Patterns and Impact of Electronic Health Records-Defined Depression Phenotypes in Spine Surgery

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Received, August 3, 2020.
Accepted, January 21, 2021.

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BACKGROUND: Preoperative depression is a risk factor for poor outcomes after spine surgery.

OBJECTIVE: To understand effects of depression on spine surgery outcomes and healthcare resource utilization.

METHODS: Using IBM's MarketScan Database, we identified 52 480 patients who underwent spinal fusion. Retained patients were classified into 6 depression phenotype groups based on International Classification of Disease, 9th/10th Revision (ICD-9/10) codes and use/nonuse of antidepressant medications: major depressive disorder (MDD), other depression (OthDep), antidepressants for other psychiatric condition (PsychRx), antidepressants for physical (nonpsychiatric) condition (NoPsychRx), psychiatric condition only (PsychOnly), and no depression (NoDep). We analyzed baseline demographics, comorbidities, healthcare utilization/payments, and chronic opioid use.

RESULTS: Breakdown of groups in our cohort: MDD (15%), OthDep (12%), PsychRx (13%), NonPsychRx (15%), PsychOnly (12%), and NoDep (33%). Postsurgery: increased outpatient resource utilization, admissions, and medication refills at 1, 2, and 5 yr in the NoDep, PsychOnly, NonPsychRx, PsychRx, and OthDep groups, and highest in MDD. Postoperative opioid usage rates remained unchanged in MDD (44%) and OthDep (36%), and reduced in PsychRx (40%), NonPsychRx (31%), and PsychOnly (20%), with greatest reduction in NoDep (13%). Reoperation rates: 1 yr after index procedure, MDD, OthDep, PsychRx, NonPsychRx, and PsychOnly had more reoperations compared to NoDep, and same at 2 and 5 yr. In NoDep patients, 45% developed new depressive phenotype postsurgery.

CONCLUSION: EHR-defined classification allowed us to study in depth the effects of depression in spine surgery. This increased understanding of the interplay of mental health will help providers identify cohorts at risk for high complication rates, and health care utilization.

KEY WORDS: Depression, Spine surgery, Health resource utilization, Mental health, Opioid use

Neurosurgery 0:1–14, 2021 DOI:10.1093/neuros/nyab096 www.neurosurgery-online.com

De novo and revision spinal surgery rates continue to increase in the United States.[1-4] Even following best management practices, many patients have poor outcomes postspinal surgery.[5,6] In many studies, preoperative depression ranks as one of the most important risk factors for poor outcomes postspine surgery.[7-17] New depression has been reported after many types of surgeries including coronary artery bypass, hysterectomy, and cholecystectomy.[18-22] Although much remains unknown about the role of depression in spine surgery outcomes or its impact on health resource utilization, patients with chronic back pain and spinal disorders have far greater prevalence of mental health disorders[23-27] compared to general population.[21-25] In recent studies,

ABBREVIATIONS: ICD-9/10, International Classification of Disease, 9th/10th Revision; **MDD,** major depressive disorder; **NoDep,** no depression; **NoPsychRx,** antidepressants for physical (nonpsychiatric) condition; **OthDep,** other depression; **PsychOnly,** psychiatric condition only; **PsychRx,** antidepressants for other psychiatric condition

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5% to 6% of patients without preexisting depressive illness appear to develop new depression after spine surgery.[28,29]

Most studies of depression's effect in spine surgery have been retrospective reviews based on International Classification of Disease, 9th/10th Revision (ICD-9/10) codes or scores on a screening question.[8,9,15,27,29,30] Many spine patients use antidepressant medication for neuropathic pain and do not have ICD-9 depression diagnoses.[31,32] Antidepressants are also prescribed for other conditions unrelated to the spinal disease or depression.[33-35] Therefore, using the antidepressant medications as proxy for depressive disorders may not be appropriate in predicting outcomes following spine surgeries and may lead to underutilization of surgical treatment options.

Depression is a heterogeneous disorder with multiple subtypes.[36,37] Treating all depressive cases, the same may be an invalid way to examine depression's impact in spinal surgery, leading to an inaccurate, imprecise estimation of its effects. Recently, a new classification of depression identifiable in electronic databases was proposed[37] using an algorithm to classify patients in electronic medical records into 1 of 5 mutually exclusive, ordinal groups: major depressive disorder (MDD), other depression (OthDep), antidepressants for other psychiatric condition (PsychRx), antidepressants for physical condition (NonPsychRx), no depression (NoDep).

Objective

Our primary goal was to determine patterns and frequency of these categorized depressive phenotypes in spine surgery. A second goal was to correlate these phenotypes with pre- and postop health resource utilization and compare effects of each phenotype on postsurgery outcomes (complications, reoperations). Our hypotheses were that (1) there will be significant differences between groups in terms of health care utilization and clinical outcomes following spine surgeries and (2) patients having ICD 9 diagnoses of MDD would have the most adverse outcomes and health resource utilization.

METHODS

Registration, Study Design, and Setting

We used IBM MarketScan Database which includes claims for covered individuals and dependents from over 260 employers. To date, MarketScan contains over 32 billion de-identified medical records representing over 245 million patients. Our study used national administrative database de-identified patient information. Therefore, patients' consent were not required. Local Institutional review board approval was obtained for Neurosurgical outcomes research using clinical registries, administrative and clinical databases.

Participants, Data Source, Bias, and Size

Patients who underwent fusion surgery constituted our population of 52 480 patients. For sample selection, we used ICD-9 code 81.01-81.08 and current procedural terminology code (**Supplementary Digital Content**) to screen for spine fusion cases. Only patients with at least 24-mo lookback and 60-mo follow-up continuous enrollment were retained. Preoperative lookback time was calculated as the difference between enrollment start date and index admission date. Postoperative follow-up was calculated as the difference between index discharge date and end enrollment date.

Definition of Depression Phenotypes

In our study, depression phenotype refers to clinical patterns associated with depression and antidepressant history. We used the method proposed by Ingram et al[37] to define depression phenotypes, with a minor modification. The ICD-9 and ICD-10 code for MDD, OthDep (atypical or depressive disorder not elsewhere specified), and psychiatric condition are also listed in **Supplementary Digital Content**. Antidepressant prescription was located by therapeutic classification as "Psychother, Antidepressants" in the medications file of MarketScan. The 6 depression groups were populated as follows:

(1) MDD: Patients with at least one diagnosis of MDD.
(2) OthDep: Everyone not qualifying for MDD, diagnosed with other atypical depression or not elsewhere specified.

The next 3 groups were patients having an antidepressant prescription and/or psychiatric condition diagnosis. To define antidepressant medication orders, Ingram et al. used RxNorm classification of "Antidepressant." In MarketScan, we used the equivalent therapeutic classification, "Psychother, Antidepressants."

(3) PsychRx: Subgroup prescribed at least one antidepressant for psychiatric condition other than depression (PsychRx), eg, antidepressants being prescribed for anxiety disorder.
(4) NoPsychRx: Patients prescribed antidepressant medication without psychiatric diagnoses/condition, eg, antidepressants being prescribed for neuropathic pain disorders.
(5) PsychOnly: Patients with psychiatric conditions/diagnoses (not MDD or OthDep), no prescribed antidepressants.

This group was put in NoDep by Ingram, and is the minor difference of our group from theirs.

(6) NoDep: The remaining patients not belonging to any other group.

Ingram and colleagues used data prior to the ICD-10.[37] Using ICD-9 diagnoses codes provided, we obtained the corresponding ICD-10.

