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Original Article

Risk and economic burden of surgical site infection following spinal fusion in adults

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Abstract

Background: Spinal fusion surgery (SFS) is one of the most common operations in the United States, >450,000 SFSs are performed annually, incurring annual costs >$10 billion.

Objectives: We used a nationwide longitudinal database to accurately assess incidence and payments associated with management of postoperative infection following SFS.

Methods: We conducted a retrospective, observational cohort analysis of 210,019 patients undergoing SFS from 2014 to 2018 using IBM MarketScan commercial and Medicaid–Medicare databases. We assessed rates of superficial/deep incisional SSIs, from 3 to 180 days after surgery using Cox proportional hazard regression models. To evaluate adjusted payments for patients with/without SSIs, adjusted for inflation to 2019 Consumer Price Index, we used generalized linear regression models with log-link and γ distribution.

Results: Overall, 6.6% of patients experienced an SSI, 1.7% superficial SSIs and 4.9% deep-incisional SSIs, with a median of 44 days to presentation for superficial SSIs and 28 days for deep-incisional SSIs. Selective risk factors included surgical approach, admission type, payer, and higher comorbidity score. Postoperative incremental commercial payments for patients with superficial SSI were $20,800 at 6 months, $26,937 at 12 months, and $32,821 at 24 months; incremental payments for patients with deep-incisional SSI were $59,766 at 6 months, $74,875 at 12 months, and $93,741 at 24 months. Corresponding incremental Medicare payments for patients with superficial incisional at 6, 12, 24-months were $11,044, $17,967, and $24,096; while payments for patients with deep-infection were: $48,662, $53,757, and $73,803 at 6, 12, 24-months.

Conclusions: We identified a 4.9% rate of deep infection following SFS, with substantial payer burden. The findings suggest that the implementation of robust evidence-based surgical-care bundles to mitigate postoperative SFS infection is warranted.

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In the United States, spinal surgery is one of the most common procedures, with >1 million performed annually, of which >450,000 are spinal fusion surgeries (SFSs).[1,2] Given their frequency, these procedures place a substantial economic burden on the healthcare system, with annual costs estimated to exceed $10 billion for lumbar fusion alone.[3] The risk of surgical site infection (SSI) presents a further burden on healthcare resources.[4–6] Several factors may contribute to this risk, including patient characteristics (eg, obesity, smoking status, and diabetes) and surgical factors (eg, length of operative procedure, type of surgical approach and anaesthesia).[6–8]

SSIs after spinal procedures are reported to range between 0.2% and 16%.[6] For lumbar fusion in the Medicare population, the rate of SSI in instrumented patients was reported as 8.5% in primary fusions and 12.2% in revisions over 10 years.[9] The American College of Surgeons' NSQIP database study of 90,551 patients following spinal surgery including fusion and decompression procedures showed a 1.4% SSI rate within 30 days.[10] In a meta-analysis of 27 studies (22,745 patients) the pooled incidence of SSI after spinal procedures was 3.1%, of which 1.4% were superficial SSIs and 1.7% were deep-incisional SSIs.[11] The financial burden that follows each SSI after spinal surgery has been previously reported to be as much as $25,962 per episode from the provider or payer perspective.[1,12,13] These costs contribute to the larger overall cost burden of SSIs to the US healthcare system, which has been estimated to range from $3 to $10 billion annually.[1,14]

Although an important consideration for patient care, the use of infection prevention care bundles has not been widely reported nor used for spinal operative procedures.[15] Infection prevention bundles have been developed to mitigate the risk of SSI after any surgical procedure. Components of these level 1A, evidence-based

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care bundles, advocated by many national and international guidelines, include preoperative, intraoperative, and postoperative interventions such as staphylococcal decolonization for high-risk surgical procedures, appropriate antibiotic prophylaxis, antiseptic skin preparation, hair removal when required using single-use clippers, and maintenance of normothermia and glycose levels.[16–20] The use of wound-closure methods, such as the use of antimicrobial sutures and postoperative dressings, particularly the use of negative-pressure devices, has also been shown to reduce the risk of SSI. Robust evidence has emerged from Systematic Reviews and Meta-analysis (SRandM),[21–25] which may be relevant and needs further research. Few studies have evaluated these selective practices in spinal surgery.[4] In spinal operative procedures, the use of antimicrobial sutures provides significant cost benefits and is a useful adjunct to the evidence-based infection prevention care bundle for spinal surgery.[26]

In the current analysis, we assessed the true incidence and real-world payments associated with SSIs following SFS procedures using a US nationwide longitudinal database.

