Long-Term Outcomes after Pediatric Injury: Results of the Assessment of Functional Outcomes and Health-Related Quality of Life after Pediatric Trauma Study

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BACKGROUND: Disability and impaired health-related quality of life can persist for months among injured children. Previous studies of long-term outcomes have focused mainly on children with specific injury types rather than those with multiple injured body regions. This study's objective was to determine the long-term functional status and health-related quality of life after serious pediatric injury, and to evaluate the associations of these outcomes with features available at hospital discharge.

STUDY DESIGN: We conducted a prospective observational study at 7 Level I pediatric trauma centers of children treated for at least 1 serious (Abbreviated Injury Scale severity 3 or higher) injury. Patients were sampled to increase the representation of less frequently injured body regions and multiple injured body regions. Six-month functional status was measured using the Functional Status Scale (FSS) and health-related quality of life using the Pediatric Quality of Life Inventory.

RESULTS: Among 323 injured children with complete discharge and follow-up assessments, 6-month FSS score was abnormal in 33 patients (10.2%)—16 with persistent impairments and 17 previously normal at discharge. Increasing levels of impaired discharge FSS score were associated with impaired FSS and lower Pediatric Quality of Life Inventory scores at 6-month follow-up. Additional factors on multivariable analysis associated with 6-month FSS impairment included older age, penetrating injury type, severe head injuries, and spine injuries, and included older age for lower 6-month Pediatric Quality of Life Inventory scores.

CONCLUSIONS: Older age and discharge functional status are associated with long-term impairment of functional status and health-related quality of life. Although most seriously injured children return to normal, ongoing disability and reduced health-related quality of life remained 6 months after injury. Our findings support long-term assessments as standard practice for

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More than 6 million children are treated for an injury in an emergency department in the US each year,[1] with more than 150,000 requiring admission to a trauma center.[2] Nearly 20% of injured children treated in an emergency department will have a residual functional limitation at 4 months and 8% will have impairment at 9 months.[2] Children hospitalized for a serious injury have a several-fold higher risk of residual functional impairment, with functional limitations being observed in as many as 60%.[2,3] Injuries have a similar impact on health-related quality of life (HRQoL), with decreases from normal observed in about 75% of hospitalized children at 1 month after injury and nearly 10% at 12 months.[4]

Although the long-term morbidity of pediatric injury has been established, measuring these outcomes is often challenging. These challenges include participant attrition, incomplete responses, and lack of resources for measuring and tracking outcomes.[5] Factors available at discharge associated with long-term status can be used to identify groups that should be prioritized for follow-up assessment or post-hospitalization interventions. Targeting resources toward evaluating those at risk would improve the efficiency of assessing long-term outcomes among injured children and partially address barriers to implementing these assessments.[6] The association between discharge and follow-up functional status has been evaluated, but a consistent relationship has not been observed in adult trauma patients.[7,8] Although these findings suggest the need for follow-up assessments, this association has not been evaluated previously in a cohort of injured children with diverse injury types.

We conducted a prospective observational 2-year, multicenter study evaluating 6-month functional status and HRQoL in a sample of children hospitalized for at least 1 serious injury at 7 pediatric trauma centers. We hypothesized that patient demographic characteristics, injury characteristics, and discharge functional status would be associated with 6-month impaired functional status and HRQoL.

METHODS

Study design

The Assessment of Functional Outcomes and Health-Related Quality of Life after Pediatric Trauma was a prospective observational study performed from March 2018 to February 2020 at the 7 pediatric trauma centers participating in the NIH-funded Collaborative Pediatric Critical Care Research Network. Using data from this study, we previously identified cohorts of injured children at the highest risk for discharge functional impairment based on injury patterns.[9] This report describes outcomes assessments at 6 months and the relationships of these outcomes with factors observed at discharge. The IRB at the University of Utah approved this study through a central mechanism. Written consent was obtained for participation in this study. The parent or guardian received financial incentives for enrollment and follow-up participation.

