

Caregiver reported long-term outcomes in children with major trauma and traumatic brain injuries: A single-centre retrospective study

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ABSTRACT

Introduction: We aim to investigate the functional outcomes and long-term health-related quality of life (HRQOL) in children with major trauma associated with traumatic brain injury (TBI).

Method: We performed a retrospective review of records among patients >2 and ≤16 years old in a tertiary paediatric hospital between January 2014 and October 2019 with major trauma (Injury Severity Score of ≥16) and TBI of all severities. We recorded each child's Glasgow Outcome Scale-Extended Pediatric Version (GOS-E Peds) at 12 months post-injury and Pediatric Quality of Life Inventory (PedsQL) scores at 6 and 12 months post-injury based on the parent proxy-report scales.

Results: We included 53 patients with a median age of 9.0 years old (interquartile range 2.3–15.5). Most injuries were due to falls (30, 56.6%) or road traffic collisions (15, 28.3%); 41 patients (77.3%) required intensive care while 30 patients (56.6%) underwent neurosurgical intervention. Most patients (43, 81.1%) had GOS-E Peds scores of ≤2 at 12 months post-injury. We reported a significant mean difference between the 6- and 12-month parent-reported scores for physical functioning (6.6, 95% confidence interval [CI] 0.3–12.8, $P=0.041$), psychosocial functioning (4.1, 95% CI 1.0–7.2, $P=0.012$) and overall scores (5.0, 95% CI 1.4–8.7, $P=0.008$). Compared with the validated PedsQL scores, our mean scores were higher across all domains at 12 months.

Conclusion: With current standard of care, parents of children with major trauma and TBI reported gains in quality of life, physical, psychosocial and overall function between 6 and 12 months post-injury.

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INTRODUCTION

Traumatic injuries in children are a significant cause of mortality and morbidity worldwide.¹ Children with major trauma are at risk of poor outcomes.²⁻⁴

CLINICAL IMPACT

What is New

- Parents of children with major trauma and traumatic brain injury (TBI) reported gains in physical, psychosocial and overall function between 6 and 12 months post-injury.

Clinical Implications

- The Glasgow Outcome Scale-Extended Pediatric Version and the Pediatric Quality of Life Inventory together provide an assessment of functional outcomes and paediatric health-related quality of life.
- School functioning post-TBI is an area of research that requires further study.

These include disabilities that require assistance with activities of daily living, intellectual disability and behavioural problems.⁵ In the US, it is estimated that more than 50 billion dollars is spent annually for inpatient treatment and 125 billion dollars for outpatient treatment.⁶ In addition to financial burden, caregivers who need to provide long-term care for these children experience emotional stress.⁶⁻⁸ The Burden of Disease in Singapore (1990–2017) reported that injuries caused 10.7% of total disability-adjusted life years (DALYs), with the percentage of total DALYs attributed to injuries increasing through childhood to young adulthood.⁹

Physical trauma in childhood results in significant consequences—traumatic brain injuries (TBIs) especially, result in morbidity and mortality, more than other anatomical sites.¹⁰⁻¹³ Children have great neuroplasticity, but TBIs can cause long-term neurological deficits,^{11,13} affecting executive function, memory and learning,¹³ which influence the child's learning ability and future employment opportunities.

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With increasing survival after major trauma, robust measurement of clinical outcomes to tailor rehabilitative interventions to the individual patient is needed. A developmentally structured interview providing holistic evaluation of the injured child is the Glasgow Outcome Scale-Extended Pediatric Version (GOS-E Peds). The GOS-E Peds is a validated, functional-outcomes assessment tool.¹⁴ In an earlier study conducted in our hospital, KK Women's and Children's Hospital in Singapore, the Functional Independence Measure for Children (WeeFIM) scoring system^{15,16} demonstrated that non-accidental trauma predicted for poor long-term outcomes.³ The Pediatric Quality of Life Inventory (PedsQL) when compared to WeeFIM, is reportedly more sensitive in self-care and mobility domains.¹⁶ The PedsQL has also been used to measure paediatric health-related quality of life (HRQOL).¹⁷ Both the GOS-E Peds and the PedsQL provide robust assessment of the injured child's ability, setting of measurable treatment goals and anticipating support when the injured child returns to the community.¹⁸

Therefore, we aim to describe both the functional outcomes based on GOS-E Peds, and the caregiver-reported HRQOL based on the PedsQL (among children with major trauma, defined as an Injury Severity Score [ISS] of ≥ 16), and TBI in the paediatric population in Singapore.

