



# A national analysis on complications and readmissions for adult cerebral palsy patients undergoing primary spinal fusion surgery

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## Abstract

**Study design** Retrospective National Database Study.

**Objective** Surgical intervention with spinal fusion is often indicated in cerebral palsy (CP) patients with progressive scoliosis. The purpose of this study was to utilize the National Readmission Database to determine the national estimates of complication rates, 90-day readmission rates, and costs associated with spinal fusion in adult patients with CP.

**Methods** The 2012–2015 NRD databases were queried for all adult (age  $\geq 19$  years) patients diagnosed with CP (ICD-9: 333.71, 343.0-4, and 343.8-9) undergoing spinal fusion (ICD-9: 81.00-08).

**Results** 1166 adult patients with CP (42.7% female) underwent spinal fusion surgery between 2012 and 2015. 153 (13.1%) were readmitted within 90 days following the primary surgery, with a mean  $33.8 \pm 26.5$  days. Mean hospital charge of the primary admission was  $\$141,416 \pm \$157,359$  and  $\$167,081 \pm \$145,416$  for the non-readmitted and readmitted patients, respectively ( $p = 0.06$ ). The mean 90-day readmission charge was  $\$72,479 \pm \$104,100$ . Most common complications with the primary admission included UTIs (no readmission vs. readmission: 7.6% vs. 4.8%;  $p = 0.18$ ), respiratory (6.9% vs. 5.6%;  $p = 0.62$ ), implant (3.8% vs. 6.0%;  $p = 0.21$ ), and paralytic ileus (3.6% vs. 3.2%;  $p = 0.858$ ). Multivariate analyses demonstrated the following as independent predictors for 90-day readmission: comorbid anemia (OR: 2.8; 95% CI: 1.6–4.9;  $p < 0.001$ ), coagulopathy (2.9, 1.1–8.0, 0.037), perioperative blood transfusion (2.0, 1.1–3.8, 0.026), wound complication (6.4, 1.3–31.6, 0.023), and transfer to short-term hospital versus routine disposition (4.9, 1.0–23.3, 0.045).

**Conclusion** Quality improvement efforts should be aimed at reducing rates of infection related complications as this was the most common reason for short-term complications and unplanned readmission following surgery.

**Keywords** Cerebral palsy · Readmission · Spinal deformity · Spinal fusion

## Introduction

Cerebral palsy (CP) is a movement and posture disorder due to a defect or lesion of the immature brain with a prevalence of 2.11 per 1000 live births worldwide [1]. The prevalence of associated scoliosis in cerebral palsy far exceeds that of the general population (15–80% vs. 1–2%) [2–4]. Surgical intervention with spinal fusion is often indicated in CP patients with progressive scoliosis to prevent deterioration in sitting ability and cardiopulmonary function [5]. Modern surgical techniques, instrumentation, and management have allowed

for improved spinal deformity correction in patients with CP [6–9]. However, large, rigid curves of adult CP patients often result in substantial risk of implant-related complications such as rod fracture, rod bending, anchor migration, junctional kyphosis, and prominent devices [4]. Therefore, surgical intervention for patients with CP remains controversial and further large-scale studies are needed to fully characterize the complications and reasons for early readmission following surgery.

Prevention of unplanned hospital readmissions following surgery is imperative for improved patient outcomes and high-quality, cost-effective care. Early readmission represents a large and increasing financial burden to the health-care system. To reduce costs and improve the quality of care, the Centers for Medicare and Medicaid Services are using readmission rates as a hospital quality metric and a means to

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penalize institutions with higher rates of readmission [10]. Hence, a current focus in surgical research has been to identify modifiable risk factors that can reduce the rates of avoidable complications and unplanned readmissions following surgery. An understanding of the risk factors for readmission is especially important for on complex patient populations, such as adult cerebral palsy patients.

Currently, there is no literature describing the complication and readmission risk profile of an adult patient with cerebral palsy undergoing spinal fusion. This paucity of information limits the ability of physicians to properly advise patients with CP regarding the risks and costs of scoliosis surgery. The purpose of this study was to utilize the National Readmission Database (NRD) to determine the national estimates of complication rates, 90-day readmission rates, costs and other outcomes associated with spinal fusion in adult patients with cerebral palsy. To the author's knowledge, the current study will provide the largest sample size for surgical outcomes following scoliosis surgery in adult CP patients.