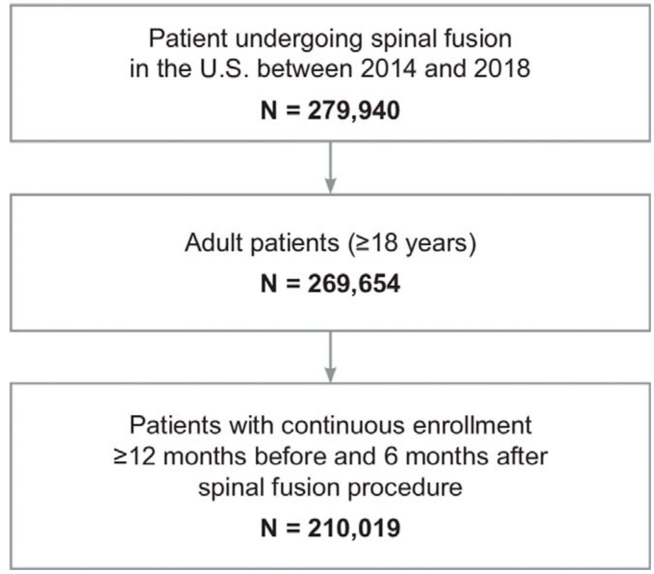

Fig. 1. Sample selection for patients undergoing spinal fusion surgery.

Materials and methods

Database analysis

This retrospective observational cohort analysis included the SFSs performed in the United States on adult patients (≥18 years) from 2014 to 2018 and captured in the IBM MarketScan commercial, and Medicaid–Medicare supplemental databases. The IBM MarketScan commercial, Medicare, and Medicaid databases contain deidentified patient data sets, and patients cannot be identified, directly or through identifiers linked to the patients. Therefore, this study was exempt from institutional review. Meeting these conditions makes this research exempt from the requirements of 45 CFR 46.101 under the Department of Health and Human Services.[27] The database contains anonymized medical records with payment information for 39.7 million individuals with data on diagnosis, procedures, hospital stays, and physician office visits. SFSs were defined as the index procedure using the *International Classification of Diseases, 9th* and *10th Revisions, Clinical Modification* (ICD-9-CM and ICD-10-CM) procedure codes and current procedural terminology (CPT) codes (Supplementary Table 1 online). Continuous enrollment for ≥12 months before and 6 months after each spinal fusion procedure was required for each patient. The Elixhauser comorbidity measure with 31 domains was used to understand clinical comorbidities.[27] The Charlson comorbidity index was used to determine overall comorbidity scores.

In this analysis, we evaluated 3 outcomes: (1) the incidence of superficial incisional SSIs and deep-incisional SSIs (using diagnostic codes) identified from postoperative day 3 to day 180; (2) risk factors associated with deep incisional SSIs; and (3) infection-associated payments by payer type (both commercial and Medicaid–Medicare patient populations) over a 24-month follow-up period.

SSIs identified within the first 48 hours after surgery were not tracked because they likely represented infections present on admission (POA). The period from the index operative procedure to identified SSIs was recorded. The diagnostic codes used to inform superficial incisional SSIs and deep-incisional SSIs are presented in Supplementary Table 2 and Supplementary Table 3 (online). If a patient had a diagnosis for both a deep-incisional SSI and a superficial incisional SSI over the 180 postoperative days, then the patient was categorized to have deep-incisional SSI.

Total healthcare costs in patients with no infection, superficial incisional SSI, and deep-incisional SSI, and marginal cost increases in patients with superficial incisional SSI and deep-incisional SSI are presented in Supplementary Table 4 (online). Variables associated with deep-incisional SSI were identified using the multivariable Cox proportional hazards model. Total incremental payments from index procedure to 6-, 12-, and 24-months follow-up after SFSs were calculated. The total payments included direct medical (inpatient and outpatient) and prescription drug payments. Generalized linear regression models with log-link and γ distribution were used to evaluate the adjusted total payments for patients with and without an SSI. The adjusted incremental payment for each infection was calculated using least-squares means over 24 months after the index procedure. All payments were inflated to the 2019 Consumer Price Index. Regression analyses were conducted using SAS version 9.0 software (SAS Institute, Cary, NC).

