Health care utilization and overall costs based on opioid dependence in patients undergoing surgery for degenerative spondylolisthesis

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OBJECTIVE Opioid abuse is highly prevalent in patients with back pain. The aim of this study was to identify health care utilization and overall costs associated with opioid dependence in patients undergoing surgery for degenerative spondylolisthesis (DS).

METHODS The authors queried the MarketScan database using ICD-9 and CPT-4 codes from 2000 to 2012. Opioid dependency was defined as having a diagnosis of opioid use disorder, having a prescription for opioid use disorder, or having 10 or more opioid prescriptions. Opioid dependency was evaluated in 12-month period leading to surgery and in the period 3–15 months following the procedure. Patients were segregated into 4 groups based on opioid dependence before and after surgery: group NDND (prior nondependent who remain nondependent), group NDD (prior nondependent who become dependent), group DND (prior dependent who become nondependent), and group DD (prior dependent who remain dependent). The outcomes of interest were discharge disposition, hospital length of stay (LOS), complications, and health care resource costs. The 4 groups were compared using the Kruskal-Wallis test and linear contrasts built from generalized regression models.

RESULTS A total of 10,708 patients were identified, with 81.57%, 3.58%, 8.54%, and 6.32% of patients in groups NDND, NDD, DND, and DD, respectively. In group DD, 96.31% of patients had decompression with fusion, compared with 93.59% in group NDND. Patients in group NDD, DND, and DD had longer hospital LOS compared with those in group NDND. Patients in group DD were less likely to be discharged home compared with those in group NDND (odds ratio 0.639, 95% confidence interval 0.52–0.785). At 3–15 months postdischarge, patients in group DD incurred 21% higher hospital readmission costs compared with those in group NDND. However, patients in groups NDD and DD were likely to incur 2.8 times the overall costs compared with patients in group NDND ($p < 0.001$) at 3–15 months after surgery (median overall payments: group NDD \$20,033 and group DD \$19,654, vs group NDND \$7994).

CONCLUSIONS Patients who continued to be opioid dependent or became opioid dependent following surgery for DS incurred significantly higher health care utilization and costs within 3 months and in the period 3–15 months after discharge from surgery.

<https://thejns.org/doi/abs/10.3171/2018.2.FOCUS17764>

KEYWORDS overall costs; health care utilization; fusion; decompression; opioid dependence; degenerative spondylolisthesis

NARCOTICS use in the US has significantly increased in the past two decades, resulting in a national opioid crisis.¹⁶ The Centers for Disease Control and Prevention reported that 73% of deaths from prescription drug overdoses are caused by opioid overdose.²⁶ Opioid

use is highly prevalent in patients with back pain either prior to or following surgery.^{1,3,5,22} Degenerative spondylolisthesis (DS) is a common condition with a prevalence of approximately 6% in the US, affecting elderly patients with a female predilection.¹⁵ A majority of these patients

ABBREVIATIONS CI = confidence interval; DD = prior dependent who remains dependent; DND = prior dependent who becomes nondependent; DS = degenerative spondylolisthesis; DVT = deep vein thrombosis; ED = emergency department; ER = emergency room; IQR = interquartile range; LOS = length of stay; NDD = prior nondependent who becomes dependent; NDND = prior nondependent who remains nondependent; NIS = Nationwide Inpatient Sample; OR = odds ratio; PE = pulmonary embolism; RR = relative risk.

SUBMITTED December 7, 2017. **ACCEPTED** February 6, 2018.

INCLUDE WHEN CITING DOI: 10.3171/2018.2.FOCUS17764.

are being managed with decompression and fusion in the US, with perioperative opioid use.^{4,8,17,21,23,28} Several studies have evaluated the relationship between spine surgery and long-term opioid use.^{8,28,30} Approximately 0.1% of patients with underlying mental health disorders have been shown to continue prolonged opioid use following surgery.^{4,8,21,28}