Comorbidities were measured with Elixhauser comorbidity score,[38] and ICD-9-CM and ICD-10 CM codes adaptation developed by Quan et al.[39]

Outcome Variables

Outcomes of interest were index hospitalization outcomes, postdischarge healthcare utilization, payments. For postdischarge healthcare use and payment, we looked at 1, 2, and 5-yr reoperation rates, inpatient admission rates, outpatient services, medication refills, and all related payments. All payments were inflated to 2018 US dollars using the medical component of consumer price index (accessible through U.S. Bureau of Labor Statistics website).[40] Complications (index, 30 d) were noted by at least one of the following: renal, cardiac, nervous system complication, cerebrovascular disease, deep vein thrombosis or pulmonary embolism, pulmonary, and infection (pneumonia or wound). Chronic opioid use was defined as 10 or more opioid prescriptions in 3- to 12-mo postindex visit period.[8,41]

Statistical Analysis

Continuous variables were compared using the Kruskal-Wallis test. Categorical variables were compared using counts with associated

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percentages and chi-square test. The degree of freedom of chi-square test for 2-category and 3-category variables were 5 and 10, respectively. Outcomes were further analyzed using multivariable regression with depression group as test variable with all demographics. We used linear regression on log-transformed values for continuous outcomes, negative binomial transformation for counting outcomes, and logistic regression for categorical outcomes. Effect size was classified as described by Cohen et al[42] and Sawilowsky et al.[43] Statistical data analyses were performed using SAS 9.4 (SAS Institute Inc, Cary, North Carolina).[44]

RESULTS

Participants

The breakdown of groups: MDD (15%), OthDep (12%), PsychRx (13%), NonPsychRx (15%), PsychOnly (12%), NoDep (33%) (Table 1). Overall median age was 56 yr (inter-quartile range 49-65) and 57% of patients were females. MDD and OthDep groups had 70% female patients compared with 46% in PsychOnly and NoDep. Only 8% of patients had comorbidity index of 3+. Lumbar region was fused in 50% of patients, instrumented fusion in 82%, 81% underwent decompression, and 64% underwent multilevel procedures. Demographic difference was maintained across the cohorts. Demographic summary data are presented in Table 1.

Outcome Data, Adverse Events, Follow-up

Health Resource Utilization Presurgery

During the 1-yr prior to index surgery, MDD phenotype had highest health resources consumption with greater utilization of outpatient services (76 services) [followed by OtherDep (66), PsychRx (65), NonPsychRx (60), PsychOnly (57) and NoDep (49)], greater number of medication refills (39 vs 18), combined payments $15 578 vs $9 854 compared to NoDep cohort (Table 2). Patients in OtherDep ($13 439), PsychRx($14 397), NonPsychRx($14 491), PsychOnly ($10 261) cohorts incurred intermediate combined payments compared to those in MDD and NoDep cohort (Table 2).

Health Resource Utilization Postsurgery

With few exceptions, there was increasing outpatient resource utilization, hospital admissions, medication refills at 1-, 2-, and 5-yr postsurgery from NoDep, PsychOnly, NonPsychRx, and PsychRx, OthDep culminating in highest risk in MDD (Table 2). In multivariate adjusted analysis (Table 3), compared to the NoDep, MDD patients had the highest risk of inpatient admission (odds ratio [OR] 2.56, CI 2.37, 2.75), outpatient services utilization (OR 1.68, CI 1.64, 1.71), medication refills (OR 1.87, CI 1.82-1.92), and total payments (OR 1.24, CI 1.22, 1.27) at 1-yr postsurgery. Similar results noted at 2- and 5-yr postsurgery. Figure 1 compares total payments utilized by groups at 1-, 2-, and 5-yr postsurgery.

Opioid Utilization Differences

In multivariate adjusted analysis (Table 3), MDD patients were most likely to have chronic opioid use 3 to 15 mo after index procedure compared to those without depression (OR 4.90, CI 4.46-5.39), $P < .001$. Patients with OthDep (OR 3.57, CI 3.23-3.94), PsychRx (OR 4.30, CI 3.91-4.73), NonPsychRx (OR 2.98, CI 2.72-3.26), and PsychOnly (OR 1.74, CI 1.57-1.93) also had higher risks of chronic opioid use postoperatively. Approximately 46% of MDD patients used more than 10 opioid prescriptions in the year presurgery, significantly higher than other groups: OthDep (40%), PsychRx (44%), NonPsychRx (36%), PsychOnly (25%), and NoDep (18%). Postoperative opioid usage rates remained unchanged in MDD (44%) and OthDep (36%) but reduced in PsychRx (40%), NonPsychRx (31%), and PsychOnly (20%) with greatest reduction in NoDep (13%).

Complication Rates

During index hospitalization, MDD patients (OR 1.22, CI 1.08-1.36), OthDep (OR 1.16, CI 1.03-1.31), and NonPsychRx (OR 1.17, CI 1.04-1.31) also had higher risks of in-hospital complications postindex surgery compared to NoDep (Tables 2 and 3). MDD patients (OR 1.66, CI 1.48-1.87), OthDep (OR 1.48, CI 1.31-1.68), PsychRx (OR1.18, CI 1.04-1.35), and NonPsychRx (OR1.08, CI 0.94-1.24) also had higher risk of postoperative complications within 30 d postsurgery postdischarge. MDD (OR 1.97 CI 1.74-2.22), OthDep (OR 1.72, CI 1.51-1.96), and PsychRx (OR 1.68, CI 1.47-1.92) had much greater risk of emergency room admissions within 30 d postsurgery compared to NoDep, respectively.

Reoperation Rates

At 1-yr postindex procedure, MDD patients (OR 2.03, CI 1.82-2.27), OthDep (OR 1.92, CI 1.71-2.16), PsychRx (OR1.74, CI 1.55-1.94), NonPsychRx (OR 1.50, CI 1.34-1.68), and PsychOnly (OR 1.4, CI 1.23-1.58) had higher risks of reoperation compared to NoDep, which were also maintained at 2 yr (OR 2.00-1.42) and 5 yr (OR 2.22-1.56) postsurgery (Table 3).

Trajectory and New Depression Incidence

Among depression cohorts, no change in phenotypic profile pre- and 5-yr postindex procedure was noted in 68% MDD, 35% OthDep, 29% PsychRx, 33% NonPsychRx, 30% PsychOnly, and 55% NoDep (Table 4 and Figures 2 and 3). Of NoDep phenotype, 45% developed new depressive phenotype postsurgery (5% MDD, 6% OthDep, 8% PsychRx, 11% NonPsychRx, 14% PsychOnly). Of original cohort, 5742 (11%) showed positive change to less severe phenotype compared to 22 688 (43%) patients who showed negative change within 5 yr postsurgery (generalized McNemar test < 0.001). Approximately 33% of OthDep patients converted to MDD phenotype in the 5 yr postsurgery which was higher than rates for PsychRx (26%),

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TABLE 1. Patient Demographics Who Underwent Fusion With/Without Depression Using MarketScan Database From 2000 to 2018