Results

In total, 210,019 patients undergoing SFSs between 2014 and 2018 were included in the analysis (Fig. 1). Demographic characteristics of patients at time of index surgery are shown in Table 1a. Most were female (55.1%), and 35.1% of the patients were between 55 and 64 years of age at the time of the SFS. Approximately one-half of the patients (49.1%) received anterior procedures for SFS. In total, 13,813 patients (6.6%) experienced an SSI, of which 10,296 (4.9%) were deep-incisional SSIs and 3,517 (1.7%) were superficial incisional SSIs. As shown in Table 1b, emergency spinal fusions were associated with an overall 2-fold higher risk of infection (13.8%) than nonemergent procedures (6.4%), and a greater number of deep-incisional SSIs (11.7%) and superficial incisional SSIs (2.1%) than elective cases. Additionally, surgical approach influenced the risk of SSI; posterior procedures had a higher rate than anterior procedures for deep-incisional SSI (8.1% vs 2.9%) and superficial incisional SSI (2.2% vs 1.3%). The median postoperative time to infection was 44 days for superficial SSI and 28 days for deep-incisional SSI (Fig. 2). A summary of patient baseline comorbidities relative to SSI numbers at 6 months is summarized in Table 2.

Table 1a. Patient Demographics at Time of Index Spinal Fusion Surgery

Demographics Characteristics	No.	%
Overall	210,019	100.0
Sex		
Male	94,241	44.9
Female	115,778	55.1
Year		
2014	57,114	27.2
2015	45,558	21.7
2016	42,199	20.1
2017	35,647	17.0
2018	29,501	14.0
Age, y		
18–24	3,241	1.5
25–34	8,114	3.9
35–44	29,707	14.1
45–54	61,019	29.1
55–64	73,717	35.1
65–74	23,510	11.2
75+	10,711	5.1
Site of care		
Outpatient	35,513	16.9
Inpatient	174,506	83.1
Admission type		
Nonemergency	203,916	97.1
Emergency	6,103	2.9
Surgical approach		
Anterior	103,187	49.1
Anterior and posterior	11,544	5.5
Anterior and posterior and posterior interbody	846	0.4
Anterior and posterior interbody	1,023	0.5
Posterior	56,034	26.7
Posterior and posterior interbody	6,474	3.1
Posterior interbody	25,360	12.1
Unknown	5,551	2.6
Database indicator		
Commercial	137,815	65.6
Medicaid	41,974	20.0
Medicare	30,230	14.4
Continuous enrollment		
1 month	162,294	77.2
24 months	97,153	46.2

Our regression analysis of patient risk factors associated with deep-incisional SSI identified several significant factors. The 10 greatest risk factors were (1) type of surgical approach, posterior versus anterior (hazards ratio [HR], 2.3; 95% confidence interval [CI], 2.2–2.5); (2) anterior and posterior and posterior interbody versus anterior (HR, 2.3; 95% CI, 1.7–3.0); (3) anterior and posterior versus anterior (HR, 2.3; 95% CI, 2.1–2.4); (4) posterior and posterior interbody versus anterior (HR, 2.1; 95% CI, 1.9–2.3); (5) anterior and posterior interbody versus anterior (HR, 1.7; 95% CI, 1.3–2.2); (6) posterior interbody vs anterior (HR, 1.7; 95% CI, 1.5–1.8), (7) emergency versus nonemergency admission type (HR, 2.2; 95% CI, 2.1–2.4); (8) Medicaid versus commercial payer (HR, 1.8; 95% CI, 1.7–1.9) or Medicare vs commercial (HR, 1.6; 95% CI, 1.5–1.8), (9) higher Charlson comorbidity score of 5+ versus 0 (HR, 1.5; 95% CI, 1.3–1.8), score of 4–5 versus 0 (HR, 1.5; 95% CI, 1.3–1.7), score of 2–3 versus 0 (HR, 1.5; 95% CI, 1.4–1.6), and score 1 versus 0 (HR, 1.3; 95% CI, 1.2–1.4); and (10) comorbid conditions like fluid and electrolyte disorders (HR, 1.5; 95% CI, 1.5–1.6), metastatic cancer (HR, 1.5; 95% CI, 1.3–1.8), drug abuse (HR, 1.4; 95% CI, 1.3–1.5), pulmonary circulation disorders (HR, 1.3; 95% CI, 1.2–1.4), diabetes (HR, 1.3; 95% CI, 1.2-1.4), and other neurological disorders (HR, 1.2; 95% CI, 1.2–1.3) (Fig. 3).

