


Original Article

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INTRODUCTION

Cervical spinal fusions have had increasing incidence, partly owing to the increasing elderly population and an increasing emphasis on quality-based reimbursement metrics and cost-effective solutions for degenerative spine disorders.^{1,2} The estimated rate of anterior cervical discectomy and fusion (ACDF) and posterior cervical fusions is 50.6 per 100,000 population and is predicted to continue to increase.¹ ACDF, the most com-

Weekend Admission Increases Risk of Readmissions Following Elective Cervical Spinal Fusion

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Objective: The “weekend effect” occurs when patients cared for during weekends versus weekdays experience worse outcomes. But reasons for this effect are unclear, especially amongst patients undergoing elective cervical spinal fusion (ECSF). Our aim was to analyze whether index weekend admission affects 30- and 90-day readmission rates post-ECSF.

Methods: All ECSF patients > 18 years were retrospectively identified from the 2016–2018 Healthcare Cost and Utilization Project Nationwide Readmissions Database (NRD), using unique patient linkage codes and International Classification of Diseases, Tenth Revision codes. Patient demographics, comorbidities, and outcomes were analyzed. Univariate logistic regression analyzed primary outcomes of 30- and 90-day readmission rates in weekday or weekend groups. Multivariate regression determined the impact of complications on readmission rates.

Results: Compared to the weekday group (n = 125,590), the weekend group (n = 1,026) held a higher percentage of Medicare/Medicaid insurance, incurred higher costs, had longer length of stay, and fewer routine home discharge (all p < 0.001). There was no difference in comorbidity burden between weekend versus weekday admissions, as measured by the Elixhauser Comorbidity Index (p = 0.527). Weekend admissions had higher 30-day (4.30% vs. 7.60%, p < 0.001) and 90-day (7.80% vs. 16.10%, p < 0.001) readmission rates, even after adjusting for sex, age, insurance status, and comorbidities. All-cause complication rates were higher for weekend admissions (8.62% vs. 12.7%, p < 0.001), specifically deep vein thrombosis, infection, neurological conditions, and pulmonary embolism.

Conclusion: Index weekend admission increases 30- and 90-day readmission rates after ECSF. In patients undergoing ECSF on weekends, postoperative care for patients at risk for specific complications will allow for improved outcomes and health care utilization.

Keywords: Elective cervical spinal fusion, Readmission rates, Weekend admission, Complications, Perioperative characteristics, Postoperative outcomes

mon surgery for degenerative cervical disease, has experienced increasing readmission rates.³ As cervical spinal fusion procedures continue to rise, it is imperative that we analyze risk factors for 30- and 90-day readmission to improve patient outcomes.

Readmission rates are an excellent measure of patient outcomes since they serve as a widespread quality and reimbursement metric. Readmission is associated with higher costs making it a current focus of improvement for both the Centers for

Medicare and Medicaid Services (CMS) as well as institutions. In 2006, an estimated \$41 billion were spent as a result of unplanned readmissions,⁴ placing significant stress on both patients and the healthcare system. Notably, the CMS and National Quality Forum use readmission rates as a metric to rate hospital performance and to determine quality-based reimbursement.⁵

The “weekend effect” is a clinical phenomenon where there are more negative outcomes in patients cared for during the weekend compared to a weekday, but reasons for this effect are unclear.^{6,7} Studies have found weekend admission to be associated with higher risk of mortality, cost, increased length of stay (LOS), and worse outcomes in patients undergoing spine procedures for idiopathic scoliosis,⁸ cervical fusion due to trauma,⁹ and thoracolumbar fusion.¹⁰ However, other studies have found no association between index weekend admission and complication or mortality rates in emergent spinal cord injury patients.¹¹ Although risk factors for readmission in patients undergoing cervical spinal fusions have been identified,¹² the day of surgery was not considered.

To our knowledge, this is the first paper to consider readmission rates in patients who were admitted on the weekend to undergo either anterior or posterior elective cervical spinal fusions (ECSF). A more contemporary analysis of specific complications and readmission rates can help elucidate the causes of different clinical outcomes associated with day of index admission. Findings may inform providers on potential methods to address causes of readmission, in the context of the weekend effect, to minimize the negative impact and costs associated with weekend admission on ECSF.