Eligibility criteria, sampling strategy, and enrollment procedures have been described previously.[9] In brief, children (younger than 15 years) who sustained a blunt or penetrating injury in 1 or more major body regions (ie head, thorax, abdomen, spine, or extremities [upper and lower]) were eligible for enrollment. We included only hospitalized patients who had an injury classified as serious, severe, or critical (Abbreviated Injury Scale 3 severity 3 to 5). Eligibility was limited to patients whose parents or guardians spoke English or Spanish for ensuring completion of discharge survey and follow-up telephone and email assessments. We prioritized sampling of children with less commonly injured body regions (least to most common: spine, thorax, abdomen, extremity, and head) and multiple injured body regions. Eligible patients were approached for enrollment based on this sampling strategy. Enrollment targets at each site were set at 50 patients per year, with a goal of 70% of children with isolated injured body regions and 30% with multiple injured body regions. After enrollment, patients were categorized based on the following 3 factors: the presence of single or multiple injured body regions, the body region injured when isolated, and the severity of head injury when present. A severe head injury was defined as an initial Glasgow Coma Scale (GCS) score of < 9 or a GCS motor score of < 5. Patients with a missing total GCS were classified as severe because missingness is associated with abnormal GCS and mortality.[10]

Data collection

Self-reported race, ethnicity, and insurance status were obtained from surveys completed by the parent or guardian. We used medical chart review to determine pre-injury medical conditions based on a prespecified classification.

Abbreviations and Acronyms

FSS = Functional Status Scale
GCS = Glasgow Coma Scale
HRQoL = health-related quality of life
PedsQL = Pediatric Quality of Life Inventory

We obtained injury type (blunt vs penetrating), injury mechanism, and initial GCS from the institutional trauma registries. Child physical abuse was based on a medical record diagnosis. Functional status was measured with the Functional Status Scale (FSS), a validated measure that assesses function in the following 6 domains: mental status, sensory, communication, motor, feeding, and respiratory status.[11] Total FSS scores are calculated as a composite of the values in each domain and range from "good" (FSS score 6 or 7) to "very severely abnormal" (FSS score > 21). Because it is performed rapidly and is easy to implement, FSS has been used in previous large-scale studies assessing the outcomes of critically ill and injured children.[12] HRQoL was assessed using the parent-proxy Pediatric Quality of Life Inventory (PedsQL).[13,14] PedsQL scores are on a 0 to 100 scale, with higher scores indicating better HRQoL. A change of 4.5 in PedsQL is the smallest change of clinical relevance.[15]

FSS at hospital discharge was obtained by interviews with clinical caretakers and the medical record. To ensure consistent outcomes measurement, trained surveyors located at the University of Utah obtained 6-month assessments using FSS and PedsQL. We evaluated long-term outcomes at this interval based on evidence showing a recovery plateau at this time point.[3,4,16] When initial contact could not be made by telephone, survey instruments were emailed for completion. FSS was obtained by electronic medical record review when possible if telephone and email contacts were not successful.[17] A data coordinating center monitored enrollment, validated collated data, and conducted the statistical analyses.

Statistical analysis

The study's primary outcomes were abnormal FSS (>7) and total PedsQL scores at 6 months. We assessed the univariable associations of demographic- and injury-related variables and discharge functional status with these 2 follow-up status measures using the Mantel-Haenszel chi-square exact, Fisher exact, Kruskal-Wallis, or Wilcoxon rank sum tests. Multivariable models were used to evaluate the associations of each primary end point with discharge functional status, age, injury type, child physical abuse, injury category, and severe head injury. We selected covariates for multivariable modeling a priori based on the potential for influencing functional outcomes using a literature review and domain knowledge. Patients with missing data were excluded from these models using casewise deletion. Six-month FSS was modeled using multivariable logistic regression (normal or abnormal), and 6-month PedsQL using multivariable linear regression. We used inverse probability weights in these regressions to adjust for the sampling strategy used at enrollment. To compare all possible pairs of injury categories as predictors of 6-month functional impairment, we varied the injury category used as the reference group in the multivariable model. We reported these pairwise adjusted odds ratios using a matrix with different reference and comparison injury categories. Analyses were performed using SAS, version 9.4 (SAS Institute). We defined significance at $p < 0.05$ with 2-sided tests.