For the commercially insured patients, after adjusting for patient demographic and clinical characteristics, the incremental payments for patients with superficial incisional SSIs were $20,800 at 6 months, $26,937 at 12 months, and $32,821 at 24 months after the index surgery. The adjusted incremental payments for patients with deep-incisional SSIs were $59,766 at 6 months, $74,875 at 12 months, and $93,741 at 24 months. For the Medicare patient population, the incremental payments for patients with superficial incisional SSIs were $11,044 at 6 months, $17,967 at 12 months, and $24,096 at 24 months after the index surgery. The adjusted incremental payments for patients with deep-incisional SSIs were $48,662 at 6 months, $53,757 at 12 months, and $73,803 at 24 months. Across the study time horizon, superficial incisional SSIs were associated with the lowest payments, whereas overall payments were consistently higher for the commercially insured patient population (Table 3).

Discussion

Overview of longitudinal database findings

This study is the first to present a large cohort of spinal fusion surgical patients for whom complete data have been collected prospectively, although analyzed retrospectively. In the current analysis, we used large longitudinal commercial, multistate Medicare and Medicaid databases (1) to determine the true incidence of SSI, together with comorbid risk factors and (2) to determine the real-world financial burden to payers from SSIs after spinal fusion surgeries. This study differed from prior analyses because we relied on patient-level claims data and did not use surrogate data based on hospital episode statistics. Such data can seriously underestimate the incidence and payments because these data only capture inpatient episodes and hospital-based care. Also, both the CDC-NHSN and American College of Surgeons NSQIP surveillance criteria are used to benchmark infection rates at 30 days. In device-related infections, which are often biofilm mediated, microbial growth occurs over days, weeks, and months, followed by dispersion into the adjacent tissues. Under these conditions, it is not unusual to document a superficial surgical site infection beyond 30 days.[28] Finally, an economic analysis of this type has policy implications and is helpful in facilitating evidence-based decision making.

The use of the cohort records from the IBM MarketScan commercial and Medicaid-Medicare supplemental databases in this study highlights the payer cost of SSI following SFS to US payers. In the studied population of >200,000 patients, the risk of SSI 6 months postoperatively was 6.6%; of these, 75% were deep-

Table 1b. Patient Demographics at Time of Index Spinal Fusion Surgery by Infection Type

	Overall SSI		Deep Incisional SSI		Superficial Incisional SSI		No Infection	
Variable	No.	%	No.	%	No.	%	No.	%
Overall	13,813	6.6	10,296	4.9	3,517	1.7	196,206	93.4
Sex								
Male	6,131	6.5	4,717	5.0	1,414	1.5	88,110	93.5
Female	7,682	6.6	5,579	4.8	2,103	1.8	108,096	93.4
Year								
2014	3,829	6.7	2,686	4.7	1,143	2.0	53,285	93.3
2015	3,162	6.9	2,314	5.1	848	1.9	42,396	93.1
2016	2,723	6.5	2,137	5.1	586	1.4	39,476	93.6
2017	2,398	6.7	1,887	5.3	511	1.4	33,249	93.3
2018	1,701	5.8	1,272	4.3	429	1.5	27,800	94.2
Age, y								
18–24	295	9.1	222	6.9	73	2.3	2,946	90.9
25–34	661	8.2	508	6.3	153	1.9	7,453	91.9
35–44	1,718	5.8	1,224	4.1	494	1.7	27,989	94.2
45–54	3,468	5.7	2,527	4.1	941	1.5	57,551	94.3
55–64	4,676	6.3	3,493	4.7	1,183	1.6	69,041	93.7
65–74	1,948	8.3	1,489	6.3	459	2.0	21,562	91.7
75+	1,047	9.8	833	7.8	214	2.0	9,664	90.2
Site of care								
Outpatient	1,185	3.3	756	2.1	429	1.2	34,328	96.7
Inpatient	12,628	7.2	9,540	5.5	3,088	1.8	161,878	92.8
Admission type								
Nonemergency	12,973	6.4	9,582	4.7	3,391	1.7	190,943	93.6
Emergency	840	13.8	714	11.7	126	2.1	5,263	86.2
Surgical approach								
Anterior	4,320	4.2	2,963	2.9	1,357	1.3	98,867	95.8
Anterior and posterior	972	8.4	731	6.3	241	2.1	10,572	91.6
Anterior and posterior and posterior interbody	69	8.2	51	6.0	18	2.1	777	91.8
Anterior and posterior interbody	64	6.3	51	5.0	13	1.3	959	93.7
Posterior	5,769	10.3	4,556	8.1	1,213	2.2	50,265	89.7
Posterior and posterior interbody	526	8.1	384	5.9	142	2.2	5,948	91.9
Posterior interbody	1,655	6.5	1,223	4.8	432	1.7	23,705	93.5
Unknown	438	7.9	337	6.1	101	1.8	5,113	92.1
Database indicator								
Commercial	6,739	4.9	4,806	3.5	1,933	1.4	131,076	95.1
Medicaid	4,495	10.7	3,496	8.3	999	2.4	37,479	89.3
Medicare	2,579	8.5	1,994	6.6	585	1.9	27,651	91.5

