Factors Associated With Unplanned Readmissions and Prolonged Length of Stay in Patients Undergoing Primary Fusion for Congenital Scoliosis

Ari R. Berg, John I. Shin, Andrew Leggett, Ashok Para, Dhruv Mendiratta, Neil Kaushal and Michael J. Vives

Int J Spine Surg published online 6 August 2024
https://www.ijssurgery.com/content/early/2024/08/02/8614

The International Journal of Spine Surgery
2397 Waterbury Circle, Suite 1,
Aurora, IL 60504, Phone: +1-630-375-1432

International Journal of Spine Surgery, Vol. 00, No. 0, 2024, pp. 1–7
https://doi.org/10.14444/8614

Factors Associated With Unplanned Readmissions and Prolonged Length of Stay in Patients Undergoing Primary Fusion for Congenital Scoliosis

ARI R. BERG, MD, MBA[1]; JOHN I. SHIN, MD[1]; ANDREW LEGGETT, MD[1]; ASHOK PARA, MD[1]; DHRUV MENDIRATTA, BS[1]; NEIL KAUSHAL, MD[1]; AND MICHAEL J. VIVES, MD[1]

[1]*Department of Orthopedics, Rutgers New Jersey Medical School, Newark, NJ, USA*

ABSTRACT

Background: Approximately 50% of patients with congenital scoliosis will require surgical treatment to prevent further progression. Outcomes following congenital scoliosis are sparse in the literature. The purpose of this study was to identify independent risk factors associated with unplanned readmission and prolonged length of stay (LOS) in patients undergoing primary surgical treatment for congenital scoliosis.

Methods: The National Surgical Quality Improvement Database-Pediatric was queried for database years 2016–2018 to identify patients with congenital scoliosis who underwent primary posterior fusion of the spine. Patient demographics, comorbidities, and operative variables, such as the number of levels fused and the American Society of Anesthesiologists (ASA) classificaiton, were collected. Univariate and multivariate analyses of patient factors were performed to test for association with readmission within 30 days and prolonged LOS (>4 days).

Results: Eight hundred sixteen patients were identified. The average age was 11.3 ± 4.02 years, and the mean postoperative LOS was 4.64 ± 3.71 days. Forty-three patients (5.40%) were readmitted, and 73 patients (8.96%) had prolonged LOS. Independent risk factors associated with prolonged LOS included chronic lung disease ($P < 0.001$), presence of a tracheostomy ($P < 0.001$), structural central nervous system abnormality ($P = 0.039$), oxygen support ($P < 0.001$), and number of levels fused ($P = 0.008$). The factors independently associated with unplanned readmission were fusion to the pelvis ($P = 0.004$) and LOS >4 days ($P = 0.008$).

Conclusions: Prolonged LOS and readmission are widely being used as quality and performance metrics for hospitals. Congenital scoliosis, which often progresses rapidly resulting in significant deformity, frequently requires surgery at an earlier age than idiopathic and neuromuscular deformity. Nevertheless, 30-day outcomes for surgical intervention have not been thoroughly studied. The present study identifies risk factors for prolonged LOS and readmission, which can facilitate preoperative planning, patient/family counseling, and postoperative care.

Clinical Relevance: Congenital scoliosis management poses certain challenges that may be mitigated by understanding the risk factors for adverse outcomes following primary fusion surgery.

Complications

Keywords: congenital scoliosis, spinal fusion, NSQIP-P, readmission

INTRODUCTION

Congenital scoliosis accounts for 10% of scoliotic deformities and arises from abnormal vertebral development during gestation.[1] The deformity may be mild, causing subclinical curvatures, or severe, causing early, crippling, progressive scoliosis often associated with neurological complications, pulmonary restriction, cor pulmonale, and premature death.[2] Approximately 50% of patients with congenital scoliosis will ultimately require surgical treatment to prevent further progression and avoid fatal complications.[1–3]

Children with congenital scoliosis have a 30% to 60% chance of having associated syndromes or systemic anomalies such as VACTERL syndrome, Klippel-Feil syndrome, cardiac defects, genitourinary defects, or spinal cord malformations.[2,3] Previous studies have shown that readmission rates and mortality risks are higher in spinal deformities caused by neuromuscular, congenital, or syndromic diseases.[4–7] In the United States, hospital length of stay (LOS) and unplanned readmissions are considered a proxy for quality of care and represent a large financial burden to the health care system.[7–10] To encourage a reduction in the readmission rate, the Centers for Medicare and Medicaid Services utilizes readmission rates as a hospital quality metric and penalizes institutions with higher rates of readmissions.[8] Given both the clinical and financial implications, it is crucial to identify modifiable perioperative risk

factors associated with prolonged hospital stays and readmissions.