Opioid dependency in these patients causes significant financial burden on the health care system and also affects quality of life.^{6,12,14,31} The total economic burden of opioid overdose, abuse, and dependency has been estimated to be \$78.5 billion in the US.^{12,24} The mean adjusted per-user total cost of prescription medications for spine problems increased from \$166 to \$397 (139%) over the past decade. Increasing use of preoperative opioids has been shown to be associated with prolonged hospital length of stay (LOS; each 100-mg morphine equivalent extends the hospital LOS by 1.1 days), delay in return to work, adverse functional outcome, and postoperative opioid dependency.^{1,3–5,8,22}

Recently, there has been widespread use of national databases to answer clinical questions on a larger scale.^{2,8,9,21,29} To that end, we aimed to identify health care utilization and overall costs based on opioid dependence in patients undergoing surgery for DS using a national database. To the best of our knowledge, this is the first study focusing on the economic burden related to the surgical management of this patient cohort.

Methods

Data Source

We used MarketScan data from Truven Health Analytics, part of IBM Watson Health. This database is constructed using paid insurance claims from approximately 100 payers and is available to researchers for a fee. Included in MarketScan are longitudinal clinical utilization of health care resources, insurance enrollment, costs associated with the treatment, and provider information¹³ across different services over the time of patient enrollment for covered individuals and their dependents. The data contain a unique encrypted identification number for each patient that is used to extract data across different files.¹¹ It has been used in medical and outcomes research since 1990.¹³ We used a custom file consisting of neurology/neurosurgery inpatient, outpatient, and prescription medication data files from commercial claims and encounters, and Medicare supplemental and Medicaid databases. For this study, we extracted data related to health care utilization and costs associated with opioid dependence in patients undergoing surgery for DS.

Patient Selection, Exploratory Variables, and Follow-Up

We used the inpatient admission tables to extract patients with a primary diagnosis of acquired lumbar spondylolisthesis (ICD-9-CM code 738.4) with a concurrent procedure of either a laminectomy or fusion using ICD-9 and CPT-4 codes (laminectomy: ICD-9 codes 03.0 or 03.09, or CPT-4 codes 63005, 63012, 63017, 63030, 63042, 63047, 63056, and 63102; fusion: ICD-9 codes 81.06, 81.07, and 81.08, or CPT-4 codes 22558, 22630, and 22612). Cases with concurrent refusion (ICD-9 codes 81.36, 81.37, and

81.38; CPT-4 codes 22830, 22849, 22850, 22852, 22855) or under 18 years of age were excluded. For each patient, the first occurring case satisfying the above conditions was flagged as the index hospitalization.

Patient characteristics at the index hospitalization including age, sex, year of index hospitalization, insurance type (commercial, Medicaid, Medicare), comorbidities, and instrumentation and number of levels were used as the variables. We used the Elixhauser comorbidity score,¹⁰ which was calculated based on modified ICD-9-CM codes (Quan et al.²⁷). Cases were classified as instrumented if the CPT-4 procedure codes 22840–22847 were present in the claims. Similarly, cases were classified as multiple-level surgery if ICD-9 procedure codes 81.62, 81.63, 81.64, or CPT-4 procedure codes 22585, 22632, 22614, 63035, 63044, 63048, 63057, 63103, or 22842–22847 were present.

To calculate the look-back period (preoperative follow-up time) and the follow-up time, we used the dates of start and end enrollment times according to the formulas below:

Pre–follow-up time = surgery admission date – start enrollment date

Post–follow-up time = end enrollment date – surgery discharge date

If the start or end enrollment dates fell outside our data, they were censored, respectively, with the beginning of our data (January 1, 2000) or the last date of our data (December 31, 2012).

Opioid Dependence and Analysis Groups

Presurgery (within 12 months prior to the procedure) and postsurgery opioid dependency (3–15 months following discharge) was determined using either ICD-9 codes for opioid use (305.50, 305.55, 305.52, 304.00, 304.01, 304.02, 304.70, 304.71 or 304.72);⁷ at least 10 prescriptions of opioid medications^{8,20} such as buprenorphine, butorphanol, codeine phosphate, dihydrocodeine, fentanyl citrate, hydrocodone, hydromorphone, levorphanol, meperidine, methadone, morphine sulfate, nalbuphine, opium alkaloids, oxycodone, oxymorphone, pentazocine, propoxyphene, tapentadol, tramadol, buprenorphine, or naltrexone;¹⁹ or a prescription for medications (buprenorphine or naltrexone)/psychotherapy (CPT-4 code 4306F)⁷ related to the management of opioid addiction disorder during the study period.