## Methods

### Data source

This is a retrospective cohort study using the Health Cost and Utilization Project (HCUP) National Readmission Database (NRD) which is sponsored by the Agency for Healthcare Research and Quality [11]. The NRD includes about 17 million discharges annually (36 million when weighted) and tracks hospital admissions across different hospitals and state lines within a given database year. Similar to other HCUP databases, the NRD contains over 100 clinical and nonclinical variables such as those relating to patient demographics, comorbidities, insurance, cost, and hospital level factors. In addition, the data include admission weights that can be used to determine national estimates of complication rates, readmission rates, and associated costs. Compared to other HCUP databases, the NRD is unique because it contains verified patient-linkage numbers which can track patients across hospitals up to one calendar year. As this is a publicly available database that contains de-identified patient information, this study was deemed exempt by the Columbia University Institutional Review Board.

### Data collection

The 2012 to 2015 NRD databases were queried for all adult (age  $\geq 19$  years) patients diagnosed with cerebral palsy (ICD-9: 333.71, 343.0-4, and 343.8-9) undergoing spinal fusion (ICD-9: 81.00-08). Exclusion criteria included non-elective patients, neoplasms (ICD-9 140–239), rheumatic conditions (714, 720.x, 725–729.x), spina bifida (741.x,

756.17), spondylolysis (756.11), spondylolisthesis (756.12), idiopathic scoliosis (737.30), fractures (800–897.x), and infections (680–698.x). Patients cannot be tracked between each year in the NRD. Therefore, patients who were discharged within the last quarter of a given year were excluded to allow for a 90-day follow-up period for every index hospitalization. After the index patient population was queried, the “NRD\_VisitLink,” “NRD\_DaysToEvent”, and “LOS” variables were used to query for subsequent readmissions and ensure we are tracking readmissions within 90 days after discharge of the index hospitalization. “NRD\_VisitLink” is an encrypted patient linkage number provided by HCUP, which allows users to study multiple hospital visits for the same patient across hospitals and time within a given calendar year while adhering to strict privacy regulations. Each hospital encounter is associated with an “NRD\_DaysToEvent” variable which was used to calculate the days between associated admissions by “NRD\_VisitLink.”

### Perioperative factors

Data were collected on patient characteristics (i.e., age, gender, income quartile and insurance type), hospital admission details (i.e., length of stay, costs and disposition), and hospital characteristics (i.e., bed size, teaching status, and urban–rural designation). The NRD also provided predefined variables for patient comorbidities including anemia, coagulopathy, chronic pulmonary disease, depression, diabetes, hypothyroidism, hypertension, liver disease, fluid and electrolyte disorders, renal failure, and obesity. Additional predictor variables were classified based on ICD-9 diagnosis and procedure codes: smoker status (305.1, v158.2), chronic steroid use (v586.5), chronic use of anticoagulants (v586.1, v586.3, v586.6); surgical characteristics including blood transfusion (99.00, 99.02, 99.04) and fusion levels (81.62, 81.63, 81.64).

### Outcomes of interest

The primary outcome variables in this study were 90-day readmissions. Secondary outcomes included any complications associated with these admissions. A 90-day readmission was defined as any inpatient admission within 90 days of discharge from the index hospital stay. Transfers to other hospitals or rehabilitation facilities following surgery were not considered as readmissions. Reason for readmission was determined using ICD-9 diagnoses codes. Complications were also defined per ICD-9 coding: pulmonary (518.81, 518.82, 518.84, 518.52, 518.53, 997.3, 518.4, 481, 482, 482.1, 482.3, 482.31, 482.32, 482.39, 485, 486, 482.40); neurologic (997.00, 997.01, 997.02, 431, 432, 432.1, 432.9, 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, 434.91); cardiac (410.00-09, 997.1); urinary tract

complications (599.0, 997.5); thromboembolic (415.11, 415.12, 415.19, 451.82, 453.1–453.3, 453.40–453.42, 453.8, 453.9, 451.19); wound-related complications (998.51, 998.59, 996.63, 996.67, 998.83, 998.13, 998.30, 998.32); intraoperative hemorrhage or hematoma (998.11–998.13); mechanical implant-related complications (996.60, 996.63, 996.67, 996.69, 996.2, 996.40, 996.49, 996.59, 996.75, 996.77, 996.78); dural tear (349.31, 349.39); paralytic ileus (560.1); syndrome of inappropriate antidiuretic hormone (SIADH, 253.6); superior mesenteric artery syndrome (SMA, 557.1) [12, 13].