While outcomes following spinal fusion for adolescent idiopathic scoliosis and neuromuscular scoliosis have been well elucidated in the literature, those following spinal fusion for congenital scoliosis remain sparse. The purpose of this study was to identify patient characteristics and operative risk factors that are independently associated with prolonged LOS and unplanned readmission in patients undergoing primary posterior spinal fusion for congenital scoliosis. In doing so, this study should facilitate enhanced preoperative planning, patient/family counseling, and postoperative care.

MATERIALS AND METHODS

No funding was received for the current study, and the study was qualified as exempt by the Institutional Review Board because the database utilized in the study is deidentified and publicly available.

Data Source

The American College of Surgeons National Surgical Quality Improvement Program Pediatric (NSQIP-P) database was used, which prospectively collects more than 150 patient variables from medical records, operative reports, and patient interviews to document comorbid conditions, as well as 30-day postoperative mortality and morbidity outcomes. We utilized spinal fusion-specific variables, which were available from the database year 2016 onward. For the year 2018, the most recent year included in the study, the NSQIP-P database contained more than 110,000 cases collected from hospitals across the country.[11] The database is maintained by surgical clinical reviewers and the NSQIP-P's internal auditing process, which ensures interrater reliability and accuracy of data.[12]

Study Population

The NSQIP-P databases from 2016 to 2018 were queried. Among the patients designated as having congenital scoliosis, those who underwent posterior spinal fusion were identified using Current Procedural Terminology codes. Posterior fusions were identified using Current Procedural Terminology codes 22,800, 22,802, 22,804, 22,842, 22,843, and 22,844. Only cases designated as "elective" with "clean" wound class were included. Those with preoperative sepsis, those with intraventricular hemorrhage, and those who needed cardiopulmonary resuscitation within 7 days before surgery were excluded.

Patient Factors and Outcome Variables

Demographic factors included age, sex, and body mass index (BMI). Comorbid conditions assessed were previous cardiac surgery, requirement of inotropic support, structural pulmonary/airway abnormality, chronic lung disease, tracheostomy, asthma, requirement of supplemental oxygen support, esophageal/gastric/intestinal disease, requirement of nutritional support (total parenteral nutrition or enteral feeding support via gastrostomy, nasogastric, or jejunal feeding device), seizure disorder, developmental delay, structural central nervous system abnormality, chronic steroid use, hematological disease, and blood transfusion within 48 hours prior to surgery. Operative variables assessed included fusion to the pelvis, osteotomy, and the number of levels fused. LOS and unplanned readmission were the primary outcomes of interest. LOS, a continuous variable, was defined as the number of days from the operation to hospital discharge.

Data Analysis

The SAS software (version 9.3, SAS Institute Inc., Cary, NC, USA) was used for statistical analyses. Student's t test and χ^2 test were used for continuous and categorical variables, respectively. All patient factors were assessed for association with LOS using bivariate and multivariate linear regressions. All patient factors and LOS greater than the median LOS (4 days) were assessed for association with the 30-day readmission rate using bivariate and multivariate logistic regressions. Patient factors associated with $P < 0.15$ on bivariate analyses with LOS and readmission were forwarded to multivariate regressions to control for possible underlying collinearity. Statistical significance level was maintained at a 2-sided alpha level of 0.05.

RESULTS

Patient Characteristics and Comorbidities

A total of 816 patients who underwent posterior spinal fusion for congenital scoliosis and met the inclusion criteria were identified and included in the analysis. The cohort of patients was 57.35% women, and the average age at the time of surgery was 11.32 ± 4.02 years. Table 1 lists the remaining patient-specific and surgery-related characteristics.

Length of Stay

The mean LOS was 4.64 ± 3.71 days, with a median LOS of 4 days. Seventy-three patients (8.96%) had prolonged LOS (LOS > 4 days).