We defined the comparative groups based on opioid dependence before and after surgery as follows: group NDND (prior nondependent who remains nondependent), group NDD (prior nondependent who becomes dependent), group DND (prior dependent who becomes nondependent), and group DD (prior dependent who remains dependent).

Postoperative Outcomes

The outcomes of interest in this study were: LOS during index hospitalization following surgery; discharge disposition; complications (renal, cardiac, general neurosurgi-

TABLE 1. ICD-9-CM codes used for extracting complications from the database

Complication Type	ICD-9-CM Codes
Renal	584, 584.5–584.9; 997.5
Cardiac	997.1; 410.0; 410.00; 410.01; 410.1; 410.10; 410.11; 410.2; 410.20; 410.21; 410.3; 410.30; 410.31; 410.4; 410.40; 410.41; 410.5; 410.50; 410.51; 410.6; 410.60; 410.61; 410.7; 410.70; 410.71; 410.8; 410.80; 410.81; 410.9; 410.90; 410.91
Neural	997.00–997.09
DVT & PE	415.1; 415.11; 415.19; 451.11; 451.12; 451.19; 451.12; 451.81; 451.9 453.4; 453.40; 453.41; 453.42; 453.8; 453.9
Pulmonary	507.3; 518.4; 518.5; 518.81; 518.82; 997.3; 997.31; 997.39
Infection	510, 510.0, 510.9; 038, 038.0–038.9, 038.10–038.19, 038.40–038.49; 320, 320.0–320.9, 320.81–320.89; 513, 513.0, 513.1; 519.2; 590.1, 590.10, 590.11; 590.80; 683
Wound	998.1–998.9, 998.11–998.13, 998.30–998.33, 998.51, 998.59, 998.81–998.89

cal, general neurological, deep vein thrombosis [DVT] or pulmonary embolism [PE], pulmonary, infection, wound infection, hydrocephalus, mechanical ventilation, laceration, or CSF rhinorrhea); health care resource use (hospital days, 30-day hospital readmission, and emergency department [ED]) and health care resource costs; outpatient services; and medication refills, with their associated payments among the 4 groups (NDND, NDD, DND, DD).

Complications

The ICD-9 codes used to search for complications are listed in Table 1. The incidence of complications was evaluated during the index hospitalization and 30 days after surgery. The presence of a complication was noted as the occurrence of any of the complication types described above. Index hospitalization complications were complications that occurred during the index procedure hospitalization. Thirty-day complications were evaluated by examining all hospitalizations and/or outpatient visits within 30 days after surgery discharge.

Health Care Resources Use

We investigated the index hospitalization and the post-discharge health care resources use. For the index hospitalization, we investigated the LOS and discharge disposition. For postdischarge health resource use outcomes, we focused on 30-day hospital readmission and outpatient emergency room (ER) use, 3-month and 3–15-month hospital admissions, outpatient services, and medication refills.

Health Care Resources Payment

We evaluated all the payments associated with the uses described in the paragraph above: index hospitalization payment, and postdischarge inpatient, outpatient, and medication payments. Payments were cumulated over all hospitalizations (inpatient payment), all outpatient services (outpatient payments), all prescription medication refills (medications payments), and a combination of all three. Outpatient ER services were a subset of the outpatient services with an indicator that they occurred in the ED. All payments were inflated to 2012 US dollars using the medical component of the consumer price index, which can be accessed through the website of the US Bureau of Labor Statistics.²⁵

Statistical Analysis

We summarized continuous variables using means and standard deviations, medians and interquartile ranges (IQRs), as well as the full range (minimum to maximum). Categorical variables were summarized using counts and percentages. To compare the patient characteristics and outcomes among different opioid use groups, we used the Kruskal-Wallis test for continuous variables and the chi-square test for categorical variables.¹⁸ We also performed a multivariable analysis for each outcome using the linear regression on log-transformed values for continuous outcomes and the logistic regression for categorical outcomes. The covariate procedure types, sex, age, Elixhauser index, insurance type, and number of levels were added to the model in addition to the opioid dependence group. From these models, we build linear contrasts to compare different groups to the reference group (NDND). Adjusted comparisons were presented in terms of relative risk (RR) for continuous variables and odds ratio (OR) for categorical variables. We used SAS software (version 9.4, SAS Institute, Inc.) for data preprocessing and data analysis.³²