Variable	Total N = 52 480	Depression groups 60 mo postsurgery: MDD n = 7659 (15%)	OthDep n = 6471 (12%)	PsychRx n = 7040 (13%)	NonPsychRx n = 7966 (15%)	Psych Only n = 6088 (12%)	NoDep n = 17 256 (33%)	*P* value	MDD vs NoDep: *P* value	SD
Age								**<.0001**	<.0001	0.316
Mean (SD)	57 (12)	54 (11)	56 (12)	55 (12)	58 (11)	57 (13)	58 (12)			
Median (IQR)	56 (49, 65)	54 (47, 61)	55 (48, 64)	55 (48, 63)	57 (51, 66)	56 (48, 66)	57 (50, 67)			
Range (min-max)	18-94	18-91	18-88	18-91	18-90	18-94	18-94			
Gender, female, n (%)	30 168 (57%)	5333 (70%)	4501 (70%)	4379 (62%)	5193 (65%)	2825 (46%)	7937 (46%)		<.0001	0.493
Insurance								**<.0001**	<.0001	0.524
Commercial, n (%)	33 832 (64%)	4855 (63%)	3795 (59%)	4889 (69%)	5351 (67%)	3596 (59%)	11 347 (66%)			
Medicaid, n (%)	5046 (10%)	1420 (19%)	1293 (20%)	497 (7%)	166 (2%)	981 (16%)	689 (4%)			
Medicare, n (%)	13 602 (26%)	1384 (18%)	1383 (21%)	1654 (23%)	2449 (31%)	1512 (25%)	5220 (30%)			
Elixhauser index								**<.0001**	<.0001	0.373
0, n (%)	25 556 (49%)	3127 (41%)	2652 (41%)	3537 (50%)	4200 (53%)	2758 (45%)	9282 (54%)			
1, n (%)	16 289 (31%)	2325 (30%)	1932 (30%)	2210 (31%)	2601 (33%)	1847 (30%)	5374 (31%)			
2, n (%)	6573 (13%)	1199 (16%)	1063 (16%)	841 (12%)	845 (11%)	886 (15%)	1739 (10%)			
3+, n (%)	4062 (8%)	1008 (13%)	824 (13%)	452 (6%)	320 (4%)	597 (10%)	861 (5%)			
Fusion level								**<.0001**	<.0001	0.11
Cervical, n (%)	17 265 (33%)	2634 (34%)	2086 (32%)	2343 (33%)	2318 (29%)	2252 (37%)	5632 (33%)			
Thoracic, n (%)	8716 (17%)	1101 (14%)	1068 (17%)	1152 (16%)	1442 (18%)	918 (15%)	3035 (18%)			
Lumbar, n (%)	26 499 (50%)	3924 (51%)	3317 (51%)	3545 (50%)	4206 (53%)	2918 (48%)	8589 (50%)			
Decompression, yes, n (%)	42 649 (81%)	6072 (79%)	5423 (84%)	5561 (79%)	6354 (80%)	4981 (82%)	14 258 (83%)	**<.0001**	<.0001	0.085
Multilevel, yes, n (%)	33 497 (64%)	5228 (68%)	4647 (72%)	4311 (61%)	4458 (56%)	4347 (71%)	10 506 (61%)	**<.0001**	<.0001	0.155
Instrumentation, yes, n (%)	42 979 (82%)	6248 (82%)	5287 (82%)	5812 (83%)	6589 (83%)	4934 (81%)	14 109 (82%)	0.0901	0.7266	0.005
Prior opioid use								**<.0001**	<.0001	0.607
0, n (%)	14 400 (27%)	1642 (21%)	1729 (27%)	1203 (17%)	1440 (18%)	2310 (38%)	6076 (35%)			
[1,9], n (%)	21 365 (41%)	2507 (33%)	2148 (33%)	2761 (39%)	3652 (46%)	2286 (38%)	8011 (46%)			
10+, n (%)	16 715 (32%)	3510 (46%)	2594 (40%)	3076 (44%)	2874 (36%)	1492 (25%)	3169 (18%)			
Comorbidity										
Tobacco use, n (%)	6103 (12%)	1321 (17%)	1090 (17%)	927 (13%)	387 (5%)	1296 (21%)	1082 (6%)	<.0001	<.0001	0.346
Osteoporosis, n (%)	1508 (3%)	271 (4%)	235 (4%)	181 (3%)	227 (3%)	158 (3%)	436 (3%)	<.0001	<.0001	0.059
Hypertension, n (%)	22 594 (43%)	3435 (45%)	2955 (46%)	2870 (41%)	3354 (42%)	2798 (46%)	7182 (42%)	<.0001	<.0001	0.065
CHF, n (%)	1199 (2%)	204 (3%)	177 (3%)	142 (2%)	160 (2%)	165 (3%)	351 (2%)	0.0001	0.0019	0.042
COPD, n (%)	6776 (13%)	1318 (17%)	1172 (18%)	1019 (14%)	894 (11%)	954 (16%)	1419 (8%)	<.0001	<.0001	0.272
MI, n (%)	1284 (2%)	202 (3%)	180 (3%)	180 (3%)	152 (2%)	187 (3%)	383 (2%)	<.0001	0.0444	0.027
Diabetes, n (%)	8111 (15%)	1264 (17%)	1077 (17%)	1021 (15%)	1267 (16%)	1000 (16%)	2482 (14%)	<.0001	<.0001	0.059
Obesity, n (%)	2820 (5%)	627 (8%)	506 (8%)	311 (4%)	257 (3%)	386 (6%)	733 (4%)	<.0001	<.0001	0.164
At least one of the above, n (%)	32 588 (62%)	5088 (66%)	4351 (67%)	4340 (62%)	4762 (60%)	4176 (69%)	9871 (57%)	<.0001	<.0001	0.191

CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease; IQR: inter-quartile range; MDD: major depressive disorder; NoDep: no depression; nonPsychRx: antidepressants for nonpsychiatric condition; OthDep: other depression; PsychOnly: other psychiatric diagnosis only; PsychRx: antidepressants for other psychiatric condition.
Covariate are significantly difference if the *P*-value < .05.
Bold: significant.
SD: standardized difference, SD < 0.1 represents covariate balance.

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TABLE 2. Outcomes in Patients With and Without Depression Who Underwent Spine Fusion With 60 Months of Follow-up

Variable	Total N = 52 480	Depression groups 60 mo postsurgery: MDD n = 7659 (15%)	OthDep n = 6471 (12%)	PsychRx n = 7040 (13%)	NonPsychRx n = 7966 (15%)	PsychOnly n = 6088 (12%)	NoDep n = 17 256 (33%)	*P* value	MDD vs NoDep: *P* value	MDD vs NoDep: Effect size
Index hospitalization outcomes										
Length of stay, median (IQR)	2 (1, 4)	2 (1, 4)	2 (1, 4)	2 (1, 4)	2 (1, 4)	2 (1, 4)	2 (1, 4)	**<.0001**	<.0001	0.098
Payment, median (IQR)	39 155 (26 249, 63 344)	42 058 (26 977, 69 665)	41 110 (27 468, 66 710)	39 675 (26 810, 64 091)	37 882 (25 099, 61 803)	39 158 (26 350, 64 277)	37 960 (25 871, 59 772)	**<.0001**	<.0001	0.117
Discharge home, n (%)	45 522 (87%)	6631 (87%)	5643 (87%)	6060 (86%)	6747 (85%)	5357 (88%)	15 084 (87%)	**<.0001**	0.069	0.025
Complications, n (%)	3451 (7%)	587 (8%)	488 (8%)	445 (6%)	519 (7%)	403 (7%)	1009 (6%)	**<.0001**	<.0001	0.072
Preindex outcomes, 1 yr										
Hospital admissions										
Admitted, n (%)	5403 (10%)	1081 (14%)	839 (13%)	794 (11%)	840 (11%)	588 (10%)	1261 (7%)	**<.0001**	<.0001	0.221
Payments, median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	**<.0001**	<.0001	0.219
Outpatient services										
No. of services, median (IQR)	59 (36, 93)	76 (47, 118)	66 (42, 101)	65 (41, 100)	60 (37, 92)	57 (35, 89)	49 (30, 77)	**<.0001**	<.0001	0.619
Payments, median (IQR)	8222 (4645, 14 002)	9805 (5331, 16 801)	8628 (4948, 14 654)	9298 (5423, 15 791)	9130 (5322, 15 163)	7324 (4061, 12 504)	7078 (4055, 11 878)	**<.0001**	<.0001	0.36
Medication refills										
No. of refills, Median (IQR)	27 (11, 47)	39 (18, 65)	32 (13, 55)	34 (19, 55)	35 (20, 53)	18 (5, 35)	18 (7, 33)	**<.0001**	<.0001	0.701
Payments, median (IQR)	2310 (514, 5329)	3311 (910, 7209)	2568 (536, 6002)	3191 (1152, 6370)	3645 (1479, 6737)	1124 (100, 3554)	1450 (261, 3781)	**<.0001**	<.0001	0.473
Combined payments, median (IQR)	12 297 (6906, 21 144)	15 578 (8514, 27 248)	13 439 (7515, 23 403)	14 397 (8567, 24 167)	14 491 (8917, 23 508)	10 216 (5539, 17 856)	9854 (5714, 16 624)	**<.0001**	<.0001	0.502
Payment: index + pre 1 yr, median (IQR)	55 507 (38 349, 84 475)	62 206 (42 195, 96 508)	59 759 (40 861, 89 296)	58 400 (40 725, 87 876)	56 082 (38 801, 84 597)	53 208 (36 577, 81 174)	50 788 (35 804, 76 760)	**<.0001**	<.0001	0.304
Postdischarge outcomes, 30 d										
Complications, n (%)	2965 (6%)	591 (8%)	466 (7%)	376 (5%)	427 (5%)	315 (5%)	790 (5%)	**<.0001**	<.0001	0.131
ER admission, n (%)	2996 (6%)	740 (10%)	545 (8%)	464 (7%)	297 (4%)	387 (6%)	563 (3%)	**<.0001**	<.0001	0.263
Postopioid use, 3-15 mo								**<.0001**	<.0001	0.792
0, n (%)	20 981 (40%)	2158 (28%)	2268 (35%)	1817 (26%)	2378 (30%)	3084 (51%)	9276 (54%)			
[1,9], n (%)	17 083 (33%)	2137 (28%)	1851 (29%)	2373 (34%)	3135 (39%)	1772 (29%)	5815 (34%)			
10+, n (%)	14 416 (27%)	3364 (44%)	2352 (36%)	2850 (40%)	2453 (31%)	1232 (20%)	2165 (13%)			
Postdischarge outcomes, 1 yr										
Reoperation										
Fusion, n (%)	2836 (5%)	585 (8%)	431 (7%)	444 (6%)	448 (6%)	314 (5%)	614 (4%)	**<.0001**	<.0001	0.178
Decompression, n (%)	2533 (5%)	474 (6%)	397 (6%)	389 (6%)	397 (5%)	286 (5%)	590 (3%)	**<.0001**	<.0001	0.13
At least one of above, n (%)	3636 (7%)	703 (9%)	561 (9%)	573 (8%)	570 (7%)	402 (7%)	827 (5%)	**<.0001**	<.0001	0.173
Hospital admissions										
Admitted, n (%)	9009 (17%)	1954 (26%)	1452 (22%)	1330 (19%)	1279 (16%)	1004 (16%)	1990 (12%)	**<.0001**	<.0001	0.366
Payments, median (IQR)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	0 (0, 0)	**<.0001**	<.0001	0.363
Outpatient services										
No. of services, median (IQR)	52 (27, 91)	76 (42, 124)	62 (35, 105)	60 (34, 100)	50 (27, 89)	49 (25, 86)	38 (19, 69)	**<.0001**	<.0001	0.783