Table 1. Demographics and comorbidities of congenital scoliosis patients who underwent posterior fusion (*N* = 816).

Variables	*n* (%)
Age, y mean ± SD	11.32 ± 4.02
Age, y	
0–4	83 (10.2)
5–9	131 (16.1)
10–14	423 (51.8)
15–19	179 (21.9)
Sex	
Women	468 (57.4)
Men	348 (42.7)
Body mass index group	
Underweight (<18.5 kg/m^2)	363 (44.5)
Nonobese (18.5–29.9 kg/m^2)	392 (48.0)
Obese I (30.0–34.9 kg/m^2)	42 (5.2)
Obese II (35.0–39.9 kg/m^2)	14 (1.7)
Obese III (≥40 kg/m^2)	5 (0.6)
Nutritional support	49 (6)
Esophageal/gastric/intestinal disease	98 (12.0)
Ionotropic support during surgery	8 (1.0)
Seizure disorder	35 (4.3)
Tracheostomy	13 (1.6)
Chronic steroid use	4 (0.5)
Developmental delay	189 (23.2)
Previous cardiac surgery	98 (12.0)
Chronic lung disease	58 (7.1)
Structural central nervous system abnormality	183 (22.4)
Asthma	89 (10.9)
Oxygen support	16 (2.0)
Hematological disease	20 (2.5)
Structural pulmonary/airway abnormality	91 (11.2)
Blood transfusions within 48 h prior to surgery	4 (0.5)
American Society of Anesthesiologists Score	
1–2	458 (56.1)
>2	358 (43.9)
Fusion to pelvis	61 (7.5)
Osteotomy	254 (31.1)
Levels fused	
<7	302 (37.0)
7–12	304 (37.3)
>12	210 (25.7)
Length of stay, d	4.64 ± 3.71
Readmission	43 (5.3)

Note: Data presented as n (%) unless otherwise indicated.

Bivariate analysis was performed to assess the association of various demographic, patient-specific, and surgery-related variables with LOS. Increased LOS after spinal fusion for congenital scoliosis was significantly associated with age ($P = 0.03$), nutritional support ($P < 0.001$), gastrointestinal disease ($P = 0.004$), seizure disorder ($P < 0.001$), tracheostomy ($P < 0.001$), developmental delay ($P = 0.0003$), previous cardiac surgery ($P = 0.007$), chronic lung disease ($P < 0.001$), structural CNS abnormality ($P = 0.001$), oxygen support ($P < 0.001$), structural pulmonary/airway abnormality ($P < 0.001$), American Society of Anesthesiologists (ASA) score ($P < 0.001$), fusion to pelvis ($P = 0.005$), and number of levels fused ($P = 0.002$). Table 2 summarizes the results. Positive vs negative change in LOS associated with each factor is also listed as an unstandardized beta coefficient.

Multivariate linear regression was performed to determine which variables were independently associated with LOS and to control for potential confounding variables. Increased LOS was determined to be significantly associated with chronic lung disease ($P < 0.001$), presence of a tracheostomy ($P < 0.001$), structural CNS abnormality ($P = 0.039$), oxygen support ($P < 0.001$), and number of levels fused ($P = 0.008$). Table 2 summarizes the results of the multivariate analysis.

Readmission

A total of 797 patients met the inclusion criteria and were included in our analysis of readmission (LOS ≤ 13 days). The readmission rate within 30 days postoperatively was 5.27% (43 patients). The mean LOS for this cohort was 5.11 ± 2.26 days, and the median LOS was 5 days. In comparison, the mean LOS for patients who were not readmitted within 30 days was 4.62 ± 3.77 days, with a median LOS of 4 days.

The results of bivariate analysis are outlined in Table 3, along with odds ratios to signify the magnitude of each variable's association with readmission. At a cutoff of $P < 0.15$, readmission was found to be associated with body mass index ($P = 0.145$), nutritional support ($P = 0.080$), developmental delay (0.048), oxygen support ($P = 0.129$), blood transfusions within 48 hours prior to surgery ($P = 0.125$), fusion to pelvis ($P < 0.001$), number of levels fused ($P = 0.101$), and LOS >4 days ($P < 0.001$).

After controlling for possible confounding variables with multivariate analysis, readmission within 30 days postoperatively was found to be significantly associated with fusion to pelvis ($P = 0.0036$) and LOS >4 days ($P = 0.008$).