Results

Patient Demographics

A cohort of 10,708 patients who underwent surgery for DS was identified using the MarketScan database: 81.57%, 3.58%, 8.54%, and 6.32% of patients were in groups NDND, NDD, DND, and DD, respectively. The overall median age was 61 years and 65.1% of patients were females. Group DD had significantly more younger females compared to the NDND group (median age 57 vs 61 years, female sex 69.7% vs 64.2%). Similarly, significantly more patients in group DD had primarily commercial insurance (69.4%) compared with those in groups NDND (60.7%), NDD (64.5%), and DND (60.5%; $p < 0.001$). There was no significant difference in the Elixhauser comorbidity index among the different groups ($p = 0.3493$). Overall, the majority of patients (94%) underwent decompression with fusion for DS: 96.3% of patients in group DD had decompression with fusion compared with 93.6% in group NDND, however, the majority of patients who underwent decompression alone were in group NDND compared to those in group DD (6.41% vs 3.69%). The demographics

TABLE 2. Demographics stratified by opioid dependency

Variable	Opioid Dependency Before & After Surgery				p Value	Combined Cohort
	NDND	NDD	DND	DD		
No. of patients (%)	8734 (81.57)	383 (3.58)	914 (8.54)	677 (6.32)		10,708 (100)
Demographics						
Age, yrs					<0.0001	
Mean (SD)	61.16 (11.85)	58.02 (13.17)	60.27 (11.54)	56.39 (11.37)		60.67 (11.91)
Median (IQR)	61 (54–70)	58 (49–67)	60 (53–69)	57 (49–63)		61 (54–69)
Range	18–95	22–92	19–86	20–86		18–95
Females, no. (%)	5612 (64.25)	259 (67.62)	632 (69.15)	472 (69.72)	0.0008	6975 (65.14)
Insurance, no. (%)					<0.0001	
Commercial	5301 (60.69)	247 (64.49)	553 (60.5)	470 (69.42)		6571 (61.37)
Medicaid	275 (3.15)	23 (6.01)	47 (5.14)	46 (6.79)		391 (3.65)
Medicare	3158 (36.16)	113 (29.5)	314 (34.35)	161 (23.78)		3746 (34.98)
Elixhauser index, no. (%)					0.3493	
0	4024 (46.07)	187 (48.83)	417 (45.62)	326 (48.15)		4954 (46.26)
1	2777 (31.8)	111 (28.98)	287 (31.4)	211 (31.17)		3386 (31.62)
2	1247 (14.28)	53 (13.84)	129 (14.11)	75 (11.08)		1504 (14.05)
3+	686 (7.85)	32 (8.36)	81 (8.86)	65 (9.6)		864 (8.07)
Surgery type, no. (%)					0.0009	
Decompression w/o fusion	560 (6.41)	18 (4.70)	37 (4.05)	25 (3.69)		640 (5.97)
Decompression w/ fusion	8174 (93.59)	365 (95.3)	877 (95.95)	652 (96.31)		10,068 (94.02)
Multiple levels	6627 (75.88)	304 (79.37)	685 (74.95)	507 (74.89)	0.3409	8123 (75.86)

Boldface type indicates statistical significance.

and other patient and treatment characteristics are noted in Table 2.

Index Hospitalization Outcomes

Overall, the median hospital LOS was 3 days, with the longest in the NDD group (4 days; Table 3). Compared to the NDND group, the hospital LOS was significantly longer ($p < 0.001$) in groups NDD (RR 1.058, 95% CI 1.005–1.114), DND (RR 1.087, 95% CI 1.05–1.124), and DD (RR 1.088, 95% CI 1.046–1.132; Table 4).