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TABLE 2. Continued

Variable	Total N = 52 480	Depression groups 60 mo postsurgery: MDD n = 7659 (15%)	OthDep n = 6471 (12%)	PsychRx n = 7040 (13%)	NonPsychRx n = 7966 (15%)	PsychOnly n = 6088 (12%)	NoDep n = 17 256 (33%)	*P* value	MDD vs NoDep: *P* value	MDD vs NoDep: Effect size
Payments, median (IQR)	6212 (2622, 12 462)	8590 (4059, 16 639)	7212 (3241, 14 217)	7669 (3596, 14 780)	6719 (3052, 12 944)	5543 (2202, 11 396)	4567 (1787, 9257)	**<.0001**	<.0001	0.574
Medication refills										
No. of refills, median (IQR)	28 (12, 49)	43 (21, 69)	35 (14, 58)	38 (22, 59)	36 (21, 54)	18 (4, 35)	17 (6, 33)	**<.0001**	<.0001	0.813
Payments, median (IQR)	2264 (528, 5281)	3541 (1044, 7663)	2659 (567, 5799)	3274 (1288, 6506)	3561 (1513, 6582)	1012 (71, 3408)	1333 (211, 3569)	**<.0001**	<.0001	0.562
Combined payments, median (IQR)	10 771 (4936, 22 496)	16 446 (7980, 33 700)	13 238 (6209, 27 522)	13 664 (6999, 26 871)	12 478 (6584, 23 753)	8738 (3627, 18 998)	7366 (3230, 15 142)	**<.0001**	<.0001	0.703
Payment: index + 1 yr, median (IQR)	55 576 (37 146, 87 734)	65 792 (42 081, 103 575)	61 332 (40 347, 96 493)	59 166 (40 559, 92 327)	55 526 (37 602, 86 530)	53 840 (35 667, 84 492)	49 265 (33 834, 77 161)	**<.0001**	<.0001	0.391
Postdischarge outcomes, 2 yr										
Reoperation										
Fusion, n (%)	4948 (9%)	978 (13%)	782 (12%)	808 (11%)	775 (10%)	541 (9%)	1064 (6%)	**<.0001**	<.0001	0.227
Decompression, n (%)	4529 (9%)	831 (11%)	691 (11%)	746 (11%)	708 (9%)	509 (8%)	1044 (6%)		<.0001	0.173
at least one of above, n (%)	6240 (12%)	1174 (15%)	968 (15%)	1027 (15%)	977 (12%)	686 (11%)	1408 (8%)	**<.0001**	<.0001	0.224
Hospital admissions										
Admitted, n (%)	15 358 (29%)	3119 (41%)	2423 (37%)	2298 (33%)	2230 (28%)	1726 (28%)	3562 (21%)	**<.0001**	<.0001	0.446
Payments, median (IQR)	0 (0, 7135)	0 (0, 17 864)	0 (0, 14 881)	0 (0, 10 521)	0 (0, 5571)	0 (0, 6478)	0 (0, 0)	**<.0001**	<.0001	0.448
Outpatient services										
No. of services, median (IQR)	98 (53, 167)	148 (87, 236)	121 (71, 195)	117 (69, 190)	97 (54, 155)	93 (51, 157)	70 (37, 122)	**<.0001**	<.0001	0.925
Payments, median (IQR)	12 179 (5679, 23 316)	17 727 (8770, 32 670)	14 560 (7121, 26 705)	15 594 (7720, 28 626)	12 982 (6585, 23 545)	10 834 (4908, 20 735)	8661 (3857, 16 615)	**<.0001**	<.0001	0.686
Medication refills										
No. of refills, median (IQR)	53 (22, 95)	85 (42, 137)	67 (28, 114)	74 (42, 116)	69 (40, 104)	34 (7, 68)	33 (11, 62)	**<.0001**	<.0001	0.863
Payments, median (IQR)	4538 (1114, 10 529)	7363 (2311, 15 608)	5292 (1259, 11 776)	6696 (2722, 13 006)	7056 (2987, 13 134)	1996 (194, 6719)	2595 (461, 7022)	**<.0001**	<.0001	0.609
Combined payments, median (IQR)	22 908 (10 332, 47 367)	36 730 (17 706, 70 474)	29 216 (13 687, 58 003)	30 133 (15 029, 57 058)	26 010 (13 615, 48 327)	19 031 (8166, 40 244)	14 701 (6527, 31 019)	**<.0001**	<.0001	0.797
Payment: index + 2 yr, median (IQR)	70 093 (46 051, 110 680)	87 229 (56 620, 138 028)	79 538 (52 232, 124 921)	77 766 (52 254, 119 238)	71 230 (48 091, 109 924)	66 403 (43 594, 103 952)	59 052 (39 881, 91 936)	**<.0001**	<.0001	0.564
Postdischarge outcomes, 5 yr										
Reoperation										
Fusion, n (%)	9160 (17%)	1784 (23%)	1442 (22%)	1492 (21%)	1431 (18%)	1035 (17%)	1976 (11%)	**<.0001**	<.0001	0.316
Decompression, n (%)	8767 (17%)	1644 (21%)	1363 (21%)	1460 (21%)	1325 (17%)	1003 (16%)	1972 (11%)	**<.0001**	<.0001	0.273
At least one of above, n (%)	11 347 (22%)	2139 (28%)	1749 (27%)	1861 (26%)	1753 (22%)	1287 (21%)	2558 (15%)	**<.0001**	<.0001	0.324

