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Post-discharge rehabilitation and functional recovery after pediatric injury

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ABSTRACT

Introduction: Variability in rehabilitation disposition has been proposed as a trauma center quality metric. Benchmarking rehabilitation disposition is limited by a lack of objective measures of functional impairment at discharge. The primary aim of this study was to determine the relative contribution of patient characteristics and hospitalization factors associated with inpatient and outpatient rehabilitation after discharge. The secondary aims were to evaluate the sensitivity of the Functional Status Scale (FSS) score for identifying functional impairments at hospital discharge and track post-discharge recovery.

Patients and methods: We report a planned secondary analysis of a prospective observational study of seriously injured children (<15 years old) enrolled at seven pediatric trauma centers. Functional Status Scale (FSS) score was measured for pre-injury, hospital discharge, and 6-month follow-up timepoints. Multinomial logistic regression identified factors associated with three dispositions: home without rehabilitation services, home with outpatient rehabilitation, and inpatient rehabilitation. Relative weight analysis was used to identify the impact of individual factors associated with inpatient or outpatient rehabilitation disposition.

Results: We analyzed 427 children with serious injuries. Functional impairment at discharge was present in 103 (24.1%) children, including 43/337 (12.8%) discharged without services, 12/38 (31.6%) discharged with outpatient rehabilitation, and 44/47 (93.6%) discharged to inpatient rehabilitation. In multivariable modeling, variables most contributing to prediction of inpatient rehabilitation were severe initial Glasgow coma scale (GCS), injured body region, and functional impairment at discharge. Severe initial GCS, private insurance, and extremity injury were independently associated with disposition with outpatient rehabilitation. Patients discharged without services or with outpatient rehabilitation most frequently had motor impairments that improved during the next 6 months. Patients discharged to inpatient rehabilitation had impairments in all domains, with many improving within 6 months. A higher proportion of patients discharged to inpatient rehabilitation had residual impairments at follow-up.

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Conclusion: Injury characteristics and discharge impairment were associated with discharge to inpatient rehabilitation. The FSS score identified impairments needing inpatient rehabilitation and characterized improvements after discharge. Less severe impairments needing outpatient rehabilitation were not identified by the FSS score.

Introduction

Although mortality after hospitalization for pediatric injury continues to decline, it remains the most common outcome metric for trauma research and for evaluating trauma center quality [1–3]. Because most hospitalized children survive their injuries, evaluation of post-injury impairments and rehabilitation potential can target therapeutic interventions that improve long-term outcomes. However, assessment for entry into rehabilitation services is not standardized, resulting in variable utilization across centers [4–6]. Objective measurement of functional impairment at discharge may identify patients who should receive rehabilitation services and facilitate more precise benchmarking of trauma center use of rehabilitation services.

Assessments to identify functional impairment and quantify recovery have been described, primarily for children with traumatic brain injuries [7–10]. An instrument that identifies functional impairments associated with recovery potential among children with a more diverse range of injuries has not been identified [3,11]. One potential instrument is the Functional Status Scale (FSS) score, which assesses functional impairments across 6 domains (mental status, sensory, communication, motor, feeding, and respiratory) [12–15]. This measure has been validated in pediatric populations and has increasingly been used to track functional impairments after traumatic injury and in general pediatric intensive care unit (PICU) populations [11,16-21].

The National Institute of Health's Collaborative Pediatric Critical Care Research Network (CPCCRN) conducted a prospective study to evaluate functional impairments after pediatric trauma: the "Assessment of Functional Outcomes and Health-Related Quality of Life after Pediatric Trauma" study [22]. This report is a planned secondary analysis to 1) determine the relative contribution of factors associated with discharge to inpatient and outpatient rehabilitation, 2) evaluate the sensitivity of the FSS score to identify functional impairments at hospital discharge, and 3) track post-discharge recovery.

Patients and methods

Patients and setting

This prospective observational cohort study was conducted at seven CPCCRN sites between March 2018 and September 2020. Each participating site is a level 1 pediatric trauma center. A complete description of this study has been previously published [22]. Briefly, children (<15 years old) were included who survived a serious, severe, or critical injury (Abbreviated Injury Scale [AIS] severity score ≥ 3) sustained by a blunt or penetrating mechanism. Patients admitted for a burn injury, those not surviving to hospital discharge, and patients whose parents did not speak English or Spanish were excluded from the parent study. Enrollment was targeted at 50 patients per site per year and designed to oversample children with less commonly injured body regions (spine > thorax > abdomen > extremity > head) and those with injuries in more than one body region. Enrollment was adjusted quarterly to enhance the inclusion of patients in each injury category, with a goal of 70% with single injured body regions and 30% with multiple regions. The Institutional Review Board at the University of Utah approved this study through a central mechanism. Written consent was obtained from the parents or guardians of subjects and assent when appropriate based on patient age.