In all, 83.55% of patients ($n = 8947$) were discharged home and 9.5% ($n = 1018$) had in-hospital complications. Patients in groups DD and DND were less likely to be discharged home compared with those in group NDND (OR 0.639, 95% CI 0.52–0.785, and OR 0.828, 95% CI 0.691–0.992). No significant difference in terms of in-hospital complications was noted among the groups ($p = 0.9062$).

The median cost of index hospitalization for the combined cohort was \$40,095. Patients in the DD group had a median cost of \$43,524, compared with \$39,654 for patients in group NDND, \$41,052 in group NDD, and \$41,027 in group DND ($p = 0.0351$). However, on adjusted analysis, these differences were not significant ($p = 0.7814$; Tables 3 and 4, Fig. 1).

Thirty-Day Postdischarge Outcomes

At 30 days after discharge, 6.79% ($n = 727$), 3.46% ($n = 371$), and 6.47% ($n = 693$) of all patients were noted to have complications, hospital readmissions, and ER readmissions, respectively. However, there was no significant

difference among the groups in terms of complications ($p > 0.05$).

Patients in the NDD group had the highest number of patients with hospital (7.05%) and ER (9.4%) readmissions at 30 days follow-up compared with those in other groups. On adjusted analysis, patients in the NDD group were 2.1 times and 61% more likely to have hospital and ER readmissions compared with those in the NDND group ($p = 0.023$ and 0.008 , respectively; Tables 3 and 4).

Postdischarge Outcomes at 3 Months and 3–15 Months

At 3 months following discharge, 6.12% ($n = 655$) of all patients were readmitted. Compared to patients in the NDND group, patients in the NDD, DND, and DD groups were 2.2 times, 42%, and 88% more likely to have hospital readmissions ($p < 0.001$). Patients in the DD group incurred 42% higher outpatient costs, 2.6 times higher medication refill costs, and 2.1 times higher overall costs compared with those in the NDND group ($p < 0.001$, Fig. 2).

At 3–15 months after discharge, overall 19% of patients were readmitted, and median outpatient cost, medication cost, and overall costs were \$4831, \$1959, and \$8987, respectively. Patients who were opioid dependent after surgery (groups NDD and DD) were 3.6 and 2.9 times more likely to have hospital readmissions compared to those in the NDND group. Also, patients in group DD incurred 21% higher hospital readmission costs compared to those in the NDND group. Patients in groups NDD and DD were likely to incur 2.8 times the overall costs compared to patients in group NDND ($p < 0.001$) at 3–15 months