incisional SSIs. The surgical approach was associated with higher risk of deep incisional SSI. Specifically, the posterior approach showed a 2-fold higher risk of deep-incisional SSI compared with the anterior approach. Also, emergent procedures similarly documented a higher risk of SSI compared with elective procedures. The costs of treating SSIs in the commercial and Medicare patient populations were substantial and continued to increase over a 24-month postoperative period of follow-up. The cost of treating deep incisional SSIs ranged from $48,662 to $93,741, whereas the cost for superficial incisional SSIs ranged from $11,044 to $32,821.

The rationale to include 12- and 24-months of follow-up is to document that the fiscal burden to payers is not limited to the first

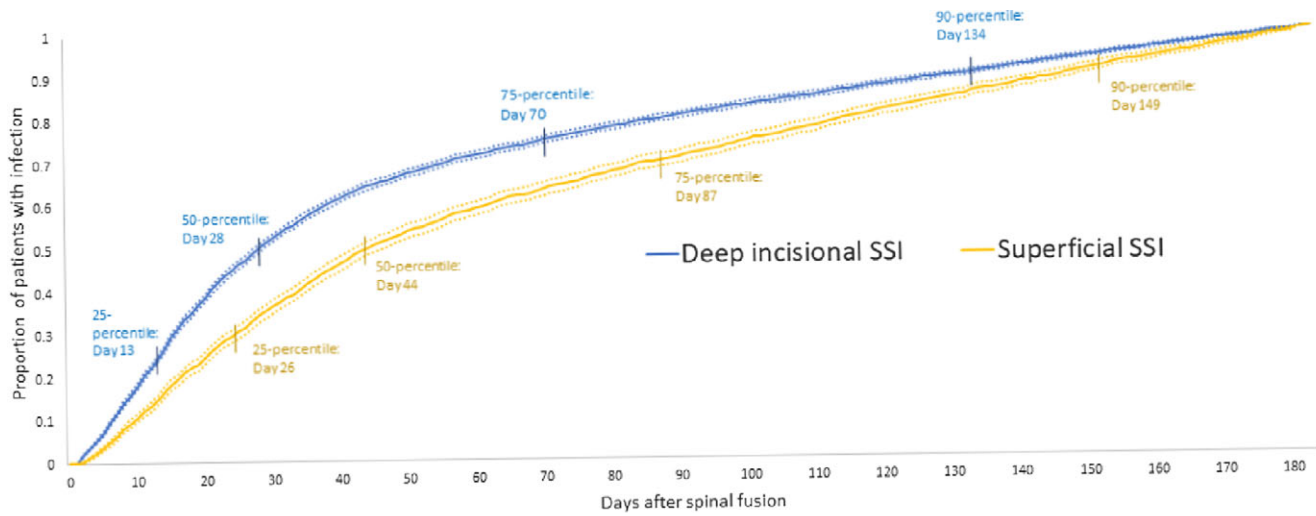

Fig. 2. Time to deep incisional infection and superficial incision infection along with 95% confidence intervals among those with surgical site infections.