Data collection

Patient and hospitalization characteristics were obtained from the medical record. The parents or guardians self-reported race, ethnicity, and insurance status. Injury and physiologic data were obtained from the trauma registry, including injured body region, injury type (blunt versus penetrating), injury mechanism, initial Glasgow Coma Scale (GCS), initial systolic blood pressure and heart rate, and intensive care unit (ICU) length of stay. Blunt injuries were further classified based on the underlying mechanism (fall, motor vehicle collision occupant, pedestrian, transport other/motorcycle, pedal cyclist, struck by/against, 'other' or 'unknown'). "Child abuse" was classified based on medical record review rather than using diagnosis codes from registry data due to known inconsistencies in trauma registry coding of child abuse [23]. Severe GCS was defined as a GCS total of <9 or a GCS motor of <5 [22]. Vital signs (blood pressure and heart rate) were standardized to a z-score using age-based data [24–26]. Discharge disposition was obtained from trauma registry data and was classified as discharge without services, outpatient rehabilitation, or inpatient rehabilitation for the primary analyses. Only three patients were discharged to skilled nursing care. These subjects are described but not included in the primary analyses.

Pre-injury, discharge, and 6-month functional status was evaluated using the Functional Status Scale (FSS) score. Pre-injury and hospital discharge FSS scores were acquired by chart review and interviews with the parent/guardian or clinical care team. The 6 FSS domains are scored 1 (normal) to 5 (severely abnormal), resulting in a total ranging from 6 to 30. Total FSS scores were categorized as normal [6–7], mildly abnormal [8–9], and moderately to very severely abnormal (>9). Post-discharge assessments were obtained at 6-month follow-up and included FSS scores and proxy reports of the PedsQL^{TM} 4.0 quality of life inventory for children older than 2 years and the infant scales for those under 2 years of age [27]. Follow-up was conducted by phone, email, or chart review when phone contact was not made. PedsQL^{TM} was unable to be obtained by chart review.

Statistical analysis

Patient and hospitalization characteristics were summarized using count and proportion for categorical variables or median and interquartile range (IQR) for continuous variables. The primary outcome was rehabilitation-related discharge disposition: no rehabilitation services, outpatient rehabilitation, or inpatient rehabilitation. We calculated the sensitivity and specificity of identifying a new domain impairment measured by FSS relative to identification of impairment based on rehabilitation disposition. Calculations evaluating parameters for inpatient rehabilitation excluded patients discharged with outpatient rehabilitation. For outpatient rehabilitation calculations, patients discharged with inpatient rehabilitation were excluded. We performed a multinomial logistic regression to evaluate patient and injury characteristics associated

with discharge to outpatient rehabilitation or inpatient rehabilitation. Univariate analyses were conducted using Fisher's exact or Kruskal-Wallis tests as appropriate. The multivariable models included age, race/ethnicity, insurance status, injured body region, initial GCS, and functional status at discharge measured by the FSS score. We assessed collinearity using condition indices and variance inflation factors and removed colinear variables. We used relative weight analysis to measure each variable's contribution to outcomes in each multinomial logistic regression model. We evaluated functional status and health-related quality of life for patients with 6-month follow-up data available. In patients with abnormal functional status at discharge (FSS score >7), we characterized the frequency of domain-specific impairments using a more sensitive threshold of an FSS domain score > 1 to define impairments at discharge and 6-month follow-up. We defined significance using two-tailed tests at $p<0.05$. Analyses were completed using SAS version 9.4 (Cary, NC).

Results

Patient characteristics

The 427-patient cohort was predominantly male (n = 271, 63.5%), White (n = 277, 64.9%) and included 64 (15.0%) patients under 1 year old and 150 (35.1%) patients over 10 years old (Table 1). A similar proportion of children had an insurance status that was private or commercial (49.9%) and Medicaid or Medicare (46.4%). Most (97.0%) patients had normal pre-injury functional status (FSS 6-7). Injured body regions included: 115 (26.9%) isolated extremity injuries, 144 (33.7%) head injuries (including 47 (32.6%) with severe injuries), 30 (7.0%) isolated thorax, 81 (19.0%) isolated abdomen, 21 (4.9%) isolated spine, and 73 (17.1%) with multiple body region injuries (Table 2). The most common mechanisms of injury were fall (29.3%), followed by motor vehicle collision (18.0%), and child abuse (10.5%). Nearly half (40.7%) of patients were admitted to the ICU with a median ICU length of stay of 4 days (IQR 2, 7). The median hospital length of stay was 3 days (IQR 2, 8).

Post-discharge rehabilitation was prescribed in 85 (19.9%) children, 38 (8.9%) outpatient and 47 (11.0%) inpatient (Table 1). Among 337 (78.9%) patients discharged without services, 43 (12.8%) had functional impairment at discharge, including 38 (88.3%) who had impairment classified as mild (FSS 8-9) (Table 2). Among patients discharged with outpatient rehabilitation, 12 (31.6%) had impairment at discharge, including mild impairment in 7 (18.4%) and moderate impairment in 5 (13.2%) (Table 2 and Fig. 1). Among patients discharged to inpatient rehabilitation, 44 (93.6%) had functional impairment at discharge, including mild impairment in 21 (44.7%) and moderate impairment in 23 (48.9%). A new domain morbidity at hospital discharge (an increase of more than two points in a domain-specific FSS score) was 79% (asymptotic confidence interval [CI] 67%-90%) sensitive and 92% (CI 89%-95%) specific for identifying impairments among patients discharged with inpatient rehabilitation and 16% (CI 4-27%) sensitive and 92% (CI 89-95%) specific for identifying impairments among those discharged with outpatient rehabilitation.

Factors associated with disposition to a rehabilitation program

Five patients were excluded from the multivariable models evaluating factors associated with disposition status due to unknown follow-up (n = 2, 0.5%) and discharge to skilled nursing or long-term care facility (n = 3, 0.7%). Patients with severe head injuries were more frequently discharged to inpatient rehabilita-

Table 1
Demographics by discharge disposition.