TABLE 3. Outcome comparison among opioid dependency groups

Variable	Opioid Dependency Before & After surgery					p Value	Combined Cohort
	NDND	NDD	DND	DD			
Index hospitalization outcomes							
Median LOS in days (IQR)	3 (2–4)	4 (2–4)	3 (3–5)	3 (3–5)	<0.0001	3 (2–4)	
Median payment in \$ (IQR)	39,654 (27,264–62,325)	41,052 (28,651–67,503)	41,027 (27,254–63,218)	43,524 (27,937–65,007)	0.0351	40,095 (27,363–62,733)	
Discharge home, no. (%)	7329 (83.91)	329 (85.9)	745 (81.51)	544 (80.35)	0.0171	8947 (83.55)	
Complications, no. (%)	836 (9.57)	37 (9.66)	86 (9.41)	59 (8.71)	0.9062	1018 (9.51)	
30-day postdischarge outcomes							
Complications, no. (%)	576 (6.59)	26 (6.79)	77 (8.42)	48 (7.09)	0.2141	727 (6.79)	
Hospital readmission, no. (%)	280 (3.21)	27 (7.05)	37 (4.05)	27 (3.99)	0.0005	371 (3.46)	
ER readmission, no. (%)	533 (6.1)	36 (9.4)	61 (6.67)	63 (9.31)	0.0009	693 (6.47)	
3-mos postdischarge outcomes							
Hospital readmissions							
Readmitted, no. (%)	474 (5.43)	44 (11.49)	69 (7.55)	68 (10.04)	<0.0001	655 (6.12)	
Outpatient services							
Median no. of services (IQR)	14 (6–28)	17 (9–34)	15 (8–31)	16 (8–33)	<0.0001	14 (6–29)	
Median payments in \$ (IQR)	1238 (417–3255)	1717 (701–4553)	1447 (592–3907)	1624 (588–4333)	<0.0001	1288 (447–3414)	
Medication refills							
Median no. of refills (IQR)	7 (2–12)	16 (11–22)	15 (9–21)	20 (14–27)	<0.0001	8 (3–15)	
Median payments (IQR)	388 (24–1019)	847 (368–1644)	916 (386–1773)	1207 (561–2298)	<0.0001	494 (62–1175)	
Median overall payments (IQR)	2068 (919–4570)	3128 (1406–7006)	2889 (1521–6213)	3583 (1870–7412)	<0.0001	2268 (1025–4928)	
3–15-mos postdischarge outcomes							
Hospital readmissions							
Admitted, no. (%)	1469 (16.82)	151 (39.43)	185 (20.24)	229 (33.83)	<0.0001	2034 (19)	
Median no. of readmissions (IQR)	0 (0–0)	0 (0–1)	0 (0–0)	0 (0–1)	0 (0–0)	0 (0–0)	
Median payments in \$ (IQR)	0 (0–0)	0 (0–15,957)	0 (0–0)	0 (0–9372)	0 (0–0)	0 (0–0)	
Outpatient services							
Median no. of services (IQR)	47 (24–85)	83 (49–135)	54 (30–96)	76 (44–127)	<0.0001	50 (26–90)	
Median payments (IQR)	4398 (1892–9501)	9238 (4871–17,133)	5444 (2472–10,770)	8269 (4112–15,619)	<0.0001	4831 (2068–10,242)	
Medication refills							
Median no. of refills (IQR)	22 (5–40)	61 (43–79)	43 (26–66)	70 (50–99)	<0.0001	27 (9–49)	
Median payments in \$ (IQR)	1563 (102–4097)	3820 (1744–7220)	3564 (1471–6913)	5234 (2592–9016)	<0.0001	1959 (275–4786)	
Median overall payments in \$ (IQR)	7994 (3498–16,977)	20,033 (9475–42,857)	11,899 (5655–23,708)	19,654 (9482–40,963)	<0.0001	8987 (3972–19,508)	

Boldface type indicates statistical significance.

TABLE 4. Outcome-adjusted comparison among opioid dependency groups

Variable	Opioid Dependency Before & After Surgery (95% CI)				p Value
	NDND	NDD	DND	DD	
Index hospitalization outcomes					
LOS, RR	Ref	1.058 (1.005–1.114)	1.087 (1.05–1.124)	1.088 (1.046–1.132)	<0.0001
Payment, RR	Ref	1.036 (0.938–1.144)	1.021 (0.955–1.091)	1.024 (0.949–1.106)	0.7814
Discharge home, OR	Ref	1.074 (0.795–1.452)	0.828 (0.691–0.992)	0.639 (0.52–0.785)	<0.0001
Complications, OR	Ref	1.057 (0.744–1.501)	0.992 (0.784–1.256)	1.007 (0.76–1.333)	0.9914
30-day postdischarge outcomes					
Complications, OR	Ref	1.085 (0.72–1.634)	1.318 (1.026–1.692)	1.201 (0.881–1.636)	0.1322
Hospital readmission, OR	Ref	2.175 (1.44–3.286)	1.256 (0.884–1.786)	1.134 (0.755–1.703)	0.0023
ER readmission, OR	Ref	1.615 (1.13–2.308)	1.08 (0.82–1.423)	1.613 (1.221–2.131)	0.0008
3-mos postdischarge outcomes					
Hospital admissions					
Admitted, OR	Ref	2.258 (1.622–3.142)	1.426 (1.095–1.856)	1.887 (1.439–2.475)	<0.0001
Outpatient services					
No. of services, RR	Ref	1.217 (1.192–1.242)	1.07 (1.054–1.085)	1.204 (1.185–1.223)	<0.0001
Payments, RR	Ref	1.463 (1.259–1.699)	1.225 (1.108–1.353)	1.428 (1.272–1.603)	<0.0001
Medication refills					
No. of refills, RR	Ref	2.086 (2.034–2.139)	1.894 (1.861–1.928)	2.66 (2.613–2.708)	<0.0001
Payments, RR	Ref	1.806 (1.578–2.067)	1.743 (1.593–1.907)	2.607 (2.352–2.89)	<0.0001
Median overall payments, RR	Ref	1.809 (1.575–2.077)	1.562 (1.425–1.713)	2.118 (1.904–2.356)	<0.0001
3–15 mos postdischarge outcomes					
Hospital admissions					
Readmitted, OR	Ref	3.592 (2.888–4.468)	1.279 (1.075–1.521)	2.936 (2.467–3.495)	<0.0001
No. of readmissions, RR	Ref	2.603 (2.255–3.005)	1.203 (1.051–1.376)	2.5 (2.223–2.811)	<0.0001
Payments, RR	Ref	1.156 (0.961–1.391)	0.875 (0.739–1.036)	1.217 (1.041–1.422)	0.0085
Outpatient services					
No. of services, RR	Ref	1.544 (1.528–1.56)	1.131 (1.122–1.14)	1.48 (1.468–1.492)	<0.0001
Payments, RR	Ref	2.149 (1.873–2.466)	1.245 (1.136–1.365)	2.01 (1.808–2.235)	<0.0001
Medication refills					
No. of refills, RR	Ref	2.471 (2.439–2.503)	1.826 (1.807–1.844)	2.969 (2.941–2.998)	<0.0001
Payments, RR	Ref	2.291 (1.985–2.643)	1.78 (1.616–1.961)	3.132 (2.805–3.498)	<0.0001
Overall payments, RR	Ref	2.778 (2.436–3.169)	1.509 (1.382–1.647)	2.853 (2.578–3.156)	<0.0001

