD-10-D-I213, ICD-10-D-I214, ICD-10-D-I220, ICD-10-D-I221, ICD-10-D-I222, ICD-10-D-I228, ICD-10-D-I229, ICD-10-D-I230, ICD-10-D-I231, ICD-10-D-I232, ICD-10-D-I233, ICD-10-D-I234, ICD-10-D-I235, ICD-10-D-I236
Atrial fibrillation	*ICD-9-D:* ICD-9-D-42 731 *ICD-10-D:* ICD-10-D-I480, ICD-10-D-I481, ICD-10-D-I482, ICD-10-D-I4891
Smoking	*ICD-9-D:* ICD-9-D-3051 *ICD-10-D:* ICD-10-D-Z720
COPD	*ICD-9-D:* ICD-9-D-49 120, ICD-9-D-49 121, ICD-9-D-49 122, ICD-9-D-49 320, ICD-9-D-49 321, ICD-9-D-49 322 *ICD-10-D:* ICD-10-D-J440, ICD-10-D-J441, ICD-10-D-J449

Abbreviations: ICD, International Classification of Diseases; BMI, body mass index; COPD, chronic obstructive pulmonary disease.

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