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TABLE 2. Continued

Variable	Total N = 52 480	Depression groups 60 mo postsurgery: MDD n = 7659 (15%)	OthDep n = 6471 (12%)	PsychRx n = 7040 (13%)	NonPsychRx n = 7966 (15%)	PsychOnly n = 6088 (12%)	NoDep n = 17 256 (33%)	*P* value	MDD vs NoDep: *P* value	MDD vs NoDep: Effect size
Hospital admissions										
Admitted, n (%)	26 312 (50%)	4934 (64%)	3938 (61%)	3931 (56%)	3859 (48%)	3158 (52%)	6492 (38%)	**<.0001**	<.0001	0.556
Payments, median (IQR)	205 (0, 34 295)	15 180 (0, 55 579)	11 908 (0, 49 536)	7826 (0, 42 371)	0 (0, 30 219)	4347 (0, 35 994)	0 (0, 18 241)	**<.0001**	<.0001	0.587
Outpatient services										
No. of services, median (IQR)	244 (137, 405)	373 (232, 583)	310 (190, 490)	296 (181, 466)	232 (136, 369)	238 (138, 389)	168 (91, 284)	**<.0001**	<.0001	1.092
Payments, median (IQR)	30 607 (15 236, 56 595)	45 956 (24 191, 81 793)	37 535 (19 653, 66 053)	40 455 (22 188, 70 656)	32 245 (17 070, 56 468)	27 884 (14 282, 51 936)	20 962 (10 243, 38 512)	**<.0001**	<.0001	0.815
Medication refills										
No. of refills, median (IQR)	132 (57, 231)	211 (110, 335)	167 (76, 277)	186 (109, 287)	164 (97, 246)	86 (23, 168)	79 (29, 148)	**<.0001**	<.0001	0.936
Payments, median (IQR)	11 206 (3089, 25 950)	18 436 (6336, 39 114)	13 037 (4027, 29 131)	16 707 (7240, 32 732)	16 734 (7425, 31 661)	5455 (720, 16 996)	6220 (1320, 16 576)	**<.0001**	<.0001	0.66
Combined payments, median (IQR)	63 044 (28 953, 122 260)	100 987 (51 087, 182 106)	80 739 (41 513, 147 064)	83 209 (44 073, 148 781)	68 051 (35 645, 121 626)	56 475 (25 765, 107 856)	38 657 (17 115, 78 337)	**<.0001**	<.0001	0.927
Payment: index + 5 yr, median (IQR)	112 157 (70 099, 181 619)	154 097 (96 234, 246 187)	135 213 (85 582, 208 956)	133 057 (85 584, 207 095)	115 417 (75 116, 180 056)	105 683 (67 852, 167 486)	86 161 (55 550, 136 193)	**<.0001**	<.0001	0.807

ER: emergency room; IQR: inter-quartile range; MDD: major depressive disorder; NoDep: no depression; NonPsychRx: antidepressants for nonpsychiatric condition; OthDep: other depression; PsychOnly: other psychiatric diagnosis only; PsychRx: antidepressants for other psychiatric condition.
EF: effect size, [(0-0 .01: trivial), (0.01-0 .2: very small), (0.2-0.5: small), (0.5-0.8: medium), (0.8-1.2: large), (1.2-2.0: very large), (>2.0: huge)].
Bold: significant.

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TABLE 3. Multivariate Regression Showing Outcome for all Patients With and Without Depression Who Underwent Spinal Fusion With 60 Months of Follow-up

	Depression groups 60 mo postsurgery					
Variable	**MDD n = 7659 (15%)**	**OthDep n = 6471 (12%)**	**PsychRx n = 7040 (13%)**	**NonPsychRx n = 7966 (15%)**	**PsychOnly n = 6088 (12%)**	**NoDep n = 17256 (33%)**
Index hospitalization outcomes						
Length of stay, RR (95% CI)	1.054 (1.022, 1.086)	1.043 (1.011, 1.077)	1.074 (1.041, 1.108)	1.082 (1.051, 1.115)	1.014 (0.981, 1.048)[a]	Reference
Payment, RR (95% CI)	1.039 (1.013, 1.065)	1.014 (0.988, 1.041)[a]	1.033 (1.007, 1.06)	1.025 (1, 1.051)	1.022 (0.995, 1.049)[a]	Reference
Discharge home, OR (95% CI)	0.812 (0.746, 0.884)	0.9 (0.822, 0.985)	0.812 (0.746, 0.884)	0.828 (0.765, 0.896)	0.943 (0.86, 1.035)[a]	Reference
Complications, OR (95% CI)	1.218 (1.085, 1.366)	1.158 (1.026, 1.306)	1.126 (0.997, 1.271)[a]	1.165 (1.039, 1.307)	1.05 (0.926, 1.19)[a]	Reference
Preindex outcomes, 1 yr						
Hospital admissions						
Admitted, OR (95% CI)	1.717 (1.565, 1.884)	1.547 (1.402, 1.707)	1.373 (1.245, 1.514)	1.302 (1.185, 1.432)	1.241 (1.116, 1.38)	Reference
Payments, RR (95% CI)	1.36 (1.171, 1.58)	1.424 (1.229, 1.649)	1.46 (1.26, 1.691)	1.765 (1.519, 2.052)	0.939 (0.776, 1.136)[a]	Reference
Outpatient services						
No. of services, RR (95% CI)	1.354 (1.329, 1.38)	1.198 (1.174, 1.221)	1.198 (1.176, 1.221)	1.097 (1.077, 1.117)	1.13 (1.108, 1.152)	Reference
Payments, RR (95% CI)	1.294 (1.257, 1.332)	1.175 (1.137, 1.214)	1.168 (1.133, 1.204)	1.128 (1.095, 1.162)	1.071 (1.032, 1.11)	Reference
Medication refills						
No. of refills, RR (95% CI)	1.593 (1.554, 1.633)	1.376 (1.341, 1.412)	1.473 (1.437, 1.51)	1.446 (1.413, 1.48)	0.989 (0.963, 1.015)[a]	Reference
Payments, RR (95% CI)	1.665 (1.604, 1.729)	1.395 (1.338, 1.455)	1.43 (1.375, 1.488)	1.429 (1.376, 1.484)	0.968 (0.914, 1.025)[a]	Reference
Combined payments, RR (95% CI)	1.41 (1.367, 1.454)	1.253 (1.211, 1.297)	1.237 (1.197, 1.278)	1.231 (1.192, 1.27)	1.068 (1.026, 1.112)	Reference
Payment: index + pre 1 yr, RR (95% CI)	1.124 (1.1, 1.148)	1.069 (1.045, 1.094)	1.081 (1.057, 1.105)	1.072 (1.049, 1.095)	1.035 (1.01, 1.06)	Reference
Postdischarge outcomes, 30 d						
Complications, OR (95% CI)	1.665 (1.48, 1.874)	1.489 (1.315, 1.687)	1.185 (1.04, 1.35)	1.149 (1.015, 1.3)	1.087 (0.947, 1.247)[a]	Reference
ER admission, OR (95% CI)	1.968 (1.741, 2.225)	1.721 (1.51, 1.961)	1.681 (1.472, 1.919)	1.148 (0.99, 1.33)[a]	1.472 (1.281, 1.691)	Reference
Postopioid use, 3-15 mo						
[1,9] vs 0, OR (95% CI)	1.692 (1.57, 1.824)	1.451 (1.344, 1.567)	1.828 (1.698, 1.968)	1.714 (1.604, 1.831)	1.091 (1.015, 1.173)	Reference
10 + vs 0, OR (95% CI)	4.902 (4.459, 5.388)	3.571 (3.235, 3.943)	4.305 (3.916, 4.732)	2.984 (2.723, 3.269)	1.741 (1.57, 1.931)	Reference
Postdischarge outcomes, 1 yr						
Reoperation						
Fusion, OR (95% CI)	2.164 (1.914, 2.447)	1.891 (1.658, 2.157)	1.738 (1.528, 1.977)	1.539 (1.355, 1.748)	1.451 (1.26, 1.671)	Reference
Decompression, OR (95% CI)	1.973 (1.731, 2.249)	1.941 (1.694, 2.224)	1.682 (1.47, 1.925)	1.501 (1.315, 1.715)	1.375 (1.187, 1.593)	Reference
At least one of above, OR (95% CI)	2.034 (1.822, 2.271)	1.924 (1.713, 2.16)	1.736 (1.549, 1.944)	1.503 (1.343, 1.682)	1.395 (1.231, 1.581)	Reference
Hospital admissions						
Admitted, OR (95% CI)	2.556 (2.372, 2.753)	2.103 (1.943, 2.275)	1.748 (1.615, 1.891)	1.407 (1.301, 1.521)	1.463 (1.344, 1.592)	Reference
Payments, RR (95% CI)	2.535 (2.259, 2.844)	2.188 (1.94, 2.469)	1.956 (1.727, 2.215)	1.561 (1.365, 1.785)	1.514 (1.318, 1.74)	Reference
Outpatient services						
No. of services, RR (95% CI)	1.68 (1.643, 1.719)	1.418 (1.385, 1.453)	1.441 (1.409, 1.474)	1.216 (1.19, 1.243)	1.219 (1.19, 1.248)	Reference
Payments, RR (95% CI)	1.774 (1.705, 1.846)	1.512 (1.447, 1.58)	1.547 (1.484, 1.613)	1.281 (1.227, 1.338)	1.248 (1.187, 1.311)	Reference
Medication refills						
No. of refills, RR (95% CI)	1.873 (1.824, 1.923)	1.563 (1.52, 1.606)	1.695 (1.651, 1.74)	1.585 (1.546, 1.625)	1.012 (0.984, 1.04)[a]	Reference
Payments, RR (95% CI)	1.85 (1.779, 1.924)	1.503 (1.438, 1.571)	1.558 (1.494, 1.623)	1.515 (1.455, 1.578)	0.988 (0.929, 1.051)[a]	Reference
Combined payments, RR (95% CI)	1.977 (1.891, 2.066)	1.672 (1.594, 1.755)	1.643 (1.567, 1.722)	1.406 (1.339, 1.476)	1.259 (1.188, 1.333)	Reference
Payment: index + 1 yr, RR (95% CI)	1.244 (1.216, 1.274)	1.16 (1.131, 1.189)	1.17 (1.142, 1.199)	1.108 (1.082, 1.135)	1.075 (1.046, 1.104)	Reference
Postdischarge outcomes, 2 yr						
Reoperation						
Fusion, OR (95% CI)	2.07 (1.88, 2.28)	1.97 (1.781, 2.18)	1.825 (1.654, 2.015)	1.526 (1.383, 1.684)	1.456 (1.305, 1.624)	Reference
Decompression, OR (95% CI)	1.932 (1.747, 2.136)	1.883 (1.695, 2.091)	1.83 (1.653, 2.025)	1.498 (1.354, 1.658)	1.399 (1.25, 1.565)	Reference
At least one of above, OR (95% CI)	1.997 (1.83, 2.179)	1.953 (1.783, 2.139)	1.848 (1.692, 2.019)	1.509 (1.382, 1.648)	1.417 (1.285, 1.563)	Reference