Adjusted comparisons were obtained from linear contrasts derived from multivariable regression models that included the covariates of procedure type, sex, age, Elixhauser index, insurance, and number of levels, in addition to opioid dependency group. Boldface type indicates statistical significance.

after surgery (median overall costs: group NDD \$20,033 and group DD \$19,654, vs group NDND \$7994; Tables 3 and 4, Figs. 3 and 4).

Discussion

In our cohort of 10,708 patients, we found that patients who remain opioid dependent (DD and NDD) after surgery for DS had longer hospital LOSs and were less likely to be discharged home compared with those who were opioid nondependent prior to surgery and remained nondependent (NDND) after surgery. Also, at 3–15 months, patients in the DD group incurred 21% higher hospital readmission costs compared with those in the NDND group. Patients in groups NDD and DD were likely to incur 2.8 times the overall costs compared with patients in group NDND, causing a significant health care burden.

The incidence of opioid dependence following major surgery in opioid-naïve patients varies from 0.1% to 0.4%.^{4,8,21,28,31} Open procedures, preprocedure opioid dependence, and mental illness are identified as risk factors for developing long-term opioid dependence.^{4,8,28,31} In our study, we found that 3.58% of opioid-naïve patients developed new-onset opioid dependence following surgery for DS.

Using the Nationwide Inpatient Sample (NIS), a recent study reported that 48,911 patients underwent surgery for DS in the US from 2001 to 2010²³ with a substantial increase in the use of interbody fusion techniques in the last decade.^{17,23} In this study, 64% of patients were female and the average age was 59.7 years,²³ which are demographics comparable to our study (65% female and mean age 61 years). The majority of patients in this study underwent posterior/transforaminal lumbar interbody fusion—only

FIG. 1. Bar graphs showing the distribution of hospital LOS (A), in-hospital complication rates (B), and hospital home discharge rates (C) among patients in the NDND, NDD, DND, and DD groups following surgery for DS.

procedures (83.9%, $n = 41,051$) followed by posterolateral fusion-only procedures (10.2%, $n = 4989$) for DS in this study.²³

In our study, the median LOS for the combined cohort was 3 days (range 2–4 days). Our results are comparable to another NIS-based study,²³ which reported an

average LOS of 4.4 days. We found that, compared to the NDND group, the median LOS was significantly longer in the NDD, DND, and DD groups ($p < 0.001$). In contrast, Walid et al.³³ reported that there was no correlation ($p > 0.1$) between preoperative opioid dependence and LOS in a cohort of 150 patients who underwent surgery for a variety

FIG. 2. Bar graphs showing the median outpatient costs (A), medication costs (B), and overall costs (C) at 3 months after discharge following surgery for DS, among patients in the NDND, NDD, DND, and DD groups.