As such, the objectives of this study are to (1) compare 30- and 90-day readmission rates between weekday and weekend admission for patients undergoing ECSF and (2) identify differences in complications between the weekday vs weekend cohorts to explain differences in readmission rates.

MATERIALS AND METHODS

We queried the 2016–2018 versions of the Nationwide Readmissions Database (NRD), which holds data on millions of hospital discharges in the United States (US) every year. Institutional review board exemption was obtained from our institution for this retrospective analysis. The 2016–2018 datasets use the International Classification of Diseases, Tenth Revision (ICD-10) diagnosis and procedural codes to identify specific medical conditions and surgical procedures. The NRD contains

data from 28 state inpatient databases. Sampling discharge weights are provided by the Healthcare Cost and Utilization Project to allow for national estimates from the NRD. The NRD discharge data includes patient demographics, hospital characteristics, payer status, total hospital charges to patient, readmission information, and patient diagnoses and procedures.

All adult patients (> 18 years of age) who underwent ECSF were identified using ICD-10, Clinical Modification procedure codes. Procedures include both ACDF and posterior spinal fusion, and nonelective procedures were excluded based on ICD-10 codes. Patients were then separated into 2 subgroups based on whether or not their index admission was on a weekday or weekend. The NRD uses the binary variable “AWEEKEND” to identify whether an admission is on a weekend (= 1) versus weekday (= 0), where weekend admission equates to receiving surgery on Saturday or Sunday. Patient characteristics were obtained from the NRD database including demographic information (sex and age), diagnoses, and payer type. Preoperative comorbidities were identified using ICD-10 codes and the R Comorbidity package.¹³ This package allows for the calculation of the Elixhauser Comorbidity Index (ECI) as well as incidence of specific comorbidities among the patient population. Additionally, total LOS and total hospital charges were analyzed for each patient. Total hospital charges for each patient were reported by the NRD in dollar amounts; we then adjusted each charge for inflation using the consumer price index.

The NRD contains data on 14 million US hospitalizations each year, and allows for the longitudinal tracking of patients and their care as they are readmitted throughout a specific year via patient-specific identifiers within the database. However, the data is specific to year and state, so if a patient is readmitted to a different facility in a different state or if their readmission occurs after the calendar year ends, the readmission is not accounted for and could be coded as an initial admission. In order to capture 90-day readmissions, patients admitted during the last quarter of the calendar year were excluded. We were able to quantify the incidence of 30- and 90-day readmissions, the primary diagnoses associated with the 30- and 90-day readmissions, and all procedures performed during the 30- and 90-day readmissions. These analyses were performed for both the weekend-admit and weekday-admit subgroups.

SciPy version 1.6.1 (The SciPy community) was used for all statistical analyses.¹⁴ Univariate regression analyses were performed to assess demographic differences, average total charges, and LOS between the weekend-admit and weekday-admit groups. Multivariate logistic regression was performed to ana-

lyze the association between weekend index admission and both 30- and 90-day readmission, adjusted for demographic and comorbidity factors.

RESULTS

1. General Patient Data

A total of 126,616 patients undergoing ECSF were identified, with 125,590 in the weekday cohort and 1,026 in the weekend cohort. Compared to the weekday group, the weekend group

had a higher percentage of elderly patients over the age of 70 ($p < 0.001$), higher percentage of Medicare/Medicaid payor status ($p < 0.001$), incurred higher costs by \$23,819.79 (\$121,780.58 vs. \$97,960.79, $p < 0.001$), and had longer postoperative LOS (5.27 days vs. 2.76 days, $p < 0.001$) (Table 1).