		Rehabilitation disposition[1]				
	Overall (n = 427)	Skilled nursing care (n = 3)	No services (n = 337)	Outpatient rehabilitation (n = 38)	Inpatient rehabilitation (n = 47)	p-value
Age Category, n (%)						.49[2]
< 1 year	64 (15.0)	0 (0.0)	54 (84.4)	4 (6.3)	5 (7.8)	
1-4 years	102 (23.9)	0 (0.0)	84 (82.4)	11 (10.8)	7 (6.9)	
5-9 years	111 (26.0)	1 (0.9)	87 (78.4)	10 (9.0)	13 (11.7)	
10-14 years	150 (35.1)	2 (1.3)	112 (74.7)	13 (8.7)	22 (14.7)	
Male Sex, n (%)	271 (63.5)	2 (0.7)	211 (77.9)	26 (9.6)	30 (11.1)	.82[2]
Race, n (%)						.41[2]
White	277 (64.9)	1 (0.4)	221 (79.8)	28 (10.1)	27 (9.7)	
Black	95 (22.2)	2 (2.1)	70 (73.7)	6 (6.3)	15 (15.8)	
Other	54 (12.6)	0 (0.0)	45 (83.3)	4 (7.4)	5 (9.3)	
Unknown[3]	1 (0.2)	0 (0.0)	1 (100.0)	0 (0.0)	0 (0.0)	
Ethnicity, n (%)						.17[2]
Hispanic or Latino	49 (11.5)	1 (2.0)	33 (67.3)	6 (12.2)	8 (16.3)	
Not Hispanic or Latino	376 (88.1)	2 (0.5)	302 (80.3)	32 (8.5)	39 (10.4)	
Unknown[3]	2 (0.5)	0 (0.0)	2 (100.0)	0 (0.0)	0 (0.0)	
Preferred Language, n (%)						.48[2]
English	412 (96.5)	3 (0.7)	326 (79.1)	37 (9.0)	44 (10.7)	
Spanish	15 (3.5)	0 (0.0)	11 (73.3)	1 (6.7)	3 (20.0)	
Insurance, n (%)						.09[2]
Private/Commercial	213 (49.9)	0 (0.0)	166 (77.9)	25 (11.7)	21 (9.9)	
Medicaid/Medicare	198 (46.4)	3 (1.5)	157 (79.3)	11 (5.6)	26 (13.1)	
Self-Pay/No Insurance	12 (2.8)	0 (0.0)	10 (83.3)	2 (16.7)	0 (0.0)	
Unknown[3]	4 (0.9)	0 (0.0)	4 (100.0)	0 (0.0)	0 (0.0)	
Baseline FSS Score Category, n (%)						.66[2]
Normal (6-7)	414 (97.0)	3 (0.7)	327 (79.0)	36 (8.7)	46 (11.1)	
Not Normal (8+)	13 (3.0)	0 (0.0)	10 (76.9)	2 (15.4)	1 (7.7)	

Percentages in overall column are column percentages; percentages under Rehabilitation disposition columns are row percentages.
FSS: Functional Status Scale
[1] Two patients had a missing discharge disposition
[2] Fisher's exact test (Monte Carlo approximation for tables larger than 2×2) comparing no rehabilitation, outpatient, and inpatient prescriptions.
[3] Not included in p-value calculation.

Table 2
Injury characteristics, initial physiology, and hospital-based resource utilization by discharge disposition group.