RESULTS

Study population

Among 835 patients assessed for eligibility, 654 met inclusion criteria, 493 were approached for consent, and 428 consented. One patient without a qualifying injury was removed after consent. Among the 427 patients, 323 (75.6%) had complete discharge and 6-month follow-up FSS assessments and were included in this report. Differences in follow-up were observed based on insurance status and ethnicity (eTable 1).

A similar proportion of the 323 patients were in each age category (Table 1). Most patients were male (n = 207 [64.1%], Table 1). Race and ethnicity were most often White (n = 215 [66.6%]) and non-Hispanic (n = 294 [91.0%]), respectively. Most had either private insurance (n = 180 [55.7%]) or Medicaid or Medicare (n = 130 [40.2%]) as primary coverage. Pre-injury comorbidities were observed in 52 children (16%). The pre-injury functional status of most patients was normal (n = 312 [96.6%]). Blunt trauma was the predominant injury type (n = 288 [89.2%]), and falls were the most frequent injury mechanism (n = 93 [29%]) (Table 2). Patients most commonly had a single body region injury (n = 264 [81.7%]), usually an isolated extremity or head injury. Thirty-two patients (10%) presented with a severe head injury based on initial GCS values.

Functional status

Long-term follow-up FSS was abnormal in 33 patients (10%), 22 with a "mildly abnormal" FSS and 11 with a more than "moderately abnormal" FSS (Table 2).

Table 1. Relationship Between Functional Status and Health-Related Quality of Life at 6-Month Follow-Up and Patient Characteristics

			FSS score at follow-up								
	Overall (n = 323)		6–7 (good) (n = 290)		8–9 (mildly abnormal) (n = 22)		> 9 (moderately to very severely abnormal) (n = 11)			PedsQL at follow-up, median (IQR) (n = 279)	
Characteristic	n	%	n	%	n	%	n	%	p Value		p Value
Age category									0.15*		0.002†
0–4 y	119	37	109	92	8	7	2	2		94.0 (89.3–98.8)	
5–9 y	89	28	81	91	5	6	3	3		91.3 (75.5–97.8)	
10–14 y	115	36	100	87	9	8	6	5		87.0 (75.0–97.8)	
Sex									0.58‡		0.49§
Male	207	64	185	89	16	8	6	3		92.4 (78.3–97.9)	
Female	116	36	105	91	6	5	5	4		92.4 (83.7–97.8)	
Race									0.70‡		0.66†
White	215	67	195	91	12	6	8	4		92.8 (81.5–97.8)	
Black	68	21	59	87	7	10	2	3		92.4 (72.8–98.4)	
Other	39	12	35	90	3	8	1	3		90.6 (81.5–98.8)	
Missing‖	1	0	1	100	0	0	0	0		90.2 (90.2–90.2)	
Ethnicity									0.21‡		0.17§
Hispanic or Latino	27	8	22	81	3	11	2	7		90.3 (67.9–95.7)	
Not Hispanic or Latino	294	91	266	91	19	6	9	3		92.4 (81.5–97.9)	
Missing‖	2	1	2	100	0	0	0	0		85.9 (71.7–100.0)	
Insurance									0.73‡		0.04†
Private or commercial	180	56	161	89	11	6	8	4		91.3 (81.0–97.8)	
Medicaid or Medicare	130	40	116	89	11	8	3	2		92.4 (76.1–97.8)	
Self-pay or no insurance	9	3	9	100	0	0	0	0		98.9 (97.3–100.0)	
Missing‖	4	1	4	100	0	0	0	0		95.7 (68.5–100.0)	
Chronic diagnosis									0.04‡		0.002†
None	271	84	248	92	15	6	8	3		93.2 (83.7–98.9)	
Respiratory (asthma)	12	4	11	92	1	8	0	0		85.9 (70.7–93.5)	
Cardiovascular disease (arrhythmia or congenital)	2	1	1	50	1	50	0	0		88.9 (82.1–95.7)	
Neurologic (seizure or other)	5	2	4	80	0	0	1	20		93.5 (76.6–99.5)	
Other	33	10	26	79	5	15	2	6		77.2 (69.6–89.8)	
Preinjury FSS									0.31‡		0.02§
Normal (6–7)	312	97	281	90	21	7	10	3		92.4 (81.5–97.9)	
Not normal (>7)	11	3	9	82	1	9	1	9		72.8 (65.2–79.3)	