METHOD

Study design and setting

We conducted a retrospective cohort study in KK Women's and Children's Hospital, Singapore, a large tertiary centre that encounters an estimated 25,000 trauma patients at the emergency department (ED) annually, mostly comprising minor trauma. These children with moderate-severe TBI receive neurorehabilitation services once they are transferred from the children's intensive care unit (ICU). The neurorehabilitation team comprises the doctor, allied health therapists, social worker, neuropsychologist and dietician. Typically, for a moderate-severe TBI, physiotherapy, occupational therapy and speech therapy sessions of 1 hour each will be given daily on weekdays. Depending on the progress and the rehabilitation needs, the multidisciplinary team determines the duration of the inpatient stay and the frequency of the subsequent outpatient follow-up. All patients receive both inpatient and outpatient neurorehabilitation following the TBI.

We included patients >2 and ≤ 16 years old who presented to the ED over the period of January 2014 to October 2019, with major trauma (ISS ≥ 16) and TBI (regardless of severity). Children <2 years were excluded because they did

not receive PedsQL assessment. We also excluded children who were >16 years, had ISS of ≤ 15 , did not have TBI or had any previously known neurological comorbidities that affected their neurological assessment.

Waiver for informed consent was approved by the institutional review board (IRB 2018/2268 and 2021/2401).

Variables

All patient demographic details were collected. Under a pre-existing electronic health record template, the attending ED physician documents the circumstances of injury for children with trauma. We reviewed the ED presentation and Systematized Nomenclature of Medicine, Clinical Terms (SNOMED-CT) diagnostic codes to document the presence of TBI. We also collected details on the Glasgow Coma Scale (GCS),¹⁹ management in ED, neurosurgical interventions, high dependency unit and ICU stay durations. We recorded if the child underwent isolated unilateral or bilateral craniectomy. Further surgical interventions were documented as complex neurosurgeries. We defined multiple neurosurgeries as ≥ 2 surgical interventions. Any postoperative complications were documented.

The ISS is an anatomical scoring system that provides an overall score for patients with multiple injuries.²⁰ Each injury is assigned an abbreviated injury scale (AIS) score and is allocated to 1 of 6 body regions including the head, face, chest, abdomen, extremities and external.²¹ The ISS is the overall summative score and a cut-off of 16 that is associated with a mortality rate of 10% is used, with mortality rising as the score increases.²² In our hospital, only children with an ISS ≥ 16 have long-term follow-up assessments. Data on both the ISS and the head AIS are reported.

Outcome measures

We reviewed each child's functional outcome based on GOS-E Peds and caregiver-reported HRQOL based on the age-appropriate PedsQL forms.

The GOS-E Peds was scored 12 months post-TBI and was derived from patient case notes. Scores were computed based on consciousness; independence at home and outside home; school; social and leisure activities; family and friendships; and return to normal life.¹⁴ GOS-E Peds scores were computed and ranged between 1 (Upper Good Recovery) and 8 (Death).¹⁴ A cut-off GOS-E Peds score of 2 differentiated between predicted disability (>2) and good functional recovery (≤ 2) outcomes.¹⁴

We used the PedsQL scoring system (parent-proxy form) to evaluate the HRQOL outcomes of this population.²³ The PedsQL measurement model is a modular approach to HRQOL in children. This scoring system is based on four individual domains (physical, emotional, social and school), used to determine the composite psychosocial score (sum of the items over the number of items answered in the emotional, social, and school functioning scales) as well as to calculate the total score. Each domain contains a set list of items that caregivers can use to measure the child's degree of functioning. To obtain the PedsQL scores, a phone call interview, based on a questionnaire at 6 and 12 months post-injury, was conducted with caregivers. In each case, we used the age-appropriate PedsQL form. In our hospital, PedsQL scoring is not done when the child is discharged from the hospital. We present those with completed data in each domain. Not all patients were able to complete all PedsQL domains, with reasons cited as not being expected to perform household chores, not returned to school or completion of the neurorehabilitation in another institution. Any child that deviated >1 standard deviation (SD) from the PedsQL Generic Core Scales or total score was considered to have poor HRQOL.²⁴ As the scores were derived from phone interviews with caregivers, the PedsQL Generic Core Scales for parent-proxy report were used as reference for our study.

We aimed to report acute resource utilisation, including length of ICU and overall hospital stays in our cohort.