		Rehabilitation disposition[1]				
	Overall (n = 427)	Skilled nursing care (n = 3)	No services (n = 337)	Outpatient rehabilitation (n = 38)	Inpatient rehabilitation (n = 47)	p-value
Injured Body Region, n (%)						< .001[2]
Multiple head (severe)	24 (5.6)	2 (8.3)	2 (8.3)	3 (12.5)	16 (66.7)	
Multiple head (not severe)	13 (3.0)	0 (0.0)	9 (69.2)	1 (7.7)	3 (23.1)	
Multiple excluding head	36 (8.4)	0 (0.0)	25 (69.4)	4 (11.1)	7 (19.4)	
Isolated head (severe)	23 (5.4)	0 (0.0)	10 (43.5)	3 (13.0)	9 (39.1)	
Isolated head (not severe)	84 (19.7)	0 (0.0)	75 (89.3)	7 (8.3)	2 (2.4)	
Isolated thorax	30 (7.0)	1 (3.3)	27 (90.0)	2 (6.7)	0 (0.0)	
Isolated abdomen	81 (19.0)	0 (0.0)	77 (95.1)	3 (3.7)	1 (1.2)	
Isolated spine	21 (4.9)	0 (0.0)	14 (66.7)	1 (4.8)	6 (28.6)	
Isolated extremity	115 (26.9)	0 (0.0)	98 (85.2)	14 (12.2)	3 (2.6)	
Number of Body Regions with a Serious Injury, n (%)						< .001[2]
1	354 (82.9)	1 (0.3)	301 (85.0)	30 (8.5)	21 (5.9)	
2	46 (10.8)	0 (0.0)	28 (60.9)	6 (13.0)	12 (26.1)	
>2	27 (6.3)	2 (7.4)	8 (29.6)	2 (7.4)	14 (51.9)	
Injury Type, n (%)						.06[2]
Blunt	380 (89.0)	2 (0.5)	303 (79.7)	34 (8.9)	40 (10.5)	
Penetrating	17 (4.0)	1 (5.9)	10 (58.8)	1 (5.9)	5 (29.4)	
Unknown[4]	30 (7.0)	0 (0.0)	24 (80.0)	3 (10.0)	2 (6.7)	
Mechanism of Injury, n (%)						< .001[2]
Child Abuse	45 (10.5)	0 (0.0)	35 (77.8)	5 (11.1)	4 (8.9)	
Penetrating	11 (2.6)	1 (9.1)	6 (54.5)	0 (0.0)	4 (36.4)	
Fall	125 (29.3)	0 (0.0)	113 (90.4)	10 (8.0)	2 (1.6)	
Motor vehicle collision occupant	77 (18.0)	2 (2.6)	47 (61.0)	10 (13.0)	18 (23.4)	
Pedestrian	30 (7.0)	0 (0.0)	18 (60.0)	3 (10.0)	8 (26.7)	
Transport other/motorcycle	20 (4.7)	0 (0.0)	18 (90.0)	2 (10.0)	0 (0.0)	
Cyclist	23 (5.4)	0 (0.0)	22 (95.7)	1 (4.3)	0 (0.0)	
Struck by/against	31 (7.3)	0 (0.0)	24 (77.4)	2 (6.5)	5 (16.1)	
Other	15 (3.5)	0 (0.0)	14 (93.3)	0 (0.0)	1 (6.7)	
Unknown[4]	50 (11.7)	0 (0.0)	40 (80.0)	5 (10.0)	5 (10.0)	
Severe Head Injury[5], n (%) 45 (10.5) 2 (4.4) 10 (22.2) 8 (17.8) 24 (53.3)						< .001
Unknown[4] 37 (8.7) 0 (0.0) 27 (73.0) 3 (8.1) 6 (16.2)						
Age Adjusted Systolic Blood Pressure Category, n (%)						.07[2]
Normal	379 (88.8)	2 (0.5)	301 (79.4)	33 (8.7)	42 (11.1)	
Not normal	15 (3.5)	1 (6.7)	8 (53.3)	3 (20.0)	3 (20.0)	
Unknown[4]	33 (7.7)	0 (0.0)	28 (84.8)	2 (6.1)	2 (6.1)	
Age Adjusted Pulse Rate Category, n (%)						.73[2]
Normal	277 (64.9)	1 (0.4)	221 (79.8)	23 (8.3)	31 (11.2)	
Not normal	132 (30.9)	2 (1.5)	102 (77.3)	14 (10.6)	14 (10.6)	
Unknown[4]	18 (4.2)	0 (0.0)	14 (77.8)	1 (5.6)	2 (11.1)	
ICU Admission, n (%)	174 (40.7)	3 (1.7)	105 (60.3)	23 (13.2)	42 (24.1)	< .001[2]
Unknown[4]	11 (2.6)	0 (0.0)	8 (72.7)	0 (0.0)	2 (18.2)	
ICU Length of Stay if Admitted to ICU, median [IQR]	4.0 [2.0, 7.0]	13.0 [8.0, 41.0]	2.0 [2.0, 4.0]	5.0 [3.0, 13.0]	10.0 [6.0, 18.0]	< .001[3]
Hospital Length of Stay (days), median [IQR]	3.0 [2.0, 8.0]	33.0 [11.0, 51.0]	3.0 [1.0, 5.0]	5.0 [4.0, 12.0]	17.0 [12.0, 29.0]	< .001[3]
Discharge Total FSS Score Category, n (%)						< .001[2]
6-7 (normal)	324 (75.9)	1 (0.3)	294 (90.7)	26 (8.0)	3 (0.9)	
8-9 (mildly abnormal)[7]	67 (15.7)	0 (0.0)	38 (56.7)	7 (10.4)	21 (31.3)	
>9 (moderately to very severely abnormal)[7]	36 (8.4)	2 (5.6)	5 (13.9)	5 (13.9)	23 (63.9)	
New Domain Morbidities at Discharge[8], n (%)						
No new domain morbidity	353 (82.7)	1 (0.3)	309 (87.5)	32 (9.1)	10 (2.8)	< .001[2]
Domains with New Morbidities[8]						
Mental status	11 (2.6)	0 (0.0)	0 (0.0)	0 (0.0)	11 (100.0)	< .001[2]
Sensory	10 (2.3)	1 (10.0)	0 (0.0)	1 (10.0)	8 (80.0)	< .001[2]
Communication	9 (2.1)	1 (11.1)	1 (11.1)	1 (11.1)	6 (66.7)	< .001[2]
Motor	60 (14.1)	2 (3.3)	25 (41.7)	3 (5.0)	29 (48.3)	< .001[2]
Feeding	23 (5.4)	1 (4.3)	2 (8.7)	1 (4.3)	18 (78.3)	< .001[2]
Respiratory	2 (0.5)	1 (50.0)	0 (0.0)	0 (0.0)	1 (50.0)	.21[2]

Percentages in overall column are column percentages; percentages under Rehab status columns are row percentages.
ICU: Intensive Care Unit; FSS: Functional Status Scale.
[1] Two patients had a missing discharge disposition
[2] Fisher's exact test (Monte Carlo approximation for tables larger than 2×2) comparing no rehabilitation, outpatient, and inpatient prescriptions.
[3] Kruskal-Wallis test comparing no rehabilitation, outpatient, and inpatient prescriptions.
[4] Not included in p-value calculation.
[5] Severe Glasgow Coma Scale (GCS) defined as total GCS < 9 or motor GCS < 5.
[6] Normal = z-score -1.96 to 1.96, not normal = < -1.96 or > 1.96.
[7] One patient in this cohort with missing disposition category.
[8] New morbidity defined as an increase in domain-specific FSS score ≥ 2.