Patients with weekend index admissions had lower incidences of routine discharge ($p < 0.001$), defined as discharge to home without further required hospital care. Additionally, the weekend cohort had higher rates of discharge to home health care (HHC) ($p < 0.001$), skilled nursing facilities (SNFs)

Table 1. General characteristics of weekday versus weekend index admission cohorts

Characteristic	Weekday (n = 125,590)	Weekend (n = 1,026)	p-value
Female sex	63,546 (50.68)	506 (49.32)	0.716
Age (yr)			< 0.001*
18–49	27,352 (21.78)	223 (21.73)	
50–59	38,096 (30.33)	262 (25.54)	
60–69	36,094 (28.74)	278 (27.1)	
70–79	20,339 (16.19)	199 (19.4)	
≥ 80	3,709 (2.95)	64 (6.24)	
Payor status			< 0.001*
Medicaid	12,453 (9.92)	111 (10.82)	
Medicare	50,141 (39.92)	501 (48.83)	
Other/unknown	11,677 (9.92)	66 (6.43)	
Private insurance	49,969 (39.79)	327 (31.87)	
Self-pay	1,187 (0.95)	19 (1.85)	
Total charges (USD)	97,960.79 ± 87,451.10	121,780.58 ± 132,717.32	< 0.001*
LOS (day)	2.76 ± 4.51	5.37 ± 9.53	< 0.001*
Elixhauser comorbidity index			0.527
0	27,180 (21.64)	238 (23.2)	0.279
1–4	89,253 (71.07)	710 (69.2)	0.187
≥ 5	9,157 (7.29)	78 (7.6)	0.794
Discharge status			< 0.001*
Routine	97,021 (77.25)	659 (64.23)	< 0.001*
Short-term hospital	255 (0.2)	†	0.816
Home health care	18,467 (14.7)	193 (18.81)	< 0.001*
Skilled nursing facility, intermediate care facility, and other facilities	9,464 (7.54)	162 (15.79)	< 0.001*
Against medical advice	181 (0.14)	†	0.910
Readmissions			
30 Days	5,423 (4.30)	78 (7.60)	< 0.001*
90 Days	9,742 (7.80)	165 (16.10)	< 0.001*

Values are presented as mean ± standard deviation or number (%).

USD, United States dollar; LOS, length of stay.

* $p < 0.05$, statistically significant differences. †Incidence is less than or equal to 11 and is omitted for data privacy.

($p < 0.001$), and intermediate care facilities ($p < 0.001$) (Table 1).

Weekend admitted patients had higher rates of coagulopathy (1.66% vs. 1.63%, $p = 0.001$) and peripheral vascular disease

Table 2. Comorbidities in weekday versus weekday index admission patients

Comorbidity	Weekday (n = 104,431)	Weekend (n = 742)	p-value
Acquired immunodeficiency syndrome	162 (0.13)	†	0.351
Alcohol abuse	2,097 (1.67)	18 (1.75)	0.945
Blood loss anemia	272 (0.22)	†	0.985
Cardiac arrhythmias	8,858 (7.05)	62 (6.04)	0.389
Congestive heart failure	3,739 (2.98)	36 (3.51)	0.572
Coagulopathy	2,042 (1.63)	17 (1.66)	0.001*
Chronic pulmonary disease	23,858 (19.0)	175 (17.06)	0.082
Deficiency anemias	1,228 (0.98)	16 (1.56)	0.167
Depression	21,944 (17.47)	173 (16.86)	0.810
Diabetes (with chronic complications)	9,381 (7.47)	79 (7.7)	0.395
Diabetes (uncomplicated)	17,578 (14.0)	133 (12.96)	0.460
Drug abuse	3,285 (2.62)	22 (2.14)	0.608
Fluid/electrolyte disorder	6,735 (5.36)	53 (5.17)	0.859
Hypertension (with chronic complications)	7,738 (6.16)	64 (6.24)	0.292
Hypertension (uncomplicated)	14,698 (11.7)	126 (12.28)	0.603
Hypothyroidism	59,976 (47.76)	481 (46.88)	0.852
Liver disease	2,153 (1.71)	19 (1.85)	0.912
Lymphoma	329 (0.26)	†	0.586
Metastatic cancer	576 (0.46)	†	0.982
Obesity	23,862 (19.0)	184 (17.93)	0.655
Other neurological disorders	4,891 (3.89)	45 (4.39)	0.664
Paralysis	2,405 (1.91)	26 (2.53)	0.341
Pulmonary circulation disorders	771 (0.61)	†	0.649
Psychoses	494 (0.39)	†	0.885
Peptic ulcer disease	351 (0.28)	†	0.454
Peripheral vascular disease	3,005 (2.39)	46 (4.48)	<0.001*
Renal failure	6,168 (4.91)	48 (4.68)	0.850
Rheumatoid arthritis/collagen vascular disease	5,845 (4.65)	35 (3.41)	0.154
Solid tumor without metastases	1,016 (0.81)	†	0.955
Valvular disease	2,732 (2.18)	20 (1.95)	0.846
Weight loss	1,063 (0.85)	†	0.835

Values are presented as number (%).