The NSQIP-P database was queried for suspected reason for readmission for all 43 patients who were readmitted within 30 days postoperatively (Table 4). The most common reason for readmission was wound-related complications (34.9%), followed by gastrointestinal-related complications, such as nausea/vomiting, constipation, fecal impaction, and ileus (9.3%). Seroma or hematoma formation (4.7%), failure of internal fixation (4.7%), seizure (4.7%), and breakdown of cranial or spinal infusion or shunt (4.7) were also listed as suspected reasons for readmission. Data on the reason for readmission were missing for 16.3% of the patients who were readmitted.

DISCUSSION

Prolonged LOS and readmission are associated with increased postoperative complications, morbidity, and cost and are widely being used as quality and

Table 2. Average postoperative length of stay for congenital scoliosis patients who underwent posterior fusion by patient factors.

Patient Factors	Length of Stay, mean (SD)	Bivariate Analyses		Multivariate Analysis	
		Beta	*P*	Beta	*P*
Overall	4.64 (3.71)				
Age, y			0.0295		0.2232
0–4	5.24 (4.71)	+0.37		+0.07	
5–9	4.30 (2.59)	−0.56		−0.62	
10–14	4.87 (4.04)	ref		ref	
15–19	4.07 (2.89)	−0.79		−0.70	
Sex			0.4977		
Men	4.74 (4.29)	ref		ref	
Women	4.57 (3.21)	−0.18			
Body mass index group			0.5259		
Underweight (<18.5 kg/m^2)	4.85 (4.50)	+0.40			
Nonobese (18.5–29.9 kg/m^2)	4.44 (2.77)	ref			
Obese I (30.0–34.9 kg/m^2)	4.50 (2.36)	+0.05			
Obese II (35.0–39.9 kg/m^2)	5.43 (6.65)	+0.98			
Obese III (≥40 kg/m^2)	3.8 (0.84)	−0.65			
Nutritional support	7.47 (6.46)	+3.00	<0.0001	+0.55	0.3715
Esophageal/gastric/intestinal disease	5.65 (4.70)	+1.15	0.0039	−0.13	0.7614
Ionotropic support during surgery	5.63 (3.20)	+0.99	0.4513		
Seizure disorder	7.14 (6.60)	+2.61	<0.0001	+0.77	0.2494
Tracheostomy	11.31 (7.64)	+6.77	<0.0001	+4.20	0.0001
Chronic steroid use	5.50 (2.52)	+0.86	0.6428		
Developmental delay	5.49 (4.28)	+1.10	0.0003	−0.02	0.9492
Previous cardiac surgery	5.58 (5.07)	+1.07	0.0074	+0.37	0.3676
Chronic lung disease	7.67 (7.11)	+3.26	<0.0001	+1.83	0.0004
Structural central nervous systm abnormality	5.50 (4.79)	+1.10	0.0004	+0.63	0.0399
Asthma	5.01 (3.52)	+0.41	0.3198		
Oxygen support	10.31 (8.77)	+5.78	<0.0001	+3.23	0.0008
Hematologic disease	4.20 (1.88)	.−0.45	0.5893		
Structural pulmonary/airway abnormality	6.08 (5.08)	+1.61	<0.0001	+0.13	0.7661
Blood transfusions within 48 h prior to surgery	5.25 (2.06)	+0.61	0.7425		
American Society of Anesthesiologists Score			<0.0001		0.3416
1–2	4.14 (3.30)	ref		ref	
>2	5.28 (4.08)	+1.14		+0.27	
Fusion to pelvis	5.92 (5.04)	+1.38	0.0051	+0.66	0.1762
Osteotomy	4.73 (3.64)	+0.13	0.6407		
Levels fused			0.0024		0.0082
<7	4.34 (3.94)	ref		ref	
7–12	4.41 (3.22)	+0.07		+0.18	
>12	5.40 (3.91)	+1.06		+0.73	

performance metrics for hospitals.[7–10] In the adult population, unplanned readmissions were associated with $41.3 billion in hospital costs in 2011.[13] In this study, we identify risk factors for increased LOS and readmission after primary spinal fusion for patients with congenital scoliosis. Bivariate and multivariate analyses were used to control for potentially confounding variables linking patient characteristics with LOS and readmission. The factors independently associated with unplanned readmission included fusion to the pelvis and extended LOS. Chronic lung disease, presence of a tracheostomy, structural CNS abnormality, oxygen support, and number of levels fused were found to be significantly associated with increased odds of prolonged LOS after confounding variables were accounted for.