*Mantel-Haenszel chi-square exact test with Monte Carlo approximation.
†Kruskal-Wallis test.
‡Fisher exact test with Monte Carlo approximation.
§Wilcoxon rank sum test.
‖Not included in p value calculation.
FSS, Functional Status Scale; IQR, interquartile range; PedsQL, Pediatric Quality of Life Inventory.

Table 2. Relationships Between Functional and Health-Related Quality of Life at 6-Month Follow-Up and Injury Characteristics

Characteristic	Overall (n = 323)		FSS at follow-up: 6–7 (good) (n = 290)		FSS at follow-up: 8–9 (mildly abnormal) (n = 22)		FSS at follow-up: > 9 (moderately to very severely abnormal) (n = 11)			PedsQL at follow-up, median (IQR) (n = 279)	
	n	%	n	%	n	%	n	%	p Value		p Value
Injury category									< 0.001*		0.004†
Multiple head (severe)	19	6	12	63	4	21	3	16		72.8 (60.9–95.7)	
Multiple head (not severe)	10	3	10	100	0	0	0	0		91.8 (86.5–95.5)	
Multiple excluding head	30	9	27	90	3	10	0	0		94.0 (78.3–98.9)	
Isolated head (severe)	13	4	9	69	3	23	1	8		85.0 (59.8–93.5)	
Isolated head (not severe)	61	19	58	95	2	3	1	2		92.4 (87.2–98.9)	
Isolated thorax	22	7	20	91	2	9	0	0		95.7 (85.3–98.9)	
Isolated abdomen	58	18	57	98	1	2	0	0		96.7 (85.9–98.9)	
Isolated spine	17	5	13	76	0	0	4	24		82.6 (71.7–93.5)	
Isolated extremity	93	29	84	90	7	8	2	2		91.3 (77.2–96.4)	
No. of body regions with AIS ≥3									0.05‡		0.02†
1	264	81.7	241	91.3	15	6	8	3		92.4 (81.5–97.9)	
2	37	11	32	86	4	11	1	3		93.8 (85.3–98.9)	
> 2	22	7	17	77	3	14	2	9		77.2 (59.8–95.7)	
Injury type									0.31*		0.66§
Blunt	288	89.2	259	89.9	18	6	11	4		92.4 (79.9–98.4)	
Penetrating	14	4	12	86	2	14	0	0		91.5 (70.0–97.3)	
Missing‖	21	7	19	90	2	10	0	0		92.4 (83.7–97.2)	
Mechanism of injury									0.23*		0.09†
Child abuse	30	9	27	90	2	7	1	3		92.9 (88.9–97.2)	
Penetrating	8	2	7	88	1	13	0	0		93.5 (52.2–100.0)	
Fall	93	29	88	95	2	2	3	3		94.0 (85.7–98.9)	
Motor vehicle collision occupant	62	19	53	85	5	8	4	6		84.8 (67.4–97.6)	
Pedestrian	22	7	15	68	5	23	2	9		83.7 (65.2–95.7)	
Transport other or motorcycle	16	5	15	94	1	6	0	0		93.5 (77.2–98.9)	
Cyclist	19	6	18	95	1	5	0	0		95.7 (85.9–100.0)	
Struck by or against	26	8	24	92	1	4	1	4		93.5 (80.4–98.9)	
Other	10	3	10	100	0	0	0	0		88.6 (76.2–97.7)	
Missing‖	37	11	33	89	4	11	0	0		91.7 (83.7–97.8)	
Severe head injury									< 0.001*		0.004§
No	291	90	269	92	15	5	7	2		92.8 (81.5–98.8)	
Yes	32	10	21	66	7	22	4	13		84.5 (60.9–93.5)	
Discharge FSS									< 0.001‡		< 0.001†