* $p < 0.05$, statistically significant differences. †Incidence is less than or equal to 11 and is omitted for data privacy.

(4.48% vs. 2.39%, $p < 0.001$), but there were no differences in comorbidity burden between the 2 groups as measured by the ECI ($p = 0.527$) (Table 2). All-cause complication rates were higher for weekend admissions (12.7% vs. 8.62%, $p < 0.001$), namely deep vein thrombosis (DVT), neurological conditions, postoperative infections, and pulmonary embolism ($p < 0.001$) (Table 3).

2. Readmission Rates

Multiple logistical analysis was conducted to investigate the association between weekend surgery and readmission rates. The 30-day readmission rates were 4.30% on weekdays and 7.60% on weekends (odds ratio [OR], 1.82; 95% confidence interval [CI], 1.44–2.30; $p < 0.001$). The 90-day readmission rates were 7.80% on weekdays and 16.10% on weekends (OR, 2.28; 95% CI, 1.93–2.70; $p < 0.001$). After adjusting for sex, age, and payor status, and comorbidities, both 30-day (OR, 1.71; 95% CI, 1.35–2.15; $p < 0.001$) and 90-day (OR, 2.15; 95% CI, 1.81–2.55; $p < 0.001$) weekend admission remained an independent risk factor for readmission (Tables 4, 5).

Table 3. Complications of weekday versus weekday index admission patients

Complication	Weekday (n = 125,590)	Weekend (n = 1,026)	p-value
All-cause	10,826 (8.62)	130 (12.7)	<0.001*
Deep vein thrombosis	300 (0.24)	13 (1.27)	<0.001*
Dehiscence	153 (0.12)	†	0.300
Dural tear	16 (0.01)	†	0.936
Foreign body reaction	142 (0.11)	†	0.239
Gastrointestinal complications	256 (0.2)	†	0.994
Genitourinary complications	149 (0.12)	†	0.542
Hardware related complications	505 (0.4)	†	0.303
Intraoperative complications	6,990 (5.57)	46 (4.48)	0.286
Neurologic complications	1,251 (1.0)	25 (2.44)	<0.001*
Nonunion	370 (0.29)	†	0.994
Peripheral vascular complications	165 (0.13)	†	0.954
Post-operative infection	418 (0.33)	27 (2.63)	<0.001*
Post-operative shock	54 (0.04)	†	0.801
Pulmonary embolism	198 (0.16)	†	<0.001*
Respiratory complications	892 (0.71)	13 (1.27)	0.107

Values are presented as number (%).

* $p < 0.05$, statistically significant differences. †Incidence is less than or equal to 11 and is omitted for data privacy.

Table 4. Odds ratios for 30-day readmission comparing weekday versus weekend admissions

Weekend effect	Odds ratio (95% CI)	p-value
Crude (unadjusted) odds ratio for readmission following weekend admission	1.82 (1.44–2.30)	< 0.001*
Odds ratio for readmission following weekend admission adjusted for sex, age, and payor status	1.70 (1.35–2.15)	< 0.001*
Odds ratio for readmission following weekend admission adjusted for sex, age, payor status, and comorbidities	1.71 (1.35–2.15)	< 0.001*

CI, confidence interval.

* $p < 0.05$, statistically significant differences.

Table 5. Odds ratios for 90-day readmission comparing weekday versus weekend admissions

Weekend effect	Odds ratio (95% CI)	p-value
Crude (unadjusted) odds ratio for readmission following weekend admission	2.28 (1.93–2.70)	< 0.001*
Odds ratio for readmission following weekend admission adjusted for sex, age, and payor status	2.14 (1.81–2.54)	< 0.001*
Odds ratio for readmission following weekend admission adjusted for sex, age, payor status, and comorbidities	2.15 (1.81–2.55)	< 0.001*

CI, confidence interval.