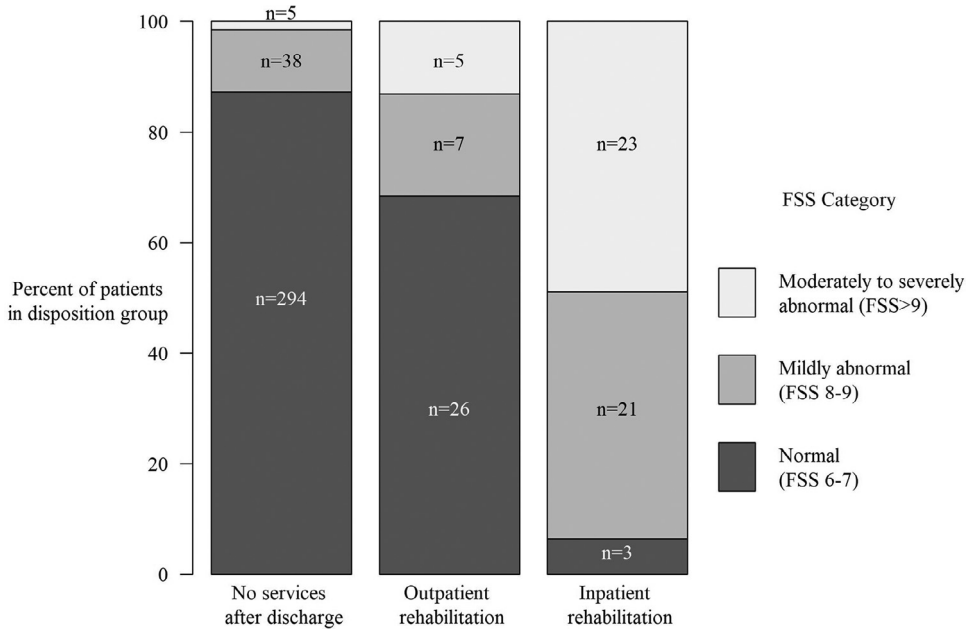

Fig. 1. Total Functional Status Scale (FSS) Score at hospital discharge is associated with rehabilitation disposition.

tion, particularly when these patients had injuries in other body regions (Table 2). Most patients with injuries to an isolated body region were discharged without services. Patients with injuries involving more than two body regions or an injury from a penetrating mechanism were more often discharged to inpatient rehabilitation. Intensive care unit and hospital lengths of stay were shortest for those discharged without services, intermediate for those discharged with outpatient rehabilitation, and longest for those discharged to inpatient rehabilitation. Patients with impairments at discharge as measured by the FSS score were most often discharged to inpatient rehabilitation. Five patients with moderately to severely abnormal FSS scores at discharge were discharged without services (Supplemental Table 3). These five patients were characterized by abnormal pre-illness FSS scores, isolated injuries most frequently caused by a fall, 4 of 5 were cared for outside of the ICU, and 4 of 5 had less than a 1-point increase between their pre-illness and hospital discharge FSS scores.

In the multivariable model comparing discharge to inpatient rehabilitation and home without services, variables most contributing to prediction were abnormal FSS score at discharge (40.00%), severely abnormal admission GCS (21.34%), and injured body region (21.26%) (Table 3). In the multivariable model comparing discharge to outpatient rehabilitation and home without services, variables most contributing to prediction were severely abnormal admission GCS (35.20%), injured body region (20.58%) weighted primarily on extremity fractures, and insurance status (19.80%) (Table 3). In a multivariable model comparing discharge to inpatient rehabilitation and outpatient rehabilitation, variables most contributing to prediction of inpatient rehabilitation were abnormal FSS score at discharge (39.63%), injured body region (21.03%), and severely abnormal admission GCS (18.87%).

Post-discharge recovery

Six-month follow-up data were available for 323 (75.6%) patients. Among these patients, most (n = 290, 89.8%) had normal functional status at 6 months (Table 4). Across all three disposition groups, the proportion of patients with impaired functional status decreased between discharge and 6-month follow-up (Fig. 2). This improvement was most notable among patients discharged to inpatient rehabilitation (3/47 [6.4%] normal at discharge to 25/38 [65.8%] normal at follow-up) (Tables 2 and 4). The effects of the impairments were also identified using the PedsQL^{TM} score (Table 4). Patients discharged without services or with outpatient rehabilitation had higher PedsQL^{TM} scores 6 months after discharge compared to those discharged to inpatient rehabilitation (median 92.9 [IQR 82.6, 98.8] versus 93.5 [82.6, 98.9] versus 81.5 [60.9, 91.3], $p < 0.001$).