## Data analysis

Patients were categorized into those with and without readmission within 90 days of the primary spinal fusion admission. Bivariate and multivariate analyses were performed to study the relationship of patient demographics, comorbidities, operative conditions, and other clinical parameters on complications and readmissions. Categorical variables were compared using Chi-squared or Fisher's exact tests. Normally distributed, continuous variables were compared using independent t tests. Independent risk factors for readmission were identified using step-wise multivariate logistic regression. Variables demonstrating a  $p$  value less than 0.2 in the univariate analysis were subsequently assessed in the step-wise multivariate logistic regression. The odds ratios (ORs) and 95% confidence intervals (CIs) were reported for the final multivariate models. The overall quality of the model was assessed by calculating the calibration of the Homer-Lemeshow goodness-of-fit test. IBM SPSS Statistics 26 was

used for the analyses, and a  $p$  value of less than 0.05 was considered statistically significant.

## Results

A total of 1166 adult patients with CP (42.7% female) underwent spinal fusion surgery between 2012 and 2015 (Fig. 1). Of the 1166 patients, 153 (13.1%) were readmitted within 90 days following the primary surgery (Table 1). The mean (standard deviation) days to readmission was 33.8 (26.5). The mean hospital cost of the primary admission was \$141,416 (\$157,359) and \$167,081 (\$145,416) for the non-readmitted and readmitted patients, respectively ( $p$  value: 0.060). The mean 90-day readmission cost was \$72,479 (\$104,100). The most common complications associated with the primary admission included urinary tract infections (no readmission vs. readmission: 7.6% vs. 4.8%,  $p=0.178$ ), respiratory complications (6.9% vs. 5.6%,  $p=0.624$ ), implant complications (3.8% vs. 6.0%,  $p=0.212$ ), and paralytic ileus (3.6% vs. 3.2%,  $p=0.858$ ) (Table 2). 302 (25.9%) of patients had a prolonged length of stay (LOS) at the index admission ( $\geq 8$  days, 75<sup>th</sup> percentile) (Table 2). Prolonged LOS was often due to urinary tract infections or respiratory complications. 12.5% of those with prolonged LOS were readmitted. Interestingly, LOS was not found to be an independent risk factor for readmission in our multivariate analysis.

The multivariate analyses demonstrated the following as independent predictors for 90-day readmission: comorbid anemia (odds ratio 2.8, 95% confidence interval 1.6–4.9,  $p$  value  $<0.001$ ), coagulopathy (2.9, 1.1–8.0,