Statistical methods

Continuous variables were presented as mean with standard deviation (SD) or median with interquartile range (IQR) depending on normality, while binary

or categorical data were presented as frequencies with percentages. We assessed univariate statistical significance for continuous variables using the t-test for parametric data and the Wilcoxon rank-sum test for non-parametric data. We used the chi-square test to assess binary or categorical variables. We stratified descriptive data by functional outcome status (GOS-E Peds ≤ 2 versus > 2).¹⁶

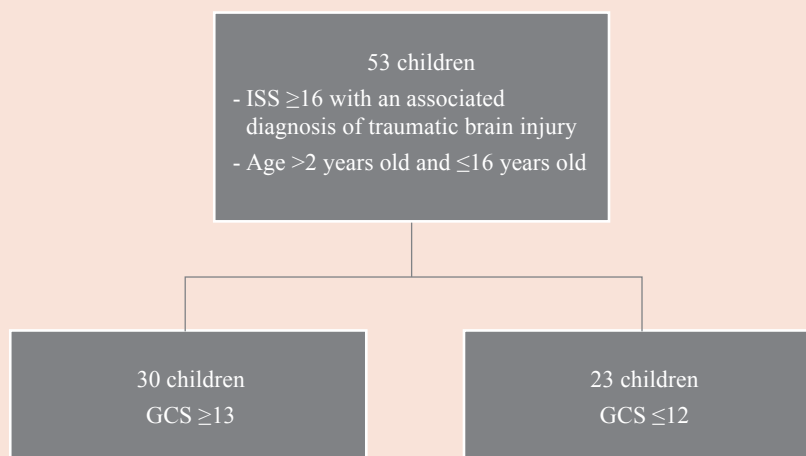
We performed subgroup analysis based on GCS to further stratify between severity of TBI, with GCS ≥ 13 denoting mild TBI and ≤ 12 denoting moderate to severe TBI.²⁵ This was undertaken due to the anticipated difference in trajectory of recovery for both groups.²⁵ Tracking the progress of patients in the different groups may provide insight into deficient domains in the rehabilitation process. To compare the 6- and 12-month scores, we obtained the mean difference and 95% confidence intervals (CIs). We performed paired t-test and presented the *P* values for each domain.

Statistical significance was taken as *P* values < 0.05 for all tests. Statistical analysis was performed using SPSS version 26 (IBM Corp, Armonk, NY, US).²⁶

RESULTS

We analysed a total of 53 children with major trauma associated with TBI (Fig. 1). The median age was 9.0 years old (IQR 2.3–15.5) and 33 were males (62%). Falls accounted for most of the injuries (30/53, 56.6%), followed by road traffic collisions (15/53, 28.3%). In our study, 30/53 (56.6%) of the cohort underwent neurosurgery. Among these 30 patients, 18/30 (60.0%) had isolated unilateral/bilateral craniectomy with the remaining 12/30 (40.0%) having more complex neurosurgery (6/30, 20.0%) or multiple surgeries (6/30, 20.0%). Postoperative complications occurred in 10/30 (33.3%) of the cases.

Fig. 1. Flowchart for study population.



GCS: Glasgow Coma Scale; ISS: Injury Severity Score

There were 43 children (43/53, 81.1%) with predicted good functional outcome (GOS-E Peds ≤ 2) and 10 children (10/53, 18.9%) with predicted poor functional outcome (GOS-E Peds > 2). The predicted good functional outcome group had a higher median GCS of 15 at presentation (IQR 6–15) compared with the predicted poor functional outcome group, which had a median GCS of 5 (IQR 3–14, $P=0.028$). The median Revised Trauma Score (RTS) for those with predicted good functional outcome was higher compared to those with predicted poor functional outcome (7.8, IQR 6.0–7.8 vs 5.0, IQR 4.1–7.6, $P=0.034$) (Table 1). There was no significant difference in ISS or head AIS for both groups. For neurosurgical interventions, 17/43 (39.5%) versus 1/10 (10.0%) had isolated unilateral/bilateral craniectomy, 7/43 (16.2%) versus 5/10 (50.0%) had complex or multiple surgeries, and 5/43 (11.6%) versus 5/10 (50.0%) had postoperative complications.

The in-hospital outcomes for the study population are shown in Table 2. Both groups had similar proportions of interventions, such as trauma code activation (4/43, 9.3% vs 1/10, 10.0%, $P=0.946$), airway intervention (10/43, 23.3% vs 3/10, 30.0%, $P=0.655$), emergency procedures (10/43, 23.3% vs 3/10, 30.0%, $P=0.655$) and neurosurgical intervention (24/43, 55.8% vs 6/10,

60.0%, $P=0.810$). Only 1 child in the group with poor outcome required massive transfusion protocol. Those with predicted good functional outcomes had a shorter length of ICU stay (median 1.0 day, IQR 0.0–4.0 vs. 5.0 days, IQR 2.5–14.0, $P=0.014$) and overall duration of hospital stay (median 5.0 days, IQR 3.0–19.0 vs 32.0 days, IQR 6.5–93.8, $P=0.01$).