* $p < 0.05$, statistically significant differences.

Common diagnosis upon 30-day readmission includes infection (7.01% weekday vs. 7.52% weekend) and sepsis (4.54% weekday vs. 6.15% weekend). Similarly, common diagnosis upon 90-day readmission includes infection (4.77% weekday vs. 5.87% weekend), sepsis (3.69% weekday vs. 6.70% weekend), and cervical spinal stenosis (6.09% weekday vs. 1.23% weekend) (Table 6).

DISCUSSION

This study is the first to demonstrate that patients with index weekend admission for both anterior and posterior ECSF procedures have increased rates of 30- and 90-day readmission, compared to patients admitted on weekdays. This relationship remains true even after controlling for demographic characteristics and comorbidities.

1. Resource Utilization and Costs

We found that weekend admitted patients incurred \$23,819.79 more in total costs, but did not achieve better outcomes than weekday admissions, as assessed by higher readmission rates, longer LOS, and all-cause complications. These findings suggest that amongst weekend admission patients, higher postoperative complication rates may have led to longer LOS and therefore increased hospital costs.

Unplanned readmissions following surgery pose a significant impact on the US healthcare system, with an estimated 3.3 million 30-day all-cause readmissions resulting in an expenditure of \$41 billion.⁴ In elective ACDF patients, the median cost of 30- and 90-day readmissions were \$6,727 and \$8,507, respec-

tively.¹⁵ In cervical trauma patients, weekend admits incurred \$11,301 more in total hospital costs than weekday admits.⁹ Factors contributing to higher costs for weekend admitted ECSF patients may be due to higher LOS, as a moderately strong correlation between LOS and hospital cost has been described in joint arthroplasty patients.¹⁶ Furthermore, Adogwa et al.¹⁷ suggests reducing LOS after ACDF can help minimize costs and optimize patient outcomes. Of note, the costs reported in this study reflect the financial burden of index admission, and did not take into account the costs of readmission. Given the financial burden of readmission events, describing the relationship between weekend index admission and possible readmission is critical for informing providers on the importance of improving weekend care to decrease the risks of readmission and the costs associated with readmission.

Comorbidities and weekend admission were found to be associated with higher hospital costs after acoustic neuroma microsurgery¹⁸ and percutaneous coronary interventions.¹⁹ Coagulopathy increased overall hospital costs by \$3,787 in patients undergoing joint arthroplasty,²⁰ and coagulopathy and peripheral vascular disease increased risks of infections and complications in patients undergoing spinal fusion.^{21,22} In our study, the weekend ECSF cohort had significantly higher rates of coagulopathy and peripheral vascular disease comorbidities, and more thromboembolic complications. Thus, optimizing preoperative coagulation profiles and being cognizant of blood transfusion sequelae for patients with coagulopathy and peripheral vascular disease may reduce complication risks and costs – associations that can be explored in future studies under the context of the “weekend effect” in ECSF patients.

Table 6. Diagnosis upon 30-day and 90-day readmissions in weekday versus weekend admission cohorts