FIG. 3. Bar graph showing the median outpatient costs (A), medication costs (B), and overall costs (C) at 3–15 months after discharge following surgery for DS, among patients in the NDND, NDD, DND, and DD groups.

FIG. 4. Scatter diagram showing the preoperative and postoperative median overall payments among patients in the NDND, NDD, DND, and DD groups and the effect of surgery on the overall costs.

of cervical and lumbar pathologies. However, this study did not examine postoperative opioid dependence and also analyzed heterogeneous spine pathologies. Based on our results, patients who were opioid dependent either prior to or after surgery for DS tend to have longer LOS following surgery for DS, compared with those who were opioid nondependent prior to and after surgery (NDND group). The overall incidence of in-hospital complications in our study was 9.5% compared to 22.5% in the study using the NIS database ($n = 48,911$).²³ This difference may be attributed to the selection bias in our study (patients with at least 12 months of follow-up prior to and after surgery were included). There was no difference in both in-hospital and 30-day complication rates among different groups in our study, which implies that opioid dependence has no correlation with complications following surgery for DS.

In our study, the overall median cost of index hospitalization was \$40,095. Patients in the DD group had a median cost of \$43,524, compared with \$39,654 for patients in group NDND, \$41,052 in group NDD, and \$41,027 in group DND ($p = 0.0351$). However, there was no significant difference among the groups on adjusted analysis ($p > 0.05$). Another NIS-based study reported a weighted index hospitalization cost of \$61,766 in patients undergoing surgery for DS.²³ Another study reported that combined medical and pharmaceutical expenditure during the 2-year period following lumbar fusion surgeries for degenerative conditions was \$12,283/individual.²¹ Similarly, we found that additional combined median inpatient, outpatient, and medication costs during the 15-month period after the index hospitalization cost of the surgery for DS was \$11,255 per patient.

Also in our study, patients in the DD group had 2.1 and 2.8 times higher overall costs at 3 months and 3–15 months, respectively, compared to patients in the NDND group ($p < 0.001$). This finding has important implications for routine clinical practice; various measures to reduce opioid dependence (psychiatric consultation, behavior therapy, etc.) should be considered prior to elective spine surgery. These measures can help reduce overall health care costs in this patient population.

Limitations of the Study

A major advantage of using the MarketScan database is that it provides longitudinal information related to inpatient and outpatient services that are inclusive of medication refills and health care utilization costs, in a large sample size across the US, thereby providing an opportunity to answer a clinically relevant question on a wider scale.

The limitations of using such a database include the retrospective nature of the study and inherent limitations associated with such methodology. Moreover, this database is based on insurance claims, which were used to charge in-hospital/outpatient services and medication costs during the treatment. Therefore, this study did not take into account the clinical scenario and thought process in the management as well the clinical follow-up of an individual patient. Other potential limitations include coding errors, inability to track the “actual consumption” of the opioid by the patient, and inability to capture the patients who

were obtaining illegal opioids, which may over- or underestimate the actual clinical scenario. Despite these limitations, our study provides an in-depth analysis of the impact of opioid dependency on health care utilization at different time points in patients undergoing surgery for DS.

Conclusions

Patients who continued to be opioid dependent or become opioid dependent following surgery for DS incur significant health care utilization and costs at 3 months and 3–15 months. These findings can be used to formulate strategies to reduce the health care costs in this patient population, given the current scenario of the opioid crisis.

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Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author Contributions

Conception and design: Sharma. Analysis and interpretation of data: Sharma. Drafting the article: Sharma, Aljuboory. Critically revising the article: Boakye, Sharma, Ugiliweneza. Reviewed submitted version of manuscript: all authors. Statistical analysis: Ugiliweneza. Administrative/technical/material support: Boakye. Study supervision: Boakye.

Supplemental Information

Videos

Video Abstract. <https://vimeo.com/261518165>.

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