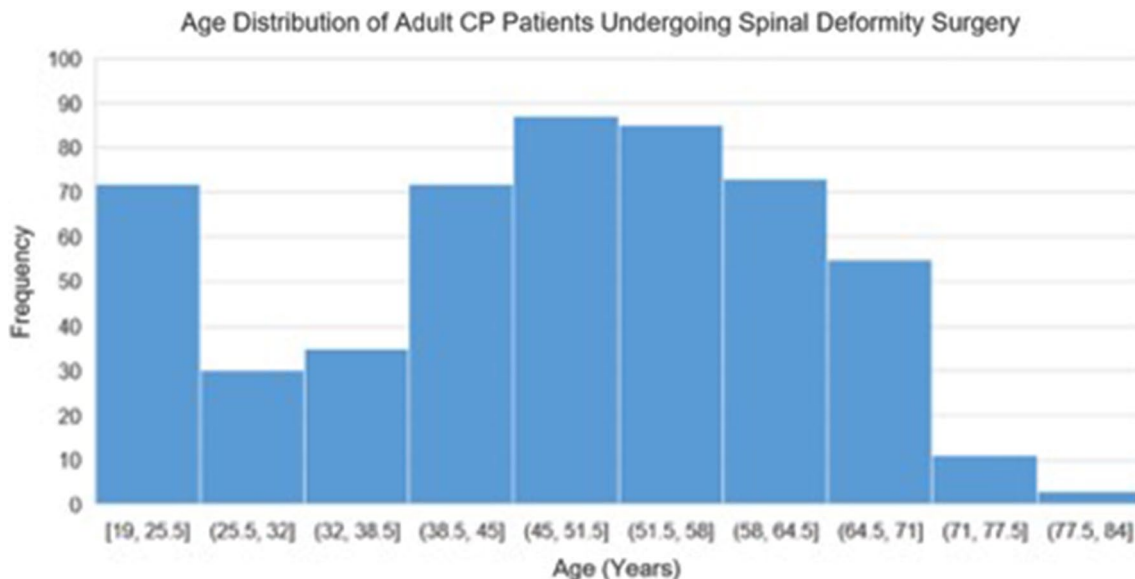


Fig. 1 Age distribution of adult CP patients undergoing spinal deformity surgery

**Table 1** Index clinical characteristics

	No 90-day readmission (n = 1013, 86.9%)	90-day readmission (n = 153, 13.1%)	P value
<i>Patient demographics</i>			
Age [Mean ± SD (Min, Max)]	47.7 ± 14.9 (19, 78)	45 ± 17.1 (19, 81)	0.043
<i>Gender (N, %)</i>			
Male	568 (56%)	100 (65.6%)	0.029
Female	446 (44%)	53 (34.4%)	
<i>Income quartile (N, %)</i>			
25th	294 (29%)	42 (27.7%)	0.336
50th	257 (25.4%)	45 (29.3%)	
75th	246 (24.3%)	35 (22.7%)	
100th	202 (19.9%)	26 (17.1%)	
<i>Primary payer (N, %)</i>			
Private	304 (30%)	42 (27.5%)	0.420
Medicaid	172 (17%)	29 (19.1%)	
Medicare	498 (49.2%)	80 (52.5%)	
Other	24 (2.4%)	1 (1%)	
Self	13 (1.3%)	0 (0%)	
<i>Patient comorbidities (N, %)</i>			
Smoker	197 (19.4%)	16 (10.1%)	0.007
Chronic steroid	4 (0.4%)	2 (1.1%)	0.144
Aspirin	38 (3.8%)	3 (1.8%)	0.262
Chronic anticoagulant	8 (0.8%)	2 (1.5%)	0.518
Osteoporosis	55 (5.4%)	9 (6.1%)	0.819
Anemia	103 (10.2%)	38 (24.8%)	<0.001
CHF	17 (1.7%)	0 (0%)	0.107
Chronic lung disease	180 (17.7%)	35 (22.9%)	0.127
Coagulopathy	23 (2.3%)	13 (8.5%)	<0.001
Depression	205 (20.2%)	15 (9.6%)	0.002
Diabetes mellitus	83 (8.2%)	10 (6.4%)	0.468
Hypertension	399 (39.4%)	62 (40.4%)	0.789
Hypothyroidism	98 (9.7%)	14 (8.9%)	0.822
Liver disease	12 (1.2%)	0 (0%)	0.176
Fluid and electrolyte disorder	133 (13.1%)	22 (14.1%)	0.690
Obesity	130 (12.8%)	9 (5.9%)	0.014
Renal failure	23 (2.3%)	0 (0%)	0.060
<i>Surgical characteristics (N, %)</i>			
<i>Fusion levels</i>			
2/3	628 (61.9%)	62 (40.3%)	<0.001
4–8	218 (21.5%)	41 (26.7%)	0.143
GE9	125 (12.4%)	43 (27.8%)	<0.001
Blood transfusion	112 (11%)	35 (22.9%)	<0.001
<i>Hospital characteristics</i>			
Length of stay [mean ± SD (Min, Max)]	7.6 ± 11.6 (0, 174)	7.9 ± 9.1 (1, 46)	0.794
<i>Bed size (N, %)</i>			
Small	96 (9.5%)	11 (6.9%)	0.004
Medium	241 (23.8%)	20 (13.3%)	
Large	676 (66.7%)	122 (79.8%)	
<i>Teaching status (N, %)</i>			
Metropolitan teaching	771 (76.1%)	119 (77.6%)	0.068
Metropolitan non-teaching	219 (21.6%)	26 (17.1%)	
Non-metropolitan	24 (2.3%)	8 (5.2%)	