(Continued)

Table 2. Continued

Characteristic	Overall (n = 323) n	%	6–7 (good) (n = 290) n	%	8–9 (mildly abnormal) (n = 22) n	%	> 9 (moderately to very severely abnormal) (n = 11) n	%	p Value	PedsQL at follow-up, median (IQR) (n = 279)	p Value
			FSS at follow-up								
6–7 (good)	242	75	225	93	13	5	4	2		93.2 (82.6–98.9)	
8–9 (mildly abnormal)	53	16	48	91	3	6	2	4		90.4 (79.3–97.6)	
> 9 (moderately to very severely abnormal)	28	9	17	61	6	21	5	18		67.9 (58.7–91.3)	

*Mantel-Haenszel chi-square exact test with Monte Carlo approximation.
†Kruskal-Wallis test.
‡Fisher exact test with Monte Carlo approximation.
§Wilcoxon rank sum test.
‖Not included in p value calculation.
AIS, Abbreviated Injury Scale; FSS, Functional Status Scale; IQR, interquartile range; PedsQL, Pediatric Quality of Life Inventory.

Seventeen of these 33 patients had no impairment at hospital discharge and 16 had persistent impairment at 6 months. Among the patients who were normal at discharge and became abnormal at follow-up, 13 changed to a "mildly abnormal" FSS and 4 to a "moderately abnormal" FSS. Eighty-one patients had hospital discharge FSS impairment, including 65 (80%) who had normal FSS at follow-up (Table 2).

Several factors at discharge were associated with 6-month follow-up FSS impairment on univariable analysis, including the presence of pre-existing chronic diagnoses, injury category, severe head injuries, and abnormal discharge FSS (Tables 1 and 2). The highest proportion of FSS follow-up impairment > 9 was among those with multiple injured body regions with a severe head injury (3 of 19 [16%]), isolated severe head injuries (1 of 13 [8%]), and isolated spine injuries (4 of 17 [24%]). Consistent with these proportions, patients with a severe head injury had a follow-up FSS > 9 more often than those without (Table 2). Among the 17 patients with spinal injuries, 4 had cord injuries in addition to fractures or ligamentous injuries. Two patients with spinal cord injuries had residual functional impairment at follow-up.

Using multivariable analysis, we observed that follow-up functional impairment was associated with older age, injuries from a penetrating mechanism, and severe head injuries (Tables 3 and 4). Pairwise comparison of injuries by body region showed isolated abdominal and thorax injuries at low risk for long-term functional impairment and spinal injuries at highest risk among injury groups (Table 5). Isolated head and isolated extremity injuries had higher risk of long-term impairment than abdomen injuries but lower risk than spinal injuries (Table 5). Patients with moderate or greater FSS impairment (>9) more often had abnormal status at 6-month follow-up than those with normal discharge status (Table 3).

Health-related quality of life

Among those enrolled in the study, 279 (65.3%) had follow-up assessments of PedsQL. The median 6-month PedsQL score was 92.4 (interquartile range 80.4 to 97.9). Several discharge features were associated with lower PedsQL scores on univariable analysis, including older age, insurance status, pre-existing diagnosis, pre-injury functional status, injury body region, number of injured body regions, severe head injuries, and discharge FSS (Tables 1 and 2). PedsQL was lowest among patients with multiple injured body regions that included a severe head injury and those with isolated spine injuries (Table 2). In a multivariable analysis, older age and

Table 3. Factors Associated with Abnormal Functional Status Scale (>7) at 6-Month Follow-Up Determined by Logistic Regression