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TABLE 3. Continued

Variable	Depression groups 60 mo postsurgery					
	MDD n = 7659 (15%)	OthDep n = 6471 (12%)	PsychRx n = 7040 (13%)	NonPsychRx n = 7966 (15%)	PsychOnly n = 6088 (12%)	NoDep n = 17 256 (33%)
Hospital admissions						
Admitted, OR (95% CI)	2.604 (2.445, 2.775)	2.192 (2.051, 2.342)	1.843 (1.726, 1.967)	1.419 (1.332, 1.513)	1.487 (1.387, 1.594)	Reference
Payments, RR (95% CI)	2.277 (2.084, 2.488)	2.057 (1.876, 2.257)	1.957 (1.781, 2.151)	1.409 (1.267, 1.568)	1.474 (1.325, 1.639)	Reference
Outpatient services						
No. of services, RR (95% CI)	1.817 (1.779, 1.857)	1.511 (1.478, 1.546)	1.534 (1.501, 1.567)	1.247 (1.222, 1.273)	1.268 (1.239, 1.296)	Reference
Payments, RR (95% CI)	1.905 (1.835, 1.978)	1.583 (1.518, 1.651)	1.638 (1.574, 1.704)	1.311 (1.258, 1.367)	1.281 (1.221, 1.345)	Reference
Medication refills						
No. of refills, RR (95% CI)	1.986 (1.933, 2.041)	1.63 (1.584, 1.677)	1.778 (1.731, 1.827)	1.612 (1.571, 1.653)	1.036 (1.007, 1.066)	Reference
Payments, RR (95% CI)	1.921 (1.846, 1.998)	1.546 (1.479, 1.617)	1.61 (1.544, 1.679)	1.533 (1.471, 1.597)	0.993 (0.933, 1.057)[a]	Reference
Combined payments, RR (95% CI)	2.01 (1.935, 2.088)	1.695 (1.626, 1.767)	1.705 (1.637, 1.775)	1.393 (1.335, 1.453)	1.267 (1.206, 1.332)	Reference
Payment: index + 2 yr, RR (95% CI)	1.383 (1.351, 1.415)	1.258 (1.226, 1.29)	1.274 (1.244, 1.306)	1.153 (1.124, 1.182)	1.112 (1.082, 1.144)	Reference
Postdischarge outcomes, 5 yr						
Reoperation						
Fusion, OR (95% CI)	2.226 (2.066, 2.399)	2.121 (1.962, 2.294)	1.951 (1.808, 2.105)	1.575 (1.46, 1.698)	1.589 (1.462, 1.727)	Reference
Decompression, OR (95% CI)	2.173 (2.014, 2.344)	2.107 (1.946, 2.28)	2.01 (1.862, 2.17)	1.505 (1.394, 1.626)	1.544 (1.42, 1.679)	Reference
A least one of above, OR (95% CI)	2.215 (2.067, 2.373)	2.127 (1.979, 2.286)	1.998 (1.864, 2.142)	1.544 (1.441, 1.655)	1.561 (1.447, 1.684)	Reference
Hospital admissions						
Admitted, OR (95% CI)	3.229 (3.037, 3.433)	2.627 (2.465, 2.799)	2.22 (2.089, 2.358)	1.489 (1.406, 1.576)	1.86 (1.747, 1.981)	Reference
Payments, RR (95% CI)	2.319 (2.177, 2.47)	2.058 (1.927, 2.199)	1.922 (1.797, 2.057)	1.353 (1.252, 1.462)	1.541 (1.43, 1.66)	Reference
Outpatient services						
No. of services, RR (95% CI)	1.965 (1.926, 2.005)	1.63 (1.596, 1.665)	1.64 (1.608, 1.674)	1.261 (1.237, 1.285)	1.362 (1.334, 1.391)	Reference
Payments, RR (95% CI)	2.015 (1.943, 2.089)	1.639 (1.574, 1.708)	1.709 (1.644, 1.775)	1.317 (1.263, 1.372)	1.37 (1.309, 1.434)	Reference
Medication refills						
No. of refills, RR (95% CI)	2.126 (2.068, 2.185)	1.732 (1.683, 1.782)	1.894 (1.843, 1.947)	1.626 (1.585, 1.668)	1.088 (1.058, 1.119)	Reference
Payments, RR (95% CI)	2.017 (1.935, 2.103)	1.579 (1.506, 1.656)	1.657 (1.585, 1.732)	1.524 (1.459, 1.593)	1.059 (0.994, 1.129)[a]	Reference
Combined payments, RR (95% CI)	2.099 (2.03, 2.169)	1.733 (1.671, 1.797)	1.758 (1.698, 1.821)	1.376 (1.325, 1.429)	1.35 (1.294, 1.408)	Reference
Payment: index + 5 yr, RR (95% CI)	1.651 (1.611, 1.691)	1.431 (1.393, 1.469)	1.453 (1.417, 1.491)	1.227 (1.195, 1.26)	1.216 (1.18, 1.252)	Reference

ER: emergency room; MDD: major depressive disorder; NoDep: no depression; NonPsychRx: antidepressants for nonpsychiatric condition; OthDep: other depression; PsychOnly: other psychiatric diagnosis only; PsychRx: antidepressants for other psychiatric condition.

[a]Not significant.