Factors affecting readmission and LOS have been extensively investigated for elective anterior cervical fusions, posterior cervical fusions, and posterior lumbar fusions for an array of spinal conditions.[14–21] These 2 measures have also been examined for adolescent idiopathic scoliosis, neuromuscular scoliosis, and fusion for pediatric spinal deformity in general.[22–25] With regard to extended LOS, Fletcher et al analyzed 197 patients with neuromuscular scoliosis who underwent posterior spinal fusions at a single hospital by 2 surgeons. They found that pulmonary complications, the need for ICU admission, longer surgical times, greater number of levels fused, the need for intraoperative or postoperative blood transfusion, pelvic obliquity, major coronal Cobb angle, and severely involved cerebral palsy were predictors of extended LOS.[22] However, this study was limited to neuromuscular scoliosis, was performed on a limited number of patients at a single institution, and did not use multivariate analysis to account for potentially confounding variables.

Other studies have identified risk factors associated with unplanned readmission after fusion for pediatric spinal deformity. Roddy et al queried the State Inpatient Database from New York, Utah, Nebraska, Florida, North Carolina, and California for data on unplanned

Table 3. Readmission rates among congenital scoliosis patients who underwent Posterior fusion by patient factors.

		Bivariate Analyses		Multivariate Analysis	
Patient Factors	**Readmission Rate, %**	**OR**	***P***	**OR**	***P***
Overall	5.27				
Age, y			0.3313		
0–4	9.84	2.15			
5–9	4.58	0.97			
10–14	4.73	Ref			
15–19	5.03	1.07			
Sex			0.5989		
Men	5.75	Ref			
Women	4.91	0.85			
Body mass index group			0.1637		0.2145
Underweight (<18.5 kg/m^2)	5.51	1.37		1.347	
Nonobese (18.5–29.9 kg/m^2)	4.08	ref		ref	
Obese I (30.0–34.9 kg/m^2)	11.9	3.18		3.217	
Obese II (35.0–39.9 kg/m^2)	14.29	3.92		3.815	
Obese III (≥40 kg/m^2)	0	<0.001		<0.001	
Nutritional support	10.2	2.181	0.1192	1.856	0.2935
Esophageal/gastric/intestinal disease	6.12	1.2	0.6873		
Ionotropic support during surgery	0	<0.001	0.99		
Seizure disorder	8.57	1.737	0.3773		
Tracheostomy	7.69	1.51	0.6955		
Chronic steroid use	0	<0.001	0.9892		
Developmental delay	7.94	1.844	0.0647	1.492	0.2867
Previous cardiac surgery	4.08	0.741	0.5765		
Chronic lung disease	3.45	0.625	0.5232		
Structural central nervous system abnormality	6.01	1.201	0.6107		
Asthma	5.62	1.079	0.8762		
Oxygen support	12.5	2.65	0.2082		
Hematologic disease	10	2.047	0.3475		
Structural pulmonary/airway abnormality	2.2	0.375	0.1808	0.221	0.0492
Blood transfusions within 48 h prior to surgery	25	6.116	0.1202	5.719	0.1588
American Society of Anesthesiologists Score			0.5009		
1–2	4.8	ref			
>2	5.87	1.235			
Fusion to pelvis	16.39	4.29	0.0002	3.241	0.0075
Osteotomy	5.91	1.197	0.5851		
Levels fused			0.112		0.9731
<7	4.3	ref		ref	
7–12	4.28	0.993		1.103	
>12	8.1	1.958		1.051	
Length of stay >4 d, median	8.96	2.838	0.0011	2.413	0.0103

readmission after spine fusion for deformity in pediatric patients. They found male sex, neuromuscular scoliosis, congenital scoliosis, Scheuermann kyphosis, Medicaid insurance, LOS ≤3 days or ≥6 days, and surgery at a teaching hospital to be independently associated with 30-day readmission.[24] Similarly, Jain et al retrospectively reviewed the records of 1002 patients at a single institution and found that patients with a diagnosis of congenital scoliosis, genetic or syndromic scoliosis, cerebral palsy, and other neuromuscular disorders had significantly higher rates of readmission.[23] While these studies focused on pediatric spinal deformity in general, they shed light on the complexity inherent in spinal fusion for patients with congenital scoliosis.