To characterize recovery in the most severely affected cohort, we evaluated the 81 (19.0%) patients who had functional impairment (FSS > 7) at discharge and completed 6-month follow-up (Supplemental Tables 1 and 2). For this analysis, we applied a more sensitive threshold of an increase of ≥ 1 in an FSS domain-specific score to define impairment. Motor impairments were most frequent among the 33 impaired patients discharged without services (93.9%, $n = 31$) (Fig. 3). At 6-month follow-up, only 7 (21.2%) of the 33 patients discharged without services had a residual motor impairment (Fig. 3). Among the 11 impaired patients discharged with outpatient rehabilitation, all had motor impairment at discharge. At 6-month follow-up, only 3 (27.3%) had a residual motor impairment. All domains were affected among the 35 impaired patients discharged to inpatient rehabilitation. Mental status, sensory, and feeding domains were most frequently impaired. Impairments improved across all domains in these 35 patients, but residual impairments occurred most often in the motor (n = 11, 31.4%) and communication (n = 11, 31.4%) domains (Fig. 3).

Discussion

In this multicenter cohort of children hospitalized after injury, we identified patient factors, injury characteristics, and impairments at discharge associated with rehabilitation disposition. Functional impairment at discharge was associated with disposition to inpatient rehabilitation and contributed to about 40% of the prediction of this outcome. While FSS score was most sensitive in detecting impairments treated with inpatient rehabilitation, other factors such as severe GCS and injured body region also contributed to the predictive model. The FSS score was less sensitive in identifying impairments treated with outpatient rehabilitation. Outpatient rehabilitation was associated with patient (e.g., insurance status) and

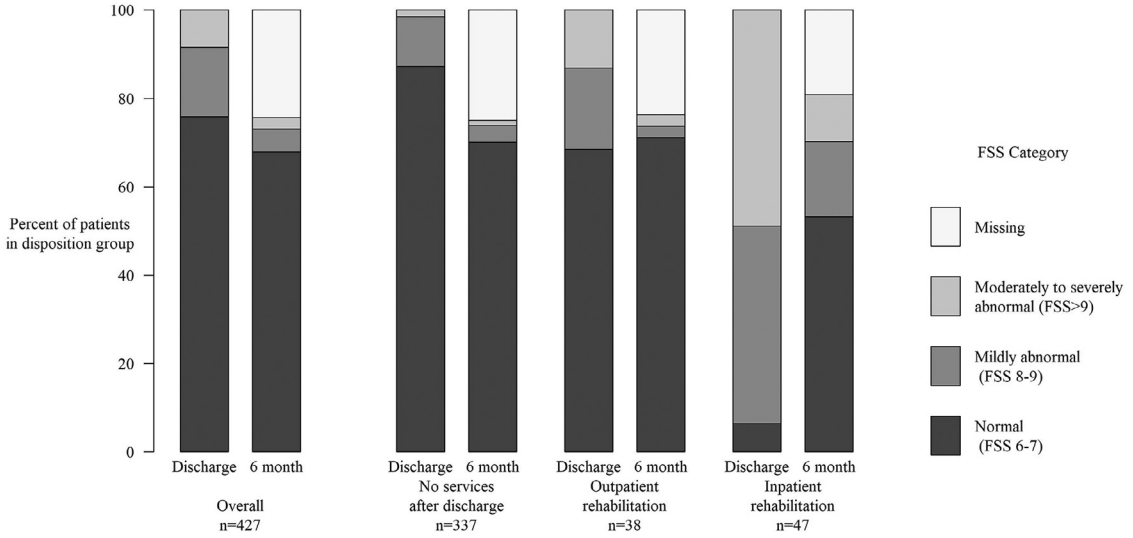

Fig. 2. Functional Status Scale (FSS) score categories at discharge and 6-month follow-up overall and by rehabilitation disposition.