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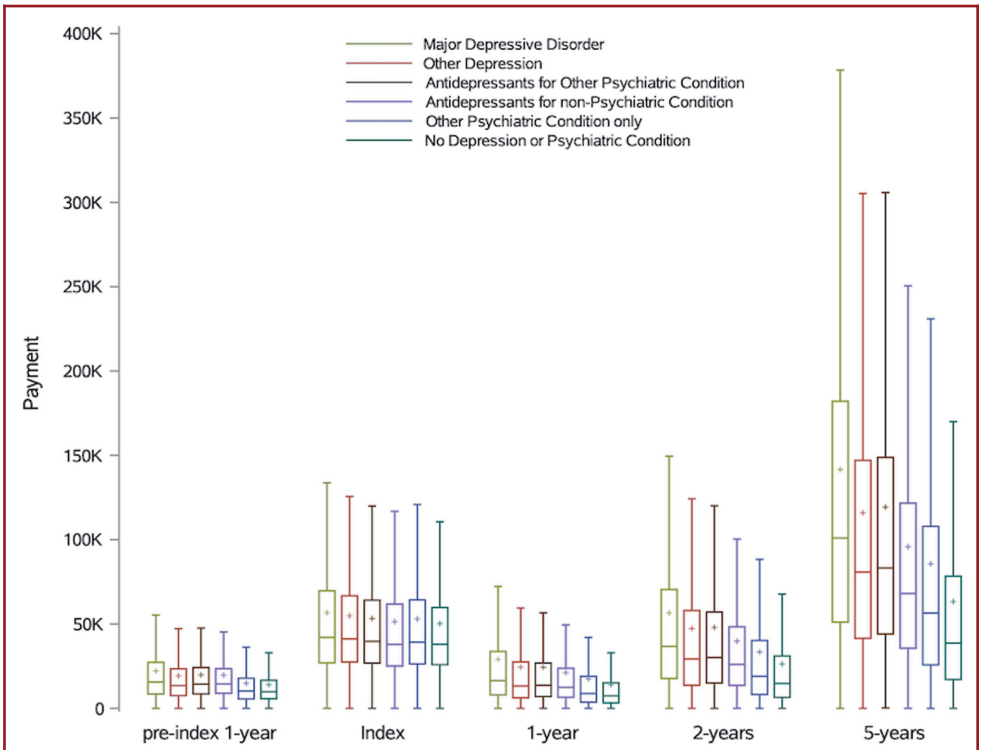

FIGURE 1. *Box plots comparing the total payments utilized by different groups at 1, 2, and 5 yr after surgery.*

TABLE 4. Showing Presurgery and Postsurgery Changes in Patients With Depression and Who Underwent Surgery

		Postdepression (within 60 mo)					
		MDD	OthDep	PsychRx	NonPsychRx	PsychOnly	NoDep
Prior depression (within 24 mo)		n = 7659	n = 6471	n = 7040	n = 7966	n = 6088	n = 17 256
MDD	n = 3223	68.35%	11.23%	8.84%	5.74%	3.01%	2.82%
OthDep	n = 3228	32.62%	35.32%	12.17%	9.39%	5.45%	5.05%
PsychRx	n = 4097	25.97%	20.01%	29.00%	13.23%	6.39%	5.39%
NonPsychRx	n = 11 080	14.12%	16.71%	20.59%	33.07%	3.94%	11.56%
PsychOnly	n = 4305	12.75%	14.56%	15.05%	5.53%	30.17%	21.93%
NoDep	n = 26 547	4.61%	6.29%	8.46%	11.43%	14.38%	54.83%

CHF: congestive heart failure; COPD: chronic obstructive pulmonary disease; IQR: inter-quartile range; MDD: major depressive disorder; NoDep: no depression; NonPsychRx: antidepressants for nonpsychiatric condition; OthDep: other depression; PsychOnly: other psychiatric diagnosis only; PsychRx: antidepressants for other psychiatric condition.

NonPsychRx (14%), and PsychOnly (13%) and considerably higher than rate for NoDep (5%).

DISCUSSION

Summary Key Results

Depressive phenotypes showed significant associations with poorer outcome and adverse health resource utilization. Among the cohorts, MDD incurred highest preoperative and postoperative health care utilization followed by OtherDep, PsychRx, NonPsychRx, PsychOnly, and NoDep cohorts. Similar pattern was noted in terms of postoperative complications, reoperation rates, and opioid utilization among the cohorts with MDD showing worst and NoDep most favorable outcomes. Postoperative opioid usage rates remained unchanged in MDD and OthDep, and reduced in PsychRx, NonPsychRx, and PsychOnly with greatest reduction in NoDep. Reoperation rates at 1, 2, and

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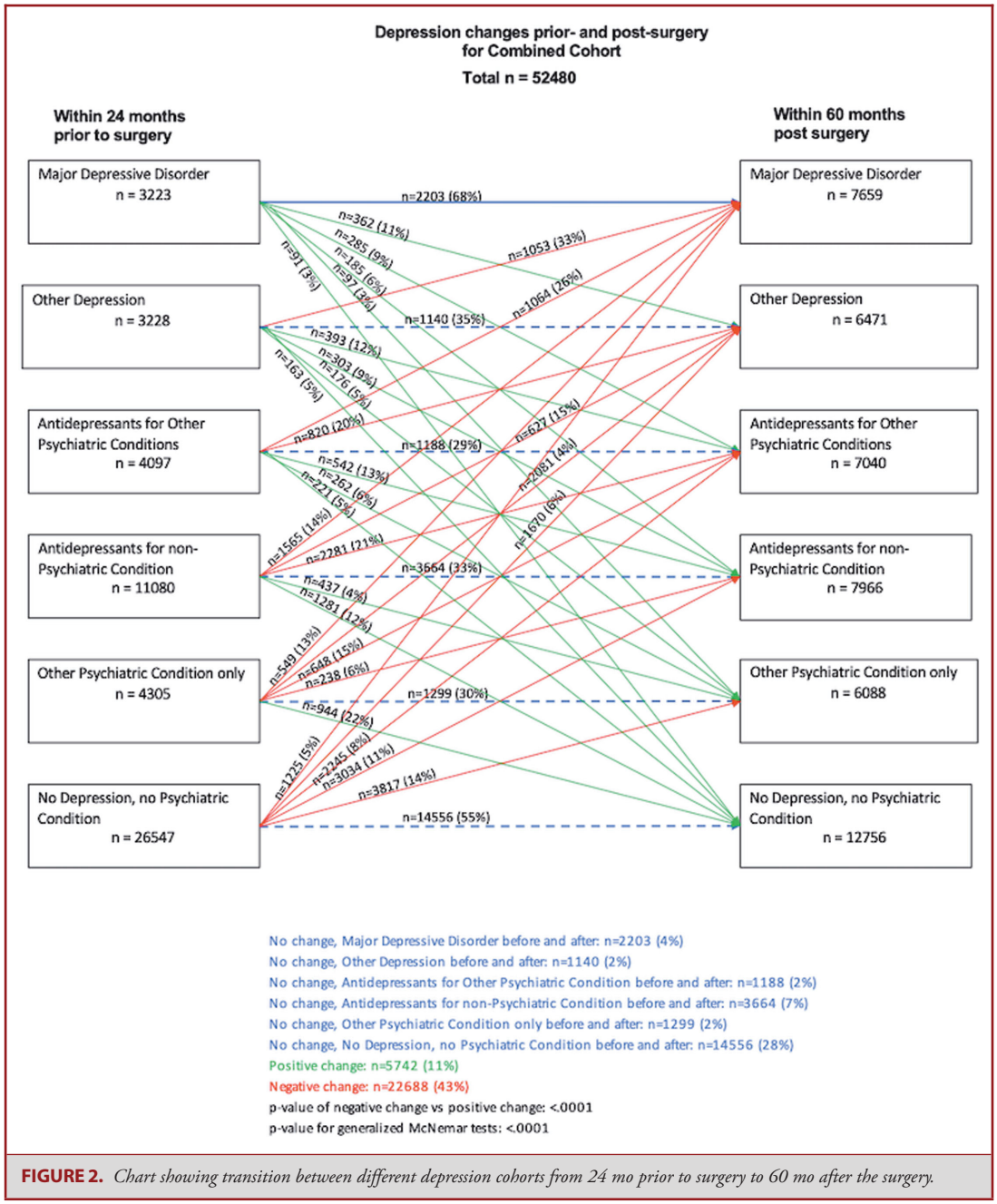

FIGURE 2. *Chart showing transition between different depression cohorts from 24 mo prior to surgery to 60 mo after the surgery.*

5 yr were highest in MDD cohort followed by OthDep, PsychRx, NonPsychRx, PsychOnly, and NoDep cohorts.