30 days after SFS but rather continues to increase over a 24-month postoperative period. Furthermore, as noted earlier, the detection and management of device-related postoperative infection often occurs beyond the 30-day NHSN (CDC) or NSQIP (ACS) threshold period.

Comparison of database findings to earlier publications

Although the rate of superficial SSI in the present analysis aligns with some of the findings from previous publications, the overall fiscal burden shown in the current analysis is higher than previously reported.[10,11,30–32] Posterior spinal-approach procedures had higher deep and superficial incisional SSI rates than anterior-approach procedures, which agrees with previous findings.[33] Risk factors, identified to have a significant impact on the risk of deep-incisional SSI, were also aligned with the current analysis.[8] However, the rate of deep-incisional SSI after SFS was much higher than estimates in earlier studies.[11] Possible explanations for this finding may be related to the 30-day postdischarge SSI surveillance time horizon reported in many of these other studies. The NSQIP database, for example, specifically utilizes a surveillance period of 30 days after discharge, whereas the current study documented SSIs up to 6 months postoperatively, a wider catchment window. For many surgical procedures, especially those involving device-related implantation, a 30-day postdischarge time horizon may be inadequate, leading to an underestimation of infection risk.[34]

Published estimates of the payment and cost of SSI after spinal surgery have ranged from $16,242 to $37,009 per episode of care.[1,5,12] Surrogate approaches to derive the cost of SSIs have been widely used for economic analyses, which are based on hospital cost records to calculate amounts based on increased length of stay.[35,36] By comparison the current study takes a payer perspective, using a large database with payment data that includes all reimbursed inpatient and outpatient claims. The current study used regression models to calculate differences in the payments between patients with and without infection, so visits that may be due to the infection but were not coded as such were identified in this analysis. In addition, a longer follow-up period (up to 24 months) suggests that healthcare protocols need to address infections that may extend beyond the conventional SSI surveillance periods (Table 3). In this manner, the amounts reimbursed by payers for services to healthcare providers would reflect the true cost of the total episode of care (surgery and follow-up). The findings of the current study emphasize the need for further research as well as implementation of robust evidence-based infection prevention surgical care bundles (and compliance with them) to mitigate the risk of infection after SFS.[4]

One study reported an infection prevention bundle that included 9 evidence-based components: (1) screening for *Staphylococcus aureus* nasal colonization and decolonization with mupirocin, (2) self-preparation bath with 4% chlorhexidine gluconate (CHG), (3) self-preparation with 2% chlorhexidine gluconate (CHG) wipes, (4) storage optimization of operating room supplies, (5) preoperative antibiotic administration algorithm, (6) staff training on betadine skin antiseptic preparation, (7) intrawound vancomycin in instrumented cases, (8) postoperative early patient mobilization, and (9) wound checks at 2 and 6 weeks postoperatively.[1] In total, 1,770 patients were included in the study from 2012 to 2013. Also, 40 infections were observed in the preintervention cohort, whereas 16 were observed in the intervention cohort (4.12% vs 2.00%; risk ratio, 0.48; 95% CI, 0.27–0.86; $P = .01$). These researchers concluded that implementation of an infection prevention bundle was associated with a 50% reduction in SSIs and an $866 per capita reduction in the surgical episode of care cost. Another cohort study that documented a significantly decreased SSI rate and associated cost reduction over a 10-year period also showed significantly decreased SSI rates and associated cost reduction after SFS with the implementation of an infection prevention bundle and increased physician awareness.[15]

This study had several limitations. The results were limited to the information captured by the IBM MarketScan databases. All information within the IBM MarketScan commercial and Medicaid-Medicare Supplemental databases are provided by individual healthcare settings and are subject to errors in incomplete hospital reporting, coding errors, or misclassification of patients. It was not possible to control for potentially important factors including physical function, socioeconomic status, clinical practice regarding postoperative wound care, and nutritional status. Additionally, due to coding limitations, important factors (eg, the number of spinal levels fused) could not be analyzed because this information only started to be captured in ICD-10-CM procedures. The exclusion of these and other potential predictive factors could impair the accuracy of the model