**Table 1** (continued)

	No 90-day readmission ( <i>n</i> = 1013, 86.9%)	90-day readmission ( <i>n</i> = 153, 13.1%)	<i>P</i> value
<i>Disposition (N, %)</i>			
Routing	527 (52%)	70 (45.6%)	0.265
AMA	2 (0.2%)	0 (0%)	
Home health care	220 (21.7%)	30 (19.7%)	
Subacute nursing facility	248 (24.4%)	49 (32.3%)	
Transfer short-term hospital	17 (1.7%)	4 (2.5%)	

**Table 2** Index-related complications

	No 90-day readmission ( <i>n</i> = 1013, 86.9%)	90-day readmission ( <i>n</i> = 153, 13.1%)	<i>P</i> value
Cardiac ( <i>N, %</i> )	10 (1%)	0 (0%)	0.217
Pulmonary	70 (6.9%)	9 (5.6%)	0.624
Neurological	8 (0.8%)	2 (1.5%)	0.518
UTI	77 (7.6%)	7 (4.8%)	0.178
Renal	12 (1.2%)	0 (0%)	0.176
DVT/PE	3 (0.3%)	0 (0%)	0.500
Paralytic Ileus	36 (3.6%)	5 (3.2%)	0.858
SIADH	3 (0.3%)	1 (0.9%)	0.481
Wound	11 (1.1%)	5 (3.6%)	0.031
Hemorrhage	16 (1.6%)	2 (1.1%)	0.729
Implant	38 (3.8%)	9 (6%)	0.212
Dural tear	29 (2.9%)	1 (0.9%)	0.108

**Table 3** Multivariate step-wise logistic regression analysis showing independent risk factors for 90-day readmissions; H–L *p* value < 0.001

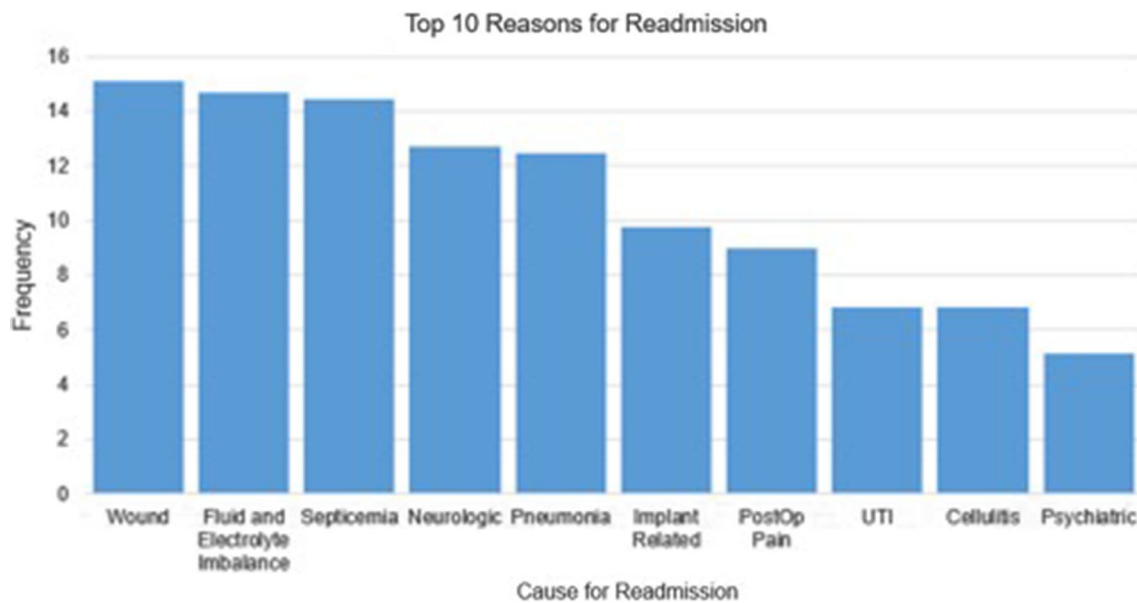
Effect	Odds ratio	95% Confidence interval	<i>P</i> value
Anemia	2.8	(1.6, 4.9)	< 0.001
Coagulopathy	2.9	(1.1, 8.0)	0.037
Blood transfusion	2	(1.1, 3.8)	0.026
Wound complication	6.4	(1.3, 31.6)	0.023
Transfer disposition	4.9	(1.0, 23.3)	0.045

0.037), perioperative blood transfusion (2.0, 1.1–3.8, 0.026), wound complication (6.4, 1.3–31.6, 0.023), and transfer to short term hospital versus routine disposition (4.9, 1.0–23.3, 0.045) (Table 3). The top three reasons for 90-day readmission included wound complication (9.8%), dehydration/electrolyte imbalance (9.6%), and septicemia (9.4%) (Fig. 2). Age, gender, smoking status, depression, obesity, and fusion level were significant in the bivariate analyses, but did not remain significant risk factors in the multivariate analyses.