Identifying Depression Cohorts and Their Impact on Spine Surgery

MDD phenotype was highest in outpatient services utilization and payments from 1 to 5 yr postsurgery. Although previous spine surgery studies have evaluated the impact of depression on outcomes using ICD-9 defined cohorts, none have segregated the cohorts into these phenotypes.[8,9,14,16,17,27-30] Prior studies combined the MDD and OthDep phenotypes. From our results, MDD group had higher risks than OthDep group in most categories [except reoperations at 1 yr (9% each) and 2 yr (15% each)]. PsychRx phenotype (11%), ie, patients on multiple antidepressant medications without prior ICD 9/10 diagnoses of depression, also had very high risks of adverse outcomes

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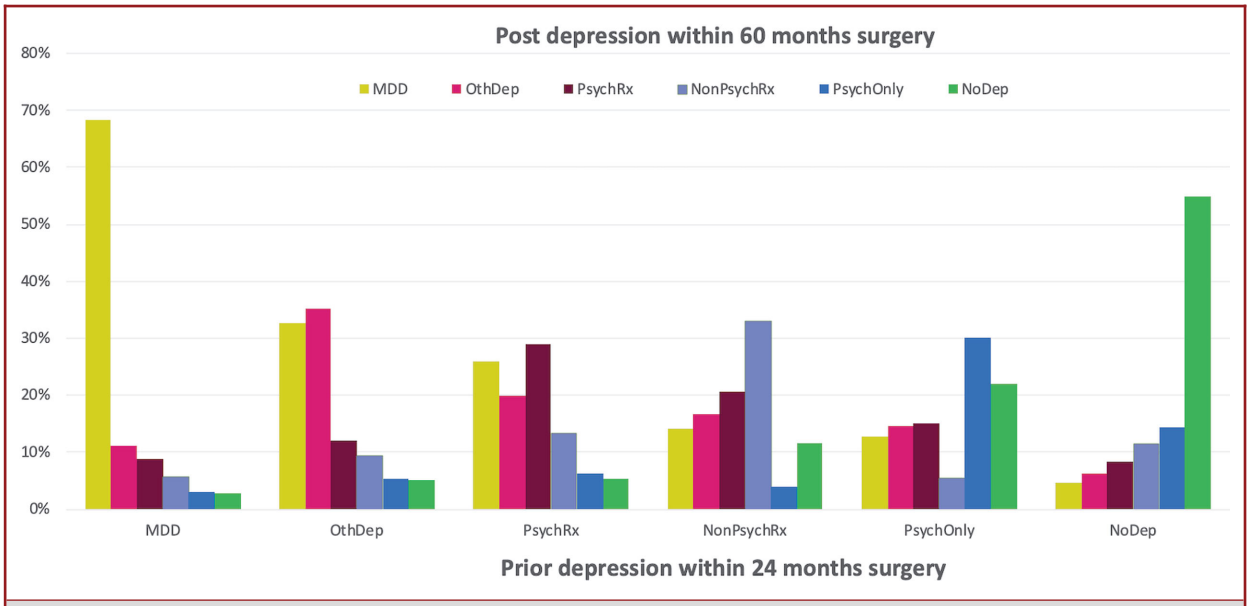

FIGURE 3. *Bar graph showing distribution of different depression cohorts 60 mo after the surgery compared to 24 mo prior to surgery.*

including approximately 4-fold increased risk of chronic opioid use. Compared to NoDep cohort, patients in PsychRx cohort incurred higher health care utilization and reoperation rates at 1, 2, and 5 yr following spine surgeries. Patients in PsychRx cohort were 1.8 and 1.9 times likely to have reoperations at 2 and 5 yr respectively compared to NoDep cohort. Patients with history of nondepressive mental illness but not on antidepressants (PsychOnly) also had increased risks but to much lower extent than MDD or other phenotypes.

Incidence of New Depression

Patients with spinal disorders are at risk for mental health disorders.[26-30] In our study, 67% of patients undergoing spine fusion for degenerative disorders had at least one of these phenotypes. New depression rates of 5% to 6% postspine surgery have been reported in patients without prior diagnosis of depression.[26,27] Wilson et al[28] reported new depression rate of 5.1%; they showed that patients who underwent spine surgery had an adjusted hazard ratio for new depression of 5.5, which was higher than after coronary artery bypass grafting (2.33), hysterectomy (3.04), cholecystectomy (2.51), congestive heart failure (2.44), and chronic obstructive pulmonary disease exacerbation (3.04).[27] Bekeris et al[29] reported overall incidence of new depression of 6% within 6 mo postspine surgery. We found that patients with no depression developed new MDD at rate of 5% and new OthDep at rate of 6%, an 11% combined MDD/OthDep rate that is higher than reported in prior studies. The Bekeris study had 6-mo follow-up, whereas our study had 5-yr follow-up. The Wilson study had 5-yr follow-up; however, their cohort differed from ours; they used only ICD 9 codes and included decompression cases and other pathologies such as neoplasia, whereas we used both ICD 9/10 and restricted ours to spinal fusion cases for degenerative disorders. We note that 45% of patients with no prior antidepressant use, depression, or mental health diagnoses in the year presurgery developed one of the other phenotypes postspine surgery. Interestingly, other phenotypes had greater rates of developing a MDD episode within 5 yr postspine surgery: OthDep (33%), PsychRx (26%), NonPsychRx (14%), PsychOnly (13%) compared to Nodep (5%).

Implications for Practice

Results presented here provide increased granularity to assess effects of the described depression phenotypes in spine surgery. These results can be used to evaluate and triage patients beyond "depression vs no depression" or "using antidepressants vs not using antidepressants" during preoperative evaluation using different phenotypes to optimize clinical outcomes. We found that patients with the diagnosis of MDD followed by OtherDep, PsychRx, NonPsychRx, and PsychOnly are likely to have worse clinical outcomes with higher health care utilization following spine surgeries compared to those with NoDep diagnosis. Therefore, this risk stratification strategy can be used to identify high-risk patients prior to spine surgeries.

Limitations

This database study relies on accuracy of ICD codes for depression. Although use of ICD-9 codes for identifying depressive cohorts has been validated, we cannot exclude some residual errors due to inaccurate coding.[45] We had no access to depression questionnaires and therefore could not evaluate them.

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Utilizing the database, opioid use was evaluated by prescription information, not based on actual documented patient ingestion.

CONCLUSION

Use of a novel EHR classification of depression allowed for a more granular analysis of 6 depression phenotypes on complication rates, reoperation rates, health resource utilization, chronic opioid use, and incidence of new depression. Patients with the diagnosis of MDD followed by OtherDep, PsychRx, NonPsychRx, and PsychOnly cohorts are likely to have worse clinical outcomes with higher health care utilization following spine surgeries compared to those with NoDep diagnosis. The findings of our study can be integrated in routine clinical practice to triage patients with depression to optimize clinical and health care utilization. Our results also emphasize the importance of detailed clinical history to elucidate these depression phenotypes instead of binary classification of depression vs no depression.

Funding

This study did not receive any funding or financial support.

Disclosures

The authors have no personal, financial, or institutional interest in any of the drugs, materials, or devices described in this article. Dr Boakye was supported by Ole A., Mabel Wise & Wilma Wise Nelson Endowment.

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Supplementary digital content. Showing ICD-9/ICD-10 and current procedural terminology codes for patient selection and depression grouping.

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