Congenital spinal deformities are particularly challenging due to the high frequency of associated medical problems and syndromes, large curves at a very young age, and the relative inflexibility of the curves compared with those found in idiopathic and neuromuscular scoliotic patients.[26] This study showed structural pulmonary abnormality, chronic lung disease, oxygen support, and tracheostomy to be independent risk factors associated with prolonged LOS. Patients with comorbid conditions may have increased difficulty with rehabilitation and healing capability, which could account for this increase in LOS and readmission rates.

Not surprisingly, fusion to the pelvis and the number of levels fused were independently associated with readmission and prolonged LOS, respectively. Patients requiring multilevel fusions and fusion to the pelvis likely presented with more severe deformity and required larger exposures with longer operation times compared with their counterparts who only required single-level fusions. The severity of deformity and longer OR times have the potential to negatively affect outcomes. Interestingly, prolonged LOS was an independent risk factor associated with readmission, highlighting the interconnectedness between these 2 outcome measures.

Table 4. Reasons for readmission within 30 days.

Reason for Readmission[a]	*n* (%)
Total patients readmitted	43 (100)
Wound-related complications	15 (34.9)
Deep incisional SSI	8
Superficial incisional SSI	1
Organ/space SSI	1
Wound disruption	5
Gastrointestinal-related complication[b]	4 (9.3)
Seroma or hematoma formation	2 (4.7)
Failure of internal fixation	2 (4.7)
Seizure	2 (4.7)
Breakdown of cranial or spinal infusion or shunt	2 (4.7)
Pain	1 (2.3)
Dehydration	1 (2.3)
Fever	1 (2.3)
Infection, unspecified	1 (2.3)
Pleural effusion	1 (2.3)
Cervical root disorder	1 (2.3)
Allergic urticaria	1 (2.3)
Weakness	1 (2.3)
Central nervous system complication	1 (2.3)
Unspecified	7 (16.3)

Abbreviation: SSI, surgical site infection.
[a]Reasons for readmission were provided in the International Classification of Disease, Ninth and Tenth Revisions (ICD-9 and ICD-10) codes.
[b]Includes nausea/vomiting ($n = 1$), constipation ($n = 1$), fecal impaction ($n = 1$), and ileus ($n = 1$).

While the ASA score was found to be associated with prolonged LOS on univariate analysis, this was not statistically significant when accounting for potential confounding variables on multivariate analysis. ASA classes 3 and 4 were previously shown to be associated with increased LOS and readmission after laminectomy and increased LOS in previous spinal fusion studies.[16,17,20,21,27] It was understood that ASA class was a proxy for comorbidity burden, and medical optimization may minimize the risk of LOS and readmission. While patients with congenital scoliosis often have concurrent medical syndromes, the comorbidity burden typically associated with a more adult population, such as diabetes and hypertension, is not present in this demographic. Similarly, obesity was found to be associated with prolonged LOS on univariate analysis but was not statistically significant on multivariate analysis. Obesity was previously found to be a predictor for prolonged LOS and readmission in lumbar fusion procedures, likely owing to difficulty with wound care and rehabilitation.[16]

The 2 most common reasons for readmission were wound-related complications (34.9%) and gastrointestinal-related complications, such as nausea/vomiting, constipation, fecal impaction, and ileus (9.3%). While these suspected reasons for readmission are mostly preventable with careful wound care, multimodal pain and nausea medication, and early mobility, there are other reasons for readmission that shed light on the more complex nature of patients with congenital scoliosis. Such reasons for readmission include seizure (4.7%), breakdown of cranial or spinal infusion or shunt (4.7%), and failure of internal fixation (4.7%).

This study is not without limitations. The NSQIP-P database consists of retrospectively collected data. As such, while it is very useful in identifying potential risk factors, it does not establish causality. Furthermore, certain variables were not available in the database, such as insurance status, presence of a dural tear, use of bone morphogenic protein, and spine-specific functional outcomes, all of which have the potential to affect LOS and readmission. The NSQIP-P contains readmission data only up to 30 days postoperatively. Thus, the readmission rate reported in this study could be underestimated. Finally, the NSQIP-P database is constructed by participating institutions that are likely more invested in health care quality improvement, contributing to potential selection bias.