## Discussion

The number of adults with cerebral palsy has increased and placed greater demands on the healthcare system [14]. Advances in the management of cerebral palsy have allowed for patients with severe cases to survive into adolescence and adulthood. Multiple medical comorbidities and severe deformities are common in the adult cerebral palsy population and as a result increase the risk of perioperative complications and readmissions. Early, unplanned readmission following surgery is associated with poor outcomes and accounts for more than \$17 billion in avoidable Medicare expenditures alone [15]. An understanding of the modifiable risk factors that can help prevent readmission after surgery is crucial for the creation of preventative strategies. The purpose of this study was to understand the complication and readmission risk profile of an adult patient with cerebral palsy undergoing spinal fusion surgery on a national level.

Overall, postoperative complications during the index inpatient stay were high in this population (22.7%). It is known that CP patients carry a high comorbidity profile prior to surgery that may not likely be improved by surgery and may actually complicate the perioperative course. The most common comorbidities reported were hypertension, chronic lung disease, fluid and electrolyte disorders, depression, and smoking. The majority of the inpatient complications were related to urinary tract infections and respiratory complications. These complications may stem from the complex nature of cerebral palsy where the risk of urinary tract infections and respiratory disease is increased. The increased morbidity in CP patients is likely secondary to urinary tract and respiratory muscle dysfunction [16]. Lower urinary tract dysfunctions such as vesicoureteral reflux and incomplete bladder emptying resulting from detrusor muscle hypertonicity often manifest as urinary tract infection [16]. In adult patients without CP, the rate of urinary tract and respiratory infections complicating primary admission for spinal deformity surgery has been reported to be 4% and 6%, respectively [17]. 84 (7.2%) patients experienced urinary tract infections during the primary admission in this patient cohort. These results are consistent with previous research reporting a prevalence of 2.2–32.5% of urinary tract



**Fig. 2** Top 10 reasons for readmission

infections among cerebral palsy patients [18, 19]. Furthermore, urinary tract infections made up 4.5% of the total reasons for 90-day readmissions. Our results highlight the importance of quality programs aimed at preventing urinary tract infections by identifying patients at risk and minimizing the prolonged use of indwelling urethral catheters following surgery.

In this cohort, 79 (6.8%) patients experienced a respiratory complication during the primary admission. Pulmonary complications (i.e., pneumonia, respiratory failure, aspiration pneumonitis) made up 12.3% of the total reasons for 90-day readmission. Respiratory diseases are the most frequent causes of morbidity and mortality in cerebral palsy [20]. Specifically, patients with cerebral palsy are prone to pulmonary infections secondary to recurrent aspiration events, impaired airway clearance and deformity of the spine and/or chest wall [21]. These results emphasize the importance of monitoring these patients for signs of postoperative pneumonia and implementing procedures to minimize high-risk events such as aspiration.

In this study, the national 90-day readmission rate for cerebral palsy patients undergoing spinal fusion was determined to be 13.1%. Manoharan et al. reported a 7.5% 30-day readmission rate after surgery for adult spinal deformity with the most common reasons for readmission being infection, bleeding or seroma, pain, implant-related complications, and thromboembolic complications [22]. The higher observed rate of readmission in adult CP patients may be secondary to a greater number of/more severe medical comorbidities and increased risk of complications at baseline when compared to adult patients without CP. In comparison with previous

studies on readmission following spine surgery in pediatric CP patients is shown a similar readmission rate of 16.1% [23]. However, this rate is calculated from single-surgeon experience and future studies estimating the national readmission rate for pediatric CP patients are needed for proper comparison to adults.