Reasons for 30-day readmission					
ICD-10 code	Frequency, weekday (%)	Diagnosis on readmission	ICD-10 code	Frequency, weekend (%)	Diagnosis on readmission
T814XXA	7.01	Infection following a procedure	T814XXA	7.52	Infection following a procedure
M4802	5.42	Spinal stenosis, cervical region	A419	6.15	Sepsis, unspecified organism
A419	4.54	Sepsis, unspecified organism	J189	2.78	Pneumonia, unspecified organism
M4712	3.22	Other spondylosis with myelopathy, cervical region	J690	2.61	Pneumonitis due to inhalation of food and vomit
I2699	2.03	Other pulmonary embolism without acute cor pulmonale	G8918	2.40	Other acute postprocedural pain
T8131XA	1.89	Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter	I2699	2.18	Other pulmonary embolism without acute cor pulmonale
G8918	1.74	Other acute postprocedural pain	R1310	1.96	Dysphagia, unspecified
J189	1.68	Pneumonia, unspecified organism	T8131XA	1.85	Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter
J690	1.48	Pneumonitis due to inhalation of food and vomit	N179	1.80	Acute kidney failure, unspecified
T8132XA	1.28	Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter	M96842	1.36	Postprocedural seroma of a musculoskeletal structure following a musculoskeletal system procedure
N179	1.28	Acute kidney failure, unspecified	G9782	1.31	Other postprocedural complications and disorders of nervous system
M4722	1.08	Other spondylosis with radiculopathy, cervical region	T8132XA	1.20	Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter
T84226A	1.08	Displacement of internal fixation device of vertebrae, initial encounter	N390	1.20	Urinary tract infection, site not specified
G9782	1.07	Other postprocedural complications and disorders of nervous system	L7632	1.03	Postprocedural hematoma of skin and subcutaneous tissue following other procedure
R1310	0.94	Dysphagia, unspecified	T8189XA	1.20	Other complications of procedures, not elsewhere classified, initial encounter
Reasons for 90-day readmission					
M4802	6.09	Spinal stenosis, cervical region	A419	6.7	Sepsis, unspecified organism
T814XXA	4.77	Infection following a procedure	T814XXA	5.87	Infection following a procedure
A419	3.69	Sepsis, unspecified organism	J189	2.47	Pneumonia, unspecified organism
M4712	3.39	Other spondylosis with myelopathy, cervical region	J690	1.87	Pneumonitis due to inhalation of food and vomit
M4806	1.54	Spinal stenosis, lumbar region	N179	1.87	Acute kidney failure, unspecified
T84226A	1.46	Displacement of internal fixation device of vertebrae, initial encounter	I2699	1.63	Other pulmonary embolism without acute cor pulmonale
I2699	1.32	Other pulmonary embolism without acute cor pulmonale	T8131XA	1.47	Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter
T8131XA	1.32	Disruption of external operation (surgical) wound, not elsewhere classified, initial encounter	G8918	1.6	Other acute postprocedural pain

(Continued)

Table 6. Diagnosis upon 30-day and 90-day readmissions in weekday versus weekend admission cohorts (Continued)

ICD-10 code	Frequency, weekday (%)	Diagnosis on readmission	ICD-10 code	Frequency, weekend (%)	Diagnosis on readmission
N179	1.28	Acute kidney failure, unspecified	M4802	1.23	Spinal stenosis, cervical region
J189	1.25	Pneumonia, unspecified organism	R1310	1.2	Dysphagia, unspecified
M4722	1.21	Other spondylosis with radiculopathy, cervical region	N390	1.1	Urinary tract infection, site not specified
G8918	0.91	Other acute postprocedural pain	I214	1.03	Non-ST elevation myocardial infarction
J690	0.90	Pneumonitis due to inhalation of food and vomit	J441	1	Chronic obstructive pulmonary disease with acute exacerbation, unspecified
M960	0.87	Pseudarthrosis after fusion or arthrodesis	G9782	0.93	Other postprocedural complications and disorders of nervous system
N390	0.83	Urinary tract infection, site not specified	T8132XA	0.9	Disruption of internal operation (surgical) wound, not elsewhere classified, initial encounter

ICD-10, International Classification of Diseases, Tenth Revision.

Patients with weekend admission in our study utilized more Medicare/Medicaid insurance and fewer private insurance plans than patients with weekday admission. However, multivariate analysis did not reveal payor status to be associated with higher readmission rates. Our results add evidence to previous findings that payor status were insignificant risk factors in predicting 30-day readmission rates in posterior cervical fusion patients.¹² However, our results also contradict previous findings that Medicaid status is independently associated with increased 30-day readmission after anterior cervical spine²³ and other orthopedic procedures.²⁴ Thus, interactions between socioeconomic status and outcomes after spinal surgeries are complex and require analysis in future studies.