In our study population, caregiver-reported PedsQL scores at 6 months showed a mean of $>80.0\%$ across all domains while at 12 months showed $>85.0\%$ across all domains (Table 3). In both 6- and 12-month periods, physical functioning recorded the lowest scores (80.9% and 88.0%) while emotional functioning recorded the highest scores (95.3% and 98.4%), respectively. When compared between the caregiver-reported mean scores of our cohort and the PedsQL Generic Core Scales, it was found that only physical functioning at 6 months post-neurorehabilitation was lower than the population-based scores (80.9 vs 84.1). The remaining mean cohort scores at 6 months and all scores at 12 months were found to be higher than that of the PedsQL population-based scores. The greatest difference between our cohort and the PedsQL population-based scores was in the 12-month emotional functioning domain (difference of 17.2%, 98.4% vs 81.2%)

Table 1. Demographics of study population.

	Good functional outcome (GOS-E Peds score of 1 or 2) n=43	Poor functional outcome (GOS-E Peds ≥ 3) n=10	P value
Age, years, median (IQR)	9.0 (6.0–11.0)	10.5 (4.8–14.0)	0.615
Male, no. (%)	26.0 (60.5)	8.0 (80.0)	0.246
Race, no. (%)			0.612
Chinese	30 (69.8)	5 (50.0)	
Malay	6 (14.0)	3 (30.0)	
Indian	4 (9.3)	1 (10.0)	
Others	3 (7.0)	1 (10.0)	
Mechanism of injury, no. (%)			0.024
Fall	28 (65.1)	2 (20.0)	
Road traffic collision	9 (20.9)	6 (60.0)	
Others	6 (14.0)	2 (20.0)	
Presenting Glasgow Coma Scale, median (IQR)	15 (6–15)	5 (3–14)	0.028
Revised Trauma Score, median (IQR)	7.8 (6.0–7.8)	5.0 (4.1–7.6)	0.034
Injury Severity Score, median (IQR)	25.0 (17–26)	23.0 (17–50)	0.428

GOS-E Peds: Glasgow Outcome Scale-Extended Pediatric Version; IQR: interquartile range

Table 2. Outcomes for study population.

	Good functional outcome (GOS-E Peds score of 1 or 2) n=43	Poor functional outcome (GOS-E Peds ≥ 3) n=10	P value
Trauma code activation, no. (%)	4 (9.3)	1 (10.0)	0.946
Airway intervention, no. (%)	10 (23.3)	3 (30.0)	0.655
Massive transfusion protocol activation, no. (%)	0 (0)	1 (10.0)	0.036
Emergency procedures, no. (%)	10 (23.3)	3 (30.0)	0.655
Neurosurgical intervention, no. (%)	24 (55.8)	6 (60.0)	0.810
Length of intensive care unit stay, median (IQR)	1.0 (0.0–4.0)	5.0 (2.5–14.0)	0.014
Length of hospital stay, median (IQR)	5.0 (3.0–19.0)	32.0 (6.5–93.8)	0.010

GOS-E Ped: Glasgow Outcome Scale-Extended Pediatric Version; IQR: interquartile range

followed by the 12-month school functioning domain (difference of 16.5%, 94.7% vs 78.2%).

We found statistically significant improvements in the caregiver-reported scores for physical functioning (mean difference 6.6, 95% CI 0.3–12.8, $P=0.041$), psychosocial functioning (4.1, 95% CI 1.0–7.2, $P=0.012$) and total score (5.0, 95% CI 1.4–8.7, $P=0.008$) (Table 4). Caregiver-reported scores on school functioning had a non-significant mean difference of 2.8 (95% CI -2.7–8.4, $P=0.304$).

We divided our cohort into those with mild TBI and those with moderate-severe TBI (Supplementary Tables S1 and S2). The greatest improvement in the moderate-severe TBI group was noted in the caregiver-reported physical functioning domain, where scores increased by 14.1% (66.7 vs 80.8).

DISCUSSION

Our study population comprised 53 children with significant trauma associated with TBI, mostly from falls and road traffic collisions. We demonstrated improvement in functional outcomes across all domains. There was improvement in caregiver-reported PedsQL scores between 6 and 12 months post-neurorehabilitation in physical functioning, psychosocial functioning and total scores. When compared with the PedsQL Generic Core Scales, our cohort had higher PedsQL scores at 12 months across all domains.