CONCLUSION

Considering the association with medical problems and syndromes, congenital scoliosis is an area where it is crucial to understand the risk factors associated with potentially adverse outcomes following spinal fusion surgery. This study is the first to utilize a large national database to determine factors independently associated with increased LOS and unplanned readmission following spinal fusion for congenital scoliosis. By optimizing the modifiable factors that have been identified, patient outcomes following this procedure could potentially be improved. Furthermore, this study may assist in physician and patient decision-making, facilitate enhanced preoperative planning, improve patient/family counseling, and enhance postoperative care.

ACKNOWLEDGMENTS

There are no sources of financial support, conflicts of interest, or other sources of assistance to report.

REFERENCES

1. Mackel CE, Jada A, Samdani AF, et al. A comprehensive review of the diagnosis and management of congenital scoliosis. *Childs Nerv Syst*. 2018;34(11):2155–2171. doi:10.1007/s00381-018-3915-6

2. Jaskwhich D, Ali RM, Patel TC, Green DW. Congenital scoliosis. *Curr Opin Pediatr*. 2000;12(1):61–66. doi:10.1097/00008480-200002000-00012

3. Hedequist D, Emans J. Congenital scoliosis. *J Am Acad Orthop Surg*. 2004;12(4):266–275. doi:10.5435/00124635-200407000-00007

4. Pugely AJ, Martin CT, Gao Y, Ilgenfritz R, Weinstein SL. The incidence and risk factors for short-term morbidity and mortality in pediatric deformity spinal surgery: an analysis of the NSQIP pediatric database. *Spine*. 2014;39(15):1225–1234. doi:10.1097/BRS.0000000000000365

5. von Heideken J, Iversen MD, Gerdhem P. Rapidly increasing incidence in scoliosis surgery over 14 years in a nationwide sample. *Eur Spine J*. 2018;27(2):286–292. doi:10.1007/s00586-017-5346-6

6. Reames DL, Smith JS, Fu KM, et al. Complications in the surgical treatment of 19,360 cases of pediatric scoliosis: a review of the scoliosis research society morbidity and mortality database. *Spine*. 2011;36(18):1484–1491. doi:10.1097/BRS.0b013e3181f3a326

7. Fruergaard S, Ohrt-Nissen S, Pitter FT, et al. Length of stay, readmission, and mortality after primary surgery for pediatric spinal deformities: a 10-year nationwide cohort study. *Spine J*. 2021;21(4):653–663. doi:10.1016/j.spinee.2021.01.004

8. Fields MW, Lee NJ, Hong DY, et al. Cervical spinal fusion in adult patients with rheumatoid arthritis: a national analysis of complications and 90-day readmissions. *Spine*. 2021;46(1):E23–E30. doi:10.1097/BRS.0000000000003753

9. Benbassat J, Taragin M. Hospital Readmissions as a measure of quality of health care: advantages and limitations. *Arch Intern Med*. 2000;160(8):1074–1081. doi:10.1001/archinte.160.8.1074

10. Krell RW, Girotti ME, Dimick JB. Extended length of stay after surgery: complications, inefficient practice, or sick patients?. *JAMA Surg*. 2014;149(8):815–820. doi:10.1001/jamasurg.2014.629

11. Khuri SF, Henderson WG, Daley J, et al. Successful implementation of the department of veterans affairs' national surgical quality improvement program in the private sector: the patient safety in surgery study. *Ann Surg*. 2008;248(2):329–336. doi:10.1097/SLA.0b013e3181823485

12. Program ACoSNSQI. *User Guide for the 2018 ACS NSQIP Pediatric Participant Use Data File (PUF)*. 2018. https//www.facs.org/-/media/files/quality-programs/nsqip-peds/peds_nsqip_userguide_2018.ashx.

13. Hines AL, Barrett ML, Jiang HJ, Steiner CA. Conditions with the largest number of adult hospital readmissions by payer, 2011. *Healthcare Cost and Utilization Project (HCUP) Statistical Briefs*. 2006.