2. Readmission Rates

Significant differences in the adjusted multivariate analysis of 30- and 90-day readmission following ECSF of weekend and weekday admitted patients suggest that weekend admission is an independent predictor of readmission. To our knowledge, weekend admission has only been described as a risk factor for 30-day readmission in the context of posterior cervical spine surgery and thoracolumbar spine fusion.^{10,12} A study using 2014 NRD data for ACDF subjects suggest payor status, NRD, comorbidities, and LOS are significant predictors for readmission, but weekend admission was not found to be a risk factor for readmission rates.²⁵ Other studies identify payor status and race,²⁶ and all-cause complications, Medicaid insurance, hospital bed size, and age,²⁷ as predictors for high readmission rates. These papers did not consider day of the week of admission as a variable in their analysis.^{23,26} Though Neifert et al.²⁸ found NHD

and postdischarge complications to be independent predictors of readmission, they did not observe the reason for readmission in these cases. Rosenberg et al.¹⁰ identified DVT, infections, and nonroutine discharge to be risk factors for 30-day readmission in patients with index weekend admission for thoracolumbar fusion surgery. In our ECSF cohort, the most common diagnoses upon readmission are related to postprocedural pain, infections, and surgical site complications. This further highlights the importance of preoperative medical optimization and postoperative management, concerns that should be especially scrutinized for patients admitted and receiving surgery on weekends.

Utilizing a larger and more recent NRD sample size and controlling for baseline characteristics, we found that weekend status is an independent predictor of higher 30- and 90-day readmission rates, as compared to weekday status. Thus, this study clarifies weekend status as an important preoperative variable to decrease risk of readmissions after ECSF. Furthermore, our findings suggest complications, NHD, and longer LOS are also associated with an increased risk of readmission. We therefore pose that the interactions between various factors such as hospital resources, complications, and postoperative care including discharge and LOS, can contribute to increased risk of readmission in weekend index admission patients.

3. Complications

Moreover, our study analyzed complication rates to explain differences in readmission rates between weekday and weekend admissions. The weekend admissions group experienced higher all-cause complications than the weekday admissions group,

specifically DVT, neurological conditions, postoperative infections, and pulmonary embolism. These complications more frequently experienced by weekend admissions patients could partially account for their increased rates of readmission. Hospital factors that contribute to the weekend effect have been described in the literature. Overnight and postcall shifts have been associated with fewer specialists, lower nurse-to-patient ratios, and increased errors in medication orders amongst postgraduate year one physician trainees.^{29,30} In our weekend cohort, there were higher rates of DVT and pulmonary embolism—complications that typically require prompt imaging tests for diagnosis. Hajibandeh et al.²⁷ describes decreased resources and staffing on weekends that delays diagnostics and treatment, such as imaging and pathology, which may explain why the weekend-admitted patients in our study experience higher thromboembolic events after ECSF.

We also found that the weekend cohort had an 8-fold higher incidence of postoperative infection rates compared to weekday admitted patients. Previous studies did not necessarily find an association between complication rates such as infections and weekend admission.^{11,31} However, our study used a 2016–2018 national dataset to provide findings from a scoping national-level perspective that contributes to existing literature and highlights the need for further investigation. Future actions to mitigate postoperative wound complications leading to readmission includes rigorous methicillin-resistant *Staphylococcus aureus* screening, optimizing operating room air quality, and ensuring antibiotic compliance.²⁴ Thus, definitively correcting such complications in the patient's initial hospitalization prior to discharge can prevent negative clinical sequelae of those complications that may result in readmission. A study of hospital support services for critical care units found delays in blood culture incubation and processing during weekends, delaying diagnosis of sepsis and antibiotic prescriptions.³² These findings can potentially be applied to the patients in our study, where emphasis on clinical care factors such as addressing gaps in weekend staffing can help minimize complications and consequently decrease readmission rates in patients undergoing ECSF. Higher complications in weekend admitted patients may also be related to our finding that weekend patients had higher rates of discharge with HHC and SNFs. Malik et al.³³ stated that discharge to inpatient-care facilities that provide higher levels of supervised care, compared to HHC, can ensure improved outcomes following lumbar fusion. Discharge to SNFs have been associated with higher rates of complications following spine surgery.³⁴ Of note, our weekend admission cohort incurred higher

costs, held more Medicare/Medicaid insurance types than weekday admissions, and SNFs have been found to account for approximately \$31 billion of Medicare spending in 2012.³⁵ Thus, decisions to discharge to costly nonhome care facilities should involve careful cost-benefit considerations. Success of home-discharge care and discharge to SNFs rely on careful patient selection, preoperative planning, and regular communication between home attendants and the patient's physician care team.³³ However, conclusions regarding discharge destination in reducing complications following weekend ECSF should involve further analysis beyond the scope of the present study.