	Multivariable	
Variable	**Adjusted odds ratio (95% CI)**	**p Value**
Functional Status Scale discharge		
6–7 (good)	Ref	—
8–9 (mildly abnormal)	0.68 (0.45–1.02)	0.06
> 9 (moderately to very severely abnormal)	3.37 (2.18–5.22)	<0.001
Age, y	1.06 (1.02–1.09)	0.001
Injury type		
Blunt	Ref	—
Penetrating	3.08 (1.70–5.58)	< 0.001
Child physical abuse		
No	Ref	—
Yes	1.67 (1.00–2.79)	0.052
Injury category		
Multiple	3.07 (0.95–9.92)	0.06
Isolated head	3.68 (1.26–10.80)	0.02
Isolated thorax	5.18 (1.50–17.90)	0.009
Isolated abdomen	Ref	
Isolated spine	18.20 (5.43–60.92)	< 0.001
Isolated extremity	6.53 (2.27–18.81)	< 0.001
Severe head injury		
No	Ref	—
Yes	4.94 (3.02–8.09)	< 0.001

Analysis based on 302 patients with complete data.
Ref, reference.

moderate to severe FSS impairment at discharge were associated with lower PedsQL scores (Table 5), and injury category and severe head injury were not.

DISCUSSION

In this study, we observed an association of 6-month functional impairment with older age, injury category (including spine and severe head injuries), and lower discharge functional status. Patients at every level of discharge FSS had residual functional impairment at 6 months, including those with normal FSS at discharge. Lower PedsQL was also associated with older age and lower discharge functional status, but not with injury category or presence of a severe head injury. Despite an association with discharge functional status, normal status at discharge was not enough to rule out the need for follow-up functional or HRQoL evaluations. Our findings support performing 6-month assessments to evaluate the long-term impact of serious pediatric injury.

Two previous studies have evaluated long-term functional status and HRQoL in a general population of injured children. In a study of 104 children hospitalized for treatment of serious injuries, functional status and HRQoL improved but remained lower than population norms at 6 months after injury.[4] Similar to our study,

Table 4. Comparison of Abnormal Functional Status Scale at Follow-Up Between Injury Categories Using Logistic Regression

	Reference				
Comparison	**Isolated abdomen**	**Isolated thorax**	**Isolated spine**	**Isolated head**	**Multiple**
Isolated head	—	—	—	—	1.20 (0.69–2.09)
Isolated spine	—	—	—	4.94 (2.45–9.96)*	5.93 (2.56–13.78)*
Isolated thorax	—	—	0.28 (0.11–0.72)*	1.41 (0.66–3.00)	1.69 (0.71–4.05)
Isolated abdomen	—	0.19 (0.06–0.67)*	0.05 (0.02–0.18)*	0.27 (0.09–0.80)*	0.33 (0.10–1.06)
Isolated extremity	6.53 (2.27–18.81)*	1.26 (0.61–2.62)	0.36 (0.19–0.69)*	1.77 (1.24–2.54)*	2.13 (1.17–3.87)*

Values represent the odds ratios and 95% CI of paired group comparisons in multivariable regression based on the model shown in Table 3.
*$p < 0.05$.

Table 5. Factors Associated with Pediatric Quality of Life Inventory at 6-Month Follow-Up Determined by Multivariable Linear Regression

Variable	Parameter estimate (95% CI)	p Value
Functional Status Scale discharge		
6–7 (good)	Ref	—
8–9 (mildly abnormal)	−1.32 (−5.86 to 3.22)	0.57
> 9 (moderately to very severely abnormal)	−14.45 (−22.06 to −6.84)	< 0.001
Age, y	−0.91 (−1.28 to −0.53)	< 0.001
Injury type		
Blunt	Ref	—
Penetrating	−7.51 (−15.53 to 0.51)	0.07
Child physical abuse		
No	Ref	—
Yes	−1.41 (−8.39 to 5.56)	0.69
Injury category		
Multiple	−2.17 (−10.92 to 6.58)	0.63
Isolated head	−5.74 (−12.25 to 0.77)	0.08
Isolated thorax	0.54 (−9.65 to 10.72)	0.92
Isolated abdomen	Ref	—
Isolated spine	−9.19 (−21.58 to 3.20)	0.15
Isolated extremity	−6.32 (−12.73 to 0.10)	0.054
Severe head injury		
No	Ref	—
Yes	−3.13 (−10.29 to 4.03)	0.39