Table 2. Key Comorbidities of Patients Included in the Study, Based on Infection Status at 6 Months After Index

			Infection Indicator					
	Overall		Deep incisional Infections		Superficial Infections		No Infections	
Comorbidity	No.	%	No.	%	No.	%	No.	%
All	210,019	100.00	10,296	100.0	3,517	100.0	196,206	100.0
Hypertension uncomplicated	110,686	52.7	6,456	62.7	2,143	60.9	102,087	52.0
Depression	49,470	23.6	3,202	31.1	1,086	30.9	45,182	23.0
Chronic pulmonary disease	43,475	20.7	3,084	30.0	987	28.1	39,404	20.1
Diabetes uncomplicated	41,944	20.0	3,059	29.7	960	27.3	37,925	19.3
Obesity	35,053	16.7	2,380	23.1	871	24.8	31,802	16.2
Hypothyroidisim	30,300	14.4	1,690	16.4	570	16.2	28,040	14.3
Cardiac arrhythmia	27,832	13.3	2,249	21.8	563	16.0	25,020	12.8
Rheumatoid arthritis/Collagen	27,357	13.0	1,733	16.8	581	16.5	25,043	12.8
Diabetes complicated	19,676	9.4	1,848	18.0	513	14.6	17,315	8.8
Fluid and electrolyte disorders	16,862	8.0	2,028	19.7	422	12.0	14,412	7.4
Peripheral vascular disorders	14,417	6.9	1,273	12.4	348	9.9	12,796	6.5
Valvular disease	13,554	6.5	1,231	12.0	277	7.9	12,046	6.1
Drug abuse	11,882	5.7	1,190	11.6	316	9.0	10,376	5.3
Other neurological disorders	11,586	5.5	1,161	11.3	258	7.3	10,167	5.2
Liver disease	11,157	5.3	1,008	9.8	239	6.8	9,910	5.1
Hypertension complicated	10,221	4.9	1,078	10.5	241	6.9	8,902	4.5
Solid tumor without metastases	10,153	4.8	830	8.1	209	5.9	9,114	4.7
Deficiency anemia	9,675	4.6	949	9.2	215	6.1	8,511	4.3
Renal failure	9,225	4.4	1,060	10.3	223	6.3	7,942	4.1
Congestive heart failure	8,239	3.9	1,018	9.9	247	7.0	6,974	3.6
Alcohol abuse	5,828	2.8	542	5.3	118	3.4	5,168	2.6
Coagulopathy	5,636	2.7	563	5.5	120	3.4	4,953	2.5
Weight loss	4,743	2.3	599	5.8	113	3.2	4,031	2.1
Paralysis	3,876	1.9	531	5.2	78	2.2	3,267	1.7
Psychoses	3,813	1.8	409	4.0	113	3.2	3,291	1.7
Pulmonary circulation disorders	3,190	1.5	436	4.2	88	2.5	2,666	1.4
Charlson comorbidity index								
0	104,787	49.9	3,328	32.3	1,337	38.0	100,122	51.0
1	49,232	23.4	2,234	21.7	885	25.2	46,113	23.5
2–3	39,436	18.8	2,712	26.3	827	23.5	35,897	18.3
4–5	10,525	5.0	1,085	10.5	291	8.3	9,149	4.7
>5	6,039	2.9	937	9.1	177	5.0	4,925	2.5

estimates. The occurrence of SSIs was identified based on ICD-9-CM and ICD-10-CM diagnostic codes, without the availability of laboratory confirmation, although diagnosis of an SSI often reflects clinical decision. Also, some infections managed in the outpatient arena may not have been identified. Although this may be possible, recent analyses of both colorectal infections and infections following abdominal hysterectomy would suggest that the probability is low.[24,37] Future prospective studies are warranted to supplement the results of the current analysis.