4. LOS and Discharge Status

In our study, LOS is significantly increased in patients who were admitted on the weekend. Previous findings identified trauma⁹ and hospital acquired conditions³¹ as factors that increase complications and prolong LOS in weekend ECSF patients. However, analysis of the direct impact of weekend admission on LOS following ECSF has been minimally explored, so our findings provide significant insight.

Patients admitted on the weekend were found to have increased rates of nonhome discharge (NHD), discharge with HHC, and discharge to a SNF, intermediate care facility (ICF), and other facilities. The correlation between LOS and NHD has been described as a result of lengthy precertification required for acceptance into a care facility and availability of beds.^{23,36} Thus, weekend admitted patients can also consider additional coordination with these facilities prior to surgery to minimize LOS and costs. Elsamadicy et al.²³ found that patients with prolonged LOS following ACDF were more often discharged to locations other than home. However, our study is the first to provide a detailed description of discharge locations and its associations with weekend index admission, thereby raising awareness of the importance of improving NHD services, specifically SNFs, ICFs, and HHC. Previous literature have suggested that risk factors of NHD are largely nonmodifiable factors such as demographics and long term comorbidities.^{37,38} Additionally, NHD can lead to a significantly increased rate of severe adverse events and death following discharge.²⁸ Therefore, in a population such as weekend admitted patients which is suggested to have increased risk of NHD, minimizing NHD when possible is critical. Because previous literature has suggested comorbidities as a risk factor of NHD,²⁸ future studies looking into whether weekend admission independently leads to NHD after ECSF can help providers closely consider criteria to suggest NHD for weekday versus weekend admission patients.

5. Limitations and Further Steps

Our findings highlight that weekend surgery is an area of improvement that can decrease readmission rates after ECSE. Currently, solutions such as the redistribution of physical therapy services from weekday to weekend has served as a successful solution in improving these quality metrics and reducing cost per patient.⁹ However, more research is needed to elucidate methods to improve outcomes for patients undergoing weekend surgery.

Limitations in this study include the data source, because the NRD only longitudinally tracks 49.3% of hospitalizations,²⁵ and incomplete data can bias results. However, inclusion of data from 2016–2018 would result in a sufficient sample size, and in general these findings shed light onto the importance of weekend admission on ECSE outcomes. A meta-analysis of studies regarding readmission rates and day of surgery could address discrepancies in the literature and compare results from studies that utilize different databases. Additionally, granular data such as the number of operating room staff and turnover rate are not tracked by the NRD. However, an institutional study found that the average number of operating room personnel was 10.0 for elective neurological procedures, and staff turnover was found to be significantly correlated with increased risk for surgical site infections and operation duration.³⁹ Thus, future studies can investigate whether the number and turnover of personnel is a significant factor in increasing risks for readmission rates, cost, infections, NHD, and prolonged LOS following weekend ECSE. Surgical approach was not analyzed in this study as a potential factor influencing readmission rates. Posterior cervical spinal fusion patients have a higher 90-day readmission rate and different baseline demographics than patients undergoing an anterior approach.⁴⁰ Thus, future studies that differentiate patients by surgical approaches can further elucidate the impact of weekend admissions on readmissions. Regardless, our paper is the first to confirm the weekend effect in patients undergoing ECSE, highlighting the significant clinical and financial benefits that can be achieved by improving care for weekend-admitted patients.

CONCLUSION

Understanding the impact of surgical operation day on postoperative outcomes is key to improving cost-effective care delivery and preoperative planning in ECSE. Our study is the first to define the association between the weekend effect and complications such as thromboembolic events and neurological

complications. Thus, postoperative infections, neurological conditions, DVT, and pulmonary embolism are important risk factors that should be carefully monitored after surgery to help mitigate the risks of readmission. On the other hand, baseline patient characteristics are not predictive of readmission rates in weekend vs weekday admissions for ECSE. Our study underscores the fact that weekend elective surgery is a potential area of focus for quality improvement.

NOTES

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