Analysis based on 264 patients with complete data.
Ref, reference.

impaired functional status and HRQoL were frequent at 6 months among children with head injuries. In another study focused on HRQoL, most of the 169 children who completed follow-up returned to normal HRQoL at 4 months after injury.[18] As in our study, older age was associated with worse HRQoL at 4 months. Although hospitalized patients had a lower HRQoL at 4 months than those not hospitalized, no association with injury severity was observed using a triage acuity scale. The association between injured body region and long-term HRQoL was not considered in this study. In contrast to these previous studies, we used a strategy for sampling children with uncommon and multiple injuries, evaluated functional status and HRQoL in children of all ages, and applied multivariable modeling to adjust for confounders.

We observed an association between the presence of a spinal or severe head injury and follow-up functional impairment. We used initial GCS to define head injury severity because our study relied mainly on trauma registry data. Previous studies have found that other severity measures, including intracranial pressure and CT findings, might be more reliable than GCS as predictors of long-term functional status.[19,20] Future studies should include these more accurate severity measures that rely on additional clinical data. In addition to identifying an association with severe head injuries, we observed that injuries to the spinal region were at higher risk for follow-up impairment. Our findings are consistent with a previous description of the dominance of head and spinal region injuries as causes of short- and long-term disability after pediatric injury.[21]

In our study, we observed an association between discharge functional status and 6-month outcomes. Although not studied after pediatric injury, the association between discharge functional status and 6-month status has been evaluated in injured adults showing inconsistent results. In a study of injured adults, discharge functional status correlated with status at 6 months when controlling for hospital length of stay, the number of days outside of the ICU, and the Disability Rating Scale score at discharge.[7] In contrast, an association between discharge and long-term functional status was not observed using the modified Functional Independence Measure or Glasgow Outcome Scale in adults hospitalized after a blunt injury.[8]

We identified a subset of children with normal status at discharge who had new impairment at follow-up. Although not previously studied in a general population of injured children, different recovery patterns have been described after adult injury, including improvement, persistent or worsening status, and new impairment.[22,23] Children with traumatic brain injury showed differences in recovery based on age and injury severity, with younger children and those with more severe injury most likely to decline after hospital discharge.[24] The domains of functional impairment after traumatic brain injury also differ by age, suggesting a relationship between developmental phase and recovery trajectory.[25] Using available data, we could not determine why a subset of patients who were normal at discharge became abnormal at follow-up. Potential explanations include new injury-related impairment, new injuries or disease, miscoding of discharge or follow-up status, or accuracy of FSS for detecting impairment across injury cohorts. Given that recovery after critical illness and injury might not always move toward continued improvement,[23,26] future studies are needed to explain new and persistent long-term impairment.

This study has several limitations. First, we used FSS as the main predictor of follow-up assessments and as the primary end point measure. Although FSS is suitable for large-scale pediatric critical care and injury studies, other metrics are available that measure age-specific and injury-specific functions that might be more sensitive or specific overall or for specific injury subgroups.[19,20] For example, among children with isolated severe head injuries, most had no residual impairment at 6 months, a proportion that might be higher using measures other than FSS. Future studies that use injury-specific measures are needed to validate the long-term outcomes that we observed in each cohort. Second, we used body region for injury classification rather than specific injuries in these regions. Although the number of serious or greater injuries precluded analysis at the level of individual injuries, variations of the injuries occurring within each body region could impact outcomes. Third, we used proxy reporting of functional status and HRQoL. Although patient self-reports are standard for measuring outcomes for adults and older children, proxy measures are a practical approach for large-scale multicenter studies and those that include younger children. Fourth, 65 patients who were approached declined to participate in the study. It is not known whether demographic or other characteristics of this cohort might have influenced our conclusions. Finally, follow-up assessments were missing for many enrolled patients. Our study's retention, however, exceeded that observed in similar reports of pediatric critical illness and injury.[26,27] Strategies are needed to retain subjects for long-term evaluation, particularly for those among demographic groups at risk for dropout.