In conclusion, the results of this study highlight the clinical and economic burden associated with SSI following SFS. The incidence and costs of an SSI found in this longitudinal study are considerably higher than those reported in studies that did not incorporate extensive postdischarge follow-up or those reported in studies that used surrogate studies of cost. Our analysis also showed that SFS SSIs often occur after the conventional 30-day postoperative surveillance period. These findings should be factored into future studies assessing the

Table 3. Summary of SSI Costs From the Database Analysis by Infection Type, Payer, and Time Point

Mean SSI Cost (95% CI)		Deep Incisional	Superficial Incisional
Commercial payers	6 mo	$59,766 ($57,550–$62,030)	$20,800 ($18,394–$23,287)
	12 mo	$74,875 ($72,209–$77,597)	$26,937 ($24,260–$29,700)
	24 mo	$93,741 ($90,045–$97,529)	$32,821 ($29,435–$36,325)
Medicare	6 mo	$48,662 ($45,251–$52,209)	$11,044 ($6,690–$15,716)
	12 mo	$53,757 ($49,955–$57,711)	$17,967 ($12,991–$23,277)
	24 mo	$73,803 ($68,387–$79,457)	$24,096 ($17,508–$31,150)

Note. CI, confidence interval; SSI, surgical site infection.

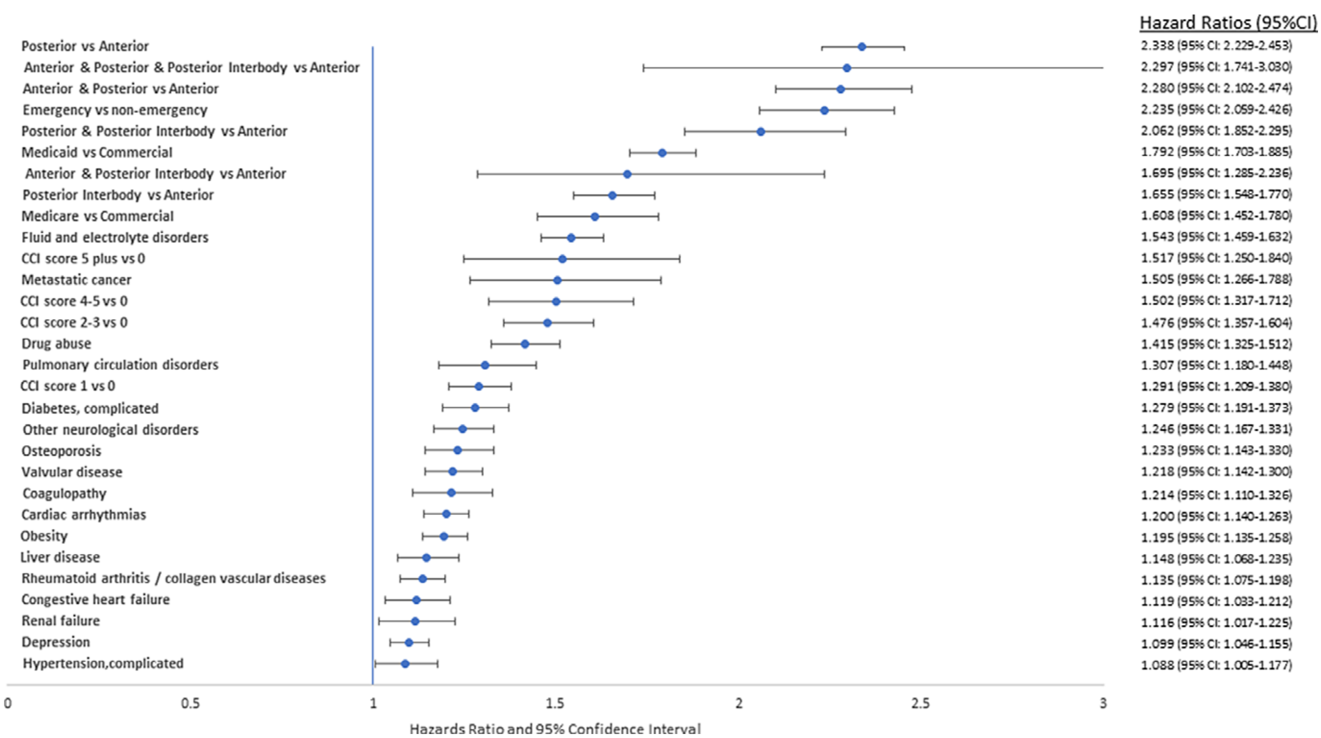

Fig. 3. Hazards ratio and 95% confidence interval for significant risk factors for deep incisional infection.

risk of postoperative infection in the spinal surgical patient population.

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