The leading cause of unplanned 90-day readmissions was infection (wound complication, sepsis, pneumonia, urinary tract infections, cellulitis, central line infection, other), 38.9%. In addition, a wound-related complication during the index stay was determined to be an independent risk factor for 90-day readmission. Wound complications after major spinal surgery is a significant problem that is burdensome to the patient and costly to the healthcare system. In prior literature, the postoperative wound infection following spine surgery in patients with neuromuscular diseases is known to be high and is [24] reported to range from 4 to 14% [9, 25–29]. It is possible that a generalized decline in the immune status of the neuromuscular patient may contribute to increased risk of postoperative wound infection. In addition, poor personal hygiene, soiling of the wound, and spasticity resulting difficulty in wound closure may also contribute to wound and implant-related complications.

Based on the adjusted analyses, other risk factors for unplanned readmissions include comorbid anemia, coagulopathy, and perioperative blood transfusion. These results are consistent with previous studies demonstrating blood transfusion to be an independent risk factor for unplanned readmission within 30 days of discharge following elective spine surgery. The mechanism by which blood transfusion increases postoperative morbidity and risk of readmission is

unknown. However, ongoing research has suggested there to be some evidence of a transient depression of the immune system following transfusion of blood products [30]. Our results suggest that perioperative hematologic status must be closely monitored prior to spinal fusion surgery. Potential perioperative interventions to limit blood loss may include better patient positioning, reduced operative time, and minimally invasive surgery when possible [31].

Primary admission and readmission following spinal fusion for adult patients with cerebral palsy was extremely costly. At the primary admission, readmitted patients were billed more than non-readmitted patients (\$167,081 vs. \$141,416). Although the reasons for this discrepancy are unclear, readmitted patients may experience higher billing charges due to more severe baseline deformities/complications requiring more extensive care. Despite this finding, total charge at primary admission was not determined to be an independent risk factor for readmission. A study utilizing the National Inpatient Sample data found hospitalization expenditures for adult spinal deformity surgery to be \$43,433 in 2013 [32]. In addition, previous literature in pediatrics found that children with neuromuscular disease undergoing scoliosis surgery incurred approximately \$20,000 more in hospital charges compared to children with other indications for surgery [33]. It can be speculated that CP patients may have more complex cases, requiring more extensive care, resulting in more costly inpatient surgical stays. Readmission costs were also found to be significant with a mean billing charge of \$72,479. Therefore, intensive monitoring programs to identify individuals at high risk of readmission will not only improve patient care but also have the potential for major cost-savings.

There are several limitations to this study that must be appreciated. One major limitation of this database is the inability to determine if the readmission was related to the primary fusion admission. The criteria to determine the relationship between hospital admissions and readmission visit are left to the analyst based on ICD-9 diagnosis/procedure codes. However, this may lead to significant reporting bias as the data provided do not give enough detail to determine whether the readmission was related. To prevent this bias, we report on all-cause readmissions in this study. In addition, ICD-9 codes were used for defining primary diagnoses, complications, reason for readmission, and procedures which may lead to misclassification bias. For example, problems with accuracy of ICD-9 coding can emerge if there is incomplete coding of data, errors caused by redundant coding, and errors caused by the coder. By design, this database does not provide in-depth operative details which can inform the reader a more accurate understanding of the complexity of surgery performed for these patients. Finally, this study's findings generate a list of potential risk factors; however, more research is needed to further understand the nature and

clinical utility of the connection between the identified risk factors and outcomes.

## Conclusion

The management of cerebral palsy is complex and carries many unique challenges especially into the adult years of life. Despite the perioperative complications and risk for readmission in spinal deformity surgery, the majority of patients with CP are satisfied with the results and report functional improvements [5]. Quality improvement efforts should be aimed at reducing rates of infection related complications as this was the most common reason for short term complications and unplanned readmission following surgery. In addition, perioperative optimization of hematological status may help to reduce readmission rates.

Although the majority of spinal deformity surgery for CP patients occurs in early/adolescent life, it is not uncommon for adults with CP to experience curve progression necessitating surgical intervention [34, 35]. This study is the first to demonstrate on a national level the short-term complications and readmissions after spine deformity surgery in adult patients with cerebral palsy. Further research is needed to understand whether earlier surgical intervention (i.e., prior to skeletal maturity and adulthood) has the potential to reduce complication/readmission rates and associated costs. Nevertheless, the results of this study may guide the development of future strategies aimed at improving the quality of care, and perhaps assist providers in efficiently allocating healthcare resources.

## Declarations

**Conflict of interest** There was no funding for this study. This manuscript has not been previously published in whole or in part or submitted elsewhere for review.

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