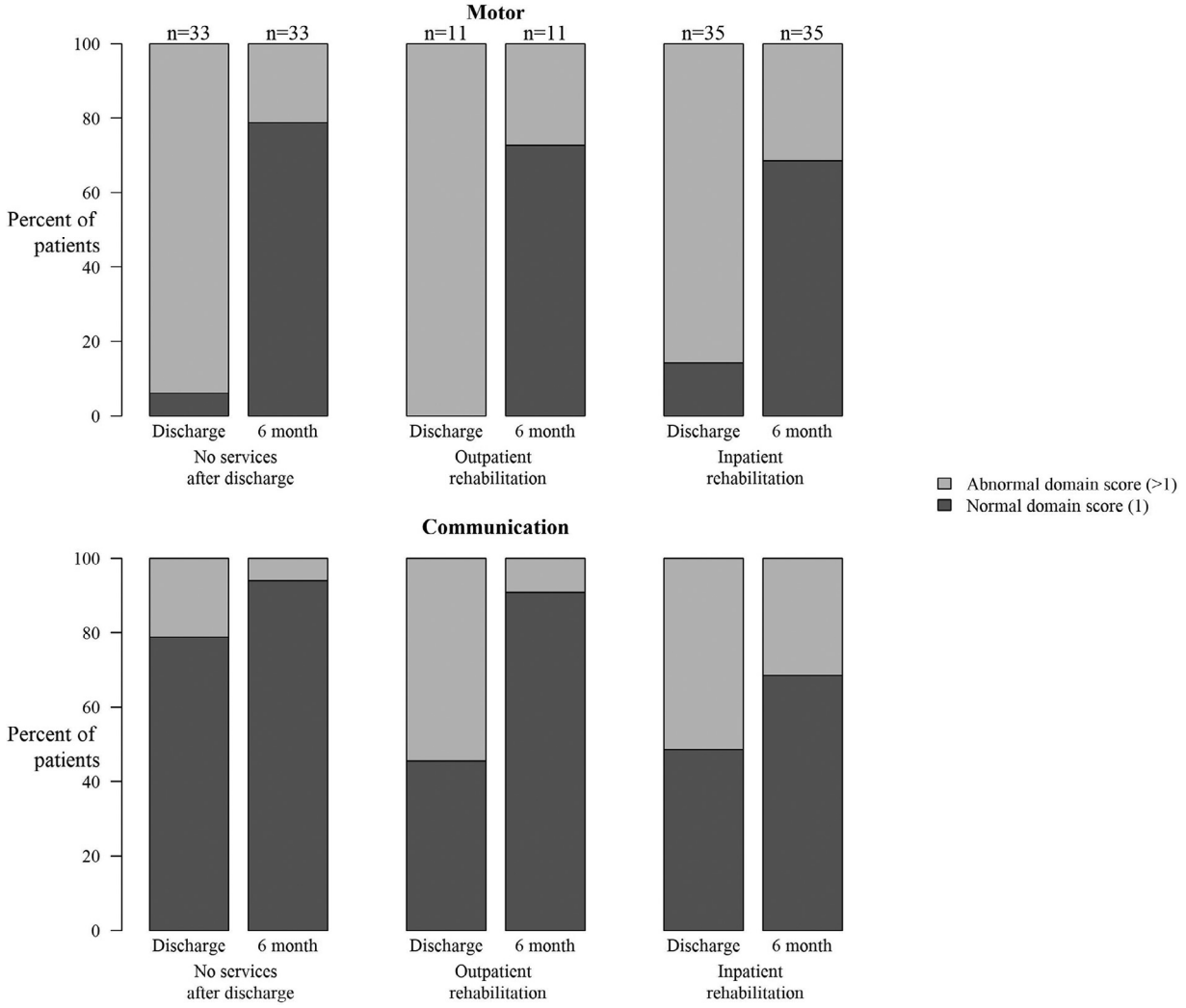

Fig. 3. Domain-specific improvements in patients with an abnormal functional status scale (fss) score at discharge and complete follow-up data (n = 81).

Table 3
Factors associated with discharge disposition to outpatient rehabilitation or inpatient rehabilitation compared to reference of no services or outpatient rehabilitation.

	Outpatient Rehabilitation (versus no services)		Inpatient Rehabilitation (versus no services)		Inpatient Rehabilitation (versus outpatient rehabilitation)	
	Odds Ratio (95% CI)	Relative weight (%)	Odds Ratio (95% CI)	Relative weight (%)	Odds Ratio (95% CI)	Relative weight (%)
Age Category (Reference: 10-14 years old age group)						
< 1 year	0.40 (0.25, 0.63)	3.74	0.03 (0.01, 0.08)	1.50	0.07 (0.02, 0.20)	3.09
1-4 years	0.47 (0.32, 0.69)	0.42	0.02 (0.01, 0.04)	9.20	0.03 (0.01, 0.09)	11.40
5-9 years	0.90 (0.64, 1.28)	0.80	0.47 (0.25, 0.88)	0.41	0.52 (0.27, 1.03)	0.50
Race/Ethnicity (Reference: non-Hispanic White)						
Hispanic/Latino	1.02 (0.65, 1.59)	3.72	0.66 (0.25, 1.73)	1.18	0.65 (0.24, 1.73)	0.65
Non-Hispanic Black	1.07 (0.73, 1.58)	0.60	5.06 (2.56, 10.02)	2.52	4.72 (2.25, 9.89)	2.10
Non-Hispanic Other	0.64 (0.39, 1.06)	5.35	20.52 (8.79, 47.89)	1.34	31.89 (12.40, 82.03)	1.75
	2.4 (1.78, 3.22)	19.80	2.35 (1.38, 4.00)	1.30	0.98 (0.56, 1.74)	1.00
Private/Commercial Insurance						
Injured Body Region						
Extremity	2.95 (1.61, 5.40)	11.22	11.12 (4.95, 24.99)	2.10	3.77 (1.52, 9.31)	2.18
Spine	0.88 (0.25, 3.12)	0.74	80.95 (28.97, 226.17)	12.00	91.53 (20.42, 410.31)	12.66
Head	2.50 (1.34, 4.67)	3.12	13.28 (5.82, 30.31)	4.69	5.31 (2.10, 13.42)	2.82
Thorax	0.90 (0.47, 1.70)	2.30	1.44 (0.65, 3.17)	2.05	1.60 (0.65, 3.91)	3.06
Abdomen	0.92 (0.51, 1.65)	3.20	2.07 (0.95, 4.49)	0.42	2.25 (0.92, 5.49)	0.31
Severe GCS[1]	10.68 (6.65, 17.13)	35.20	146.98 (66.70, 323.89)	21.34	13.77 (6.13, 30.91)	18.87
Discharge FSS Score Category (Reference: Total FSS Score 6-7 (normal))						
FSS 8-9 (mildly abnormal)	1.32 (0.89, 1.96)	1.88	42.43 (21.55, 83.52)	19.54	32.08 (15.52, 66.30)	19.92
FSS > 9 (moderately to very severely abnormal)	1.36 (0.72, 2.57)	7.91	66.05 (28.60, 152.54)	20.42	48.67 (19.52, 121.34)	19.71

Model includes 383 subjects, patients with missing data elements and those discharged to skilled nursing facilities ($n = 3$) were not included.
CI: confidence interval; FSS: functional status scale.
[1] Severe Glasgow Coma Scale (GCS) defined as total GCS < 9 or motor GCS < 5.