14. Shin JI, Kim JS, Steinberger J, DiCapua J, Cho SK. Patient factors contributing to prolonged postoperative length of stay and increased rate of readmission after elective posterior cervical fusion. *Clin Spine Surg*. 2018;31(1):E55–E61. doi:10.1097/BSD.0000000000000512

15. Eleswarapu A, Mikhael MM, Koh JL. Number of recent inpatient admissions as a risk factor for increased complications, length of stay, and cost in patients undergoing posterior lumbar fusion. *Spine*. 2014;39(26):2148–2156. doi:10.1097/BRS.0000000000000639

16. Basques BA, Fu MC, Buerba RA, Bohl DD, Golinvaux NS, Grauer JN. Using the ACS-NSQIP to identify factors affecting hospital length of stay after elective posterior lumbar fusion. *Spine*. 2014;39(6):497–502. doi:10.1097/BRS.0000000000000184

17. Gruskay JA, Fu M, Bohl DD, Webb ML, Grauer JN. Factors affecting length of stay after elective posterior lumbar spine surgery: a multivariate analysis. *Spine J*. 2015;15(6):1188–1195. doi:10.1016/j.spinee.2013.10.022

18. Wang MC, Shivakoti M, Sparapani RA, Guo C, Laud PW, Nattinger AB. Thirty-day readmissions after elective spine surgery for degenerative conditions among US Medicare beneficiaries. *Spine J*. 2012;12(10):902–911. doi:10.1016/j.spinee.2012.09.051

19. Lovecchio F, Hsu WK, Smith TR, Cybulski G, Kim B, Kim JYS. Predictors of thirty-day readmission after anterior cervical fusion. *Spine*. 2014;39(2):127–133. doi:10.1097/BRS.0000000000000051

20. Basques BA, Bohl DD, Golinvaux NS, Gruskay JA, Grauer JN. Preoperative factors affecting length of stay after elective anterior cervical discectomy and fusion with and without corpectomy: a multivariate analysis of an academic center cohort. *Spine*. 2014;39(12):939–946. doi:10.1097/BRS.0000000000000307

21. Gruskay JA, Fu M, Basques BA, et al. Factors affecting length of stay and complications after elective anterior cervical discectomy and fusion: a study of 2164 patients from the American college of surgeons national surgical quality improvement project database (ACS NSQIP): clin spine surg. *Feb*. 2016;29(1):E34–E42. doi:10.1097/BSD.0000000000000080

22. Fletcher ND, Bellaire LL, Dilbone ES, Ward LA, Bruce RW. Variability in length of stay following neuromuscular spinal fusion. *Spine Deform*. 2020;8(4):725–732. doi:10.1007/s43390-020-00081-w

23. Jain A, Puvanesarajah V, Menga EN, Sponseller PD. Unplanned hospital readmissions and reoperations after pediatric spinal fusion surgery. *Spine*. 2015;40(11):856–862. doi:10.1097/BRS.0000000000000857

24. Roddy E, Diab M. Rates and risk factors associated with unplanned hospital readmission after fusion for pediatric spinal deformity. *Spine J*. 2017;17(3):369–379. doi:10.1016/j.spinee.2016.10.008

25. Sultan AA, Berger RJ, Cantrell WA, et al. Predictors of extended length of hospital stay in adolescent idiopathic scoliosis patients undergoing posterior segmental Instrumented fusion: an analysis of 407 surgeries performed at a large academic center. *Spine*. 2019;44(10):715–722. doi:10.1097/BRS.0000000000002919

26. Winter RB, Lonstein JE, Boachie-Adjei O. Congenital spinal deformity. *Instr Course Lect*. 1996;45:117–127.

27. Basques BA, Varthi AG, Golinvaux NS, Bohl DD, Grauer JN. Patient characteristics associated with increased postoperative length of stay and readmission after elective laminectomy for lumbar spinal stenosis. *Spine*. 2014;39(10):833–840. doi:10.1097/BRS.0000000000000276

Funding: The authors received no financial support for the research, authorship, and/or publication of this article.

Declaration of Conflicting Interests: The authors report no conflicts of interest in this work.

IRB Approval: IRB approval was deemed not required as per Rutgers New Jersey Medical School guidelines.

Corresponding Author: Ari R. Berg, 185 S Orange Ave, Newark, NJ 07103, USA; ari.r.berg@gmail.com