CONCLUSIONS

We identified several features associated with long-term functional impairment and decreased HRQoL. For 6-month FSS, these factors included older age, penetrating injury, injured body region, and discharge functional impairment. For follow-up HRQoL, these included older age and discharge functional impairment. Although discharge functional status was associated with follow-up status, a subset of children were normal at discharge and developed later impairment, suggesting that new injury-related morbidity can occur after hospital discharge in some patients. Our findings support long-term assessments as standard practice for evaluating the health impact of serious pediatric injury.

Appendix

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eTable 1. Relationship Between Complete and Missing Functional Status Scale Value at Follow-Up and Patient and Injury Characteristics

	Observed FSS score at 6 mo				
	Yes (n = 323)		No (n = 104)		
Characteristic	**n**	**%**	**n**	**%**	**p Value**
Age category					0.29*
0–4 y	119	71.7	47	28	
5–9 y	89	80	22	20	
10–14 y	115	76.7	35	23	
Sex					0.64†
Male	207	76.4	64	24	
Female	116	74.4	40	26	
Race					0.41†
White	215	77.6	62	22	
Black	68	72	27	28	
Other	39	72	15	28	
Missing‡	1	100	0	0	
Ethnicity					< 0.001†
Hispanic or Latino	27	55	22	45	
Not Hispanic or Latino	294	78.2	82	22	
Missing‡	2	100	0	0	
Insurance					< 0.001§
Private or commercial	180	84.5	33	15	
Medicaid or Medicare	130	65.7	68	34	
Self-pay or no insurance	9	75	3	25	
Missing‡	4	100	0	0	
Chronic diagnosis					0.68§
None	271	75.1	90	25	
Asthma	12	92	1	8	
Cardiovascular disease (combined arrhythmia and congenital)	2	67	1	33	
Neurologic (combined seizure and other)	5	83	1	17	
Other	33	75	11	25	
Preinjury FSS					0.74§
Normal (6–7)	312	75.4	102	24.6	
Not normal (>7)	11	85	2	15	
Injury category					0.36§
Multiple head (severe)	19	79	5	21	
Multiple head (not severe)	10	77	3	23	
Multiple excluding head	30	83	6	17	
Isolated head (severe)	13	57	10	43	
Isolated head (not severe)	61	73	23	27	
Isolated thorax	22	73	8	27	
Isolated abdomen	58	72	23	28	
Isolated spine	17	81	4	19	
Isolated extremity	93	81	22	19	
No. of body regions with AIS ≥ 3					0.27*
1	264	74.6	90	25	
2	37	80	9	20	
≥ 3	22	81	5	19	
Injury type					0.77§

(Continued)

eTable 1. Continued

	Observed FSS score at 6 mo				
	Yes (n = 323)		No (n = 104)		
Characteristic	**n**	**%**	**n**	**%**	**p Value**
Blunt	288	75.8	92	24	
Penetrating	14	82	3	18	
Missing‡	21	70	9	30	
Mechanism of injury					0.66§
Child abuse	30	67	15	33	
Penetrating	8	73	3	27	
Fall	93	74	32	26	
Motor vehicle collision occupant	62	81	15	19	
Pedestrian	22	73	8	27	
Transport other or motorcycle	16	80	4	20	
Cyclist	19	83	4	17	
Struck by or against	26	84	5	16	
Other	10	67	5	33	
Missing‡	37	74	13	26	
Severe head injury					0.20†
No	291	76.6	89	23	
Yes	32	68	15	32	
Discharge FSS					0.76§
6—7 (good)	242	74.7	82	25	
8—9 (mildly abnormal)	53	79	14	21	
≥ 10 (moderately to very severely abnormal)	28	78	8	22	

*Cochran-Armitage test for trend.
†Chi-square test.
‡Not included in p value calculation.
§Fisher exact test with Monte Carlo approximation.
AIS, Abbreviated Injury Scale; FSS, Functional Status Scale.