Table 4
Six month outcomes.

		Rehabilitation disposition				
	Overall ($n = 427$)	Skilled nursing care ($n = 3$)	No services ($n = 337$)	Outpatient rehabilitation ($n = 38$)	Inpatient rehabilitation ($n = 47$)	*p*-value
FSS Score Category at 6-month Follow-up, n (%)						< .001[1]
6-7 (normal)	290 (67.9)	2 (66.7)	236 (70.0)	27 (71.1)	25 (53.2)	
8-9 (mildly abnormal)	22 (5.2)	0 (0.0)	13 (3.9)	1 (2.6)	8 (17.0)	
≥ 10 (moderately to very severely abnormal)	11 (2.6)	1 (33.3)	4 (1.2)	1 (2.6)	5 (10.6)	
Unknown[3]	104 (24.4)	0 (0.0)	84 (24.9)	9 (23.7)	9 (19.1)	
PedsQL™ Total Score						< .001[2]
Mean (SD)	86.5 (15.0)	58.0 (5.5)	88.4 (13.1)	88.3 (14.1)	74.8 (20.2)	
Median [IQR]	92.0 [79.3, 97.8]	58.7 [52.2, 63.0]	92.9 [82.6, 98.8]	93.5 [82.6, 98.9]	81.5 [60.9, 91.3]	

FSS: Functional Status Scale; SD: Standard deviation; IQR: interquartile range.
[1] Fisher's exact test with Monte Carlo approximation compare no rehabilitation, outpatient, and inpatient prescriptions.
[2] Kruskal-Wallis test compare no rehabilitation, outpatient, and inpatient prescriptions.
[3] Not included in *p*-value calculation

injury (e.g., injured body region and severe GCS) characteristics. Additionally, the FSS score was useful for tracking morbidities and identifying severe discharge impairments and recovery patterns.

Injury factors including severe GCS and injured body region were key predictors in models comparing disposition to inpatient rehabilitation and with outpatient rehabilitation relative to home without services. When evaluating inpatient rehabilitation relative to discharge with outpatient rehabilitation or without services, FSS at discharge was also a key predictor suggesting its value as an identifier of the need for inpatient rehabilitation. When evaluating outpatient rehabilitation relative to discharge without services, the FSS score contributed less than 10% of the relative weight of the model and private or commercial insurance contributed nearly 20%. These findings suggest that inpatient rehabilitation is allocated based on impairments at discharge and injury characteristics, but that access to outpatient rehabilitation may differ based on a patient's insurance [28–30].

The FSS score at discharge was highly specific for identifying new impairments treated with rehabilitation, but the sensitivity varied. The FSS score identified nearly all patients with impairments discharged to inpatient rehabilitation but was less effective in identifying patients with impairments discharged with outpa-

tient rehabilitation. The low sensitivity of the FSS in identifying patients discharged to an outpatient rehabilitation program shows its limited value in detecting less severe impairments. As previously reported in a pediatric brain injured cohort, application of scores sensitive to less severe injury, such as the Pediatric Functional Independence Measure, in combination with the FSS may provide a better approach that addresses the heterogeneity of impairments among injured children [7].

Among patients with functional impairments at discharge, impairments improved across all disposition groups during the 6 months after hospitalization. Patients discharged without services and those discharged with outpatient rehabilitation most frequently had motor impairments. Similar to other reports, a significant proportion of the motor impairments improved at 6 months even though full recovery was not observed in all patients [8]. Among patients discharged to inpatient rehabilitation, discharge impairments were observed across all domains, most commonly mental status, communication, motor, and feeding. During the 6 months after discharge, improvements were observed in nearly all domains. Similar to findings reported in studies of survivors of pediatric injury, most gains were identified in the communication, motor, and feeding domains [31,32]. Despite overall improvement, nearly one-third of patients with disposition to inpatient rehabilitation had residual communication and motor impairments at 6 months.

This study has several limitations. First, about one-fourth of our cohort did not have 6-month follow-up data. These data may not be missing at random, leading to bias in applying complete case analysis. Second, follow-up was limited to 6-month outcomes. A longer follow-up period may show additional changes in the trajectory of recovery. Third, we conducted this study at pediatric hospitals with level 1 trauma centers. Assessment of rehabilitation use in other hospital types will be needed to establish the generalizability of these findings. Finally, although relative weight analysis can evaluate contribution of the variable to the prediction model, this approach has several limitations, including how closely sampled values represent true population values and residual effects arising when variables are highly correlated. Although multivariable regression remains the mainstay of evaluating the relationship between predictors and outcomes, relative weight analysis provides additional insight into the strength of these relationships [33].

Conclusions

This study identifies that the FSS can be used to identify the most severe impairments at discharge, particularly impairments needing inpatient rehabilitation. However, other injury factors also contributed to the allocation of inpatient rehabilitation. The FSS score may be a useful tool for determining the post-discharge recovery of patients with severe impairment but is less useful for identifying less severe impairments requiring outpatient rehabilitation. Future research should focus on identifying impairments in the less severely impaired patients and characterizing the trajectory of recovery over a longer period.

Declaration of Competing Interest

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2022.05.023.

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