Patients with higher GOS-E Peds scores required greater acute resource utilisation, with longer ICU and total hospital stay. Although not statistically significant, we reported a higher proportion of patients needing intervention in those with higher GOS-E Peds scores, including airway intervention, emergency procedures, neurosurgical intervention and trauma code

activation. These findings reinforce our understanding that the greater the injury, the more resource-intensive subsequent interventions would be.²⁷

Similar to a recent systematic review and meta-analysis, our results showed a direct correlation between injury severity and the extent of neurocognitive delays.¹³ Low presenting GCS (15, IQR 15–6 vs 5, IQR 14–3, $P=0.028$) and low RTS (7.8, IQR 7.8–6.0 vs 5.0, IQR 7.6–4.1, $P=0.034$) were associated with poorer functional outcomes. In children with severe injuries, poor long-term outcomes include physical, intellectual disabilities and behavioural issues.⁵ In our study population, we were not adequately powered to study the correlation between AIS scoring and GOS-E Peds. Future larger studies should compare the relationship between AIS head scores and functional outcomes.

Parents reported an improvement in physical functioning (mean difference 6.6, 95% CI 0.3–12.8, $P=0.041$). This is consistent with expected outcomes since neurorehabilitation is primarily focused on regaining of physical functional skills.²⁸ Starting at the lowest (80.9%) at the 6-month period, it also had the largest room for improvement. Overall, parents reported an improvement in quality of life with a significant improvement in total mean scores (mean difference 5.0, 95% CI 1.4–8.7, $P=0.008$).

Parents reported limited improvement in emotional and social scores. These are developing fields in neurorehabilitation with limited data on evidence-based interventions.²⁹ Children with TBI will benefit from detailed assessments in these non-physical domains. Better assessments will inform if current interventions are effective, providing adequate guidance to help them in their

Table 3. Pediatric Quality of Life Inventory (PedsQL) outcome scores for all patients.

	No.	SD	Cohort mean	PedsQL mean	>1SD based on cohort mean, no. (%)	>1SD based on PedsQL mean, no. (%)
PedsQL Physical Functioning (6 months)	53.0	34.2	80.9	84.1	9.0 (16.9)	9.0 (16.9)
PedsQL Emotional Functioning (6 months)	53.0	15.6	95.3	81.2	5.0 (9.4)	2.0 (3.7)
PedsQL Social Functioning (6 months)	49.0	24.6	92.2	83.1	4.0 (8.1)	3.0 (6.1)
PedsQL School Functioning (6 months)	43.0	19.1	93.0	78.2	4.0 (9.3)	2.0 (4.6)
PedsQL Psychosocial Functioning (6 months)	44.0	14.3	93.7	81.2	5.0 (11.3)	5.0 (11.3)
PedsQL total (6 months)	53.0	21.8	87.5	82.3	8.0 (15.0)	7.0 (13.2)
PedsQL Physical Functioning (12 months)	45.0	15.4	88.0	84.1	7.0 (15.5)	5.0 (11.1)
PedsQL Emotional Functioning (12 months)	45.0	5.5	98.4	81.2	4.0 (8.8)	1.0 (2.2)
PedsQL Social Functioning (12 months)	45.0	17.4	95.4	83.1	3.0 (6.6)	3.0 (6.6)
PedsQL School Functioning (12 months)	39.0	15.7	94.7	78.2	4.0 (10.2)	3.0 (7.6)
PedsQL Psychosocial Functioning (12 months)	40.0	8.7	96.7	81.2	4.0 (10.0)	2.0 (5.0)
PedsQL total (12 months)	45.0	15.4	93.0	82.3	7.0 (15.5)	4.0 (15.5)

SD: standard deviation

Table 4. Comparison of Pediatric Quality of Life Inventory (PedsQL) outcomes scores in the study cohort.

	6-month mean (SD)	12-month mean (SD)	Mean difference (95% CI)	P value for mean difference
PedsQL Physical Functioning	80.9 (34.6)	88.0 (28.4)	6.6 (0.3–12.8)	0.041
PedsQL Emotional Functioning	95.3 (15.8)	98.4 (5.6)	3.3 (-0.4–7.1)	0.080
PedsQL Social Functioning	92.2 (24.9)	95.4 (17.6)	6.3 (-0.6–13.1)	0.071
PedsQL School Functioning	93.0 (19.3)	94.7 (16.0)	2.8 (-2.7–8.4)	0.304
PedsQL Psychosocial Functioning	93.7 (14.5)	96.7 (8.8)	4.1 (1.0–7.2)	0.012
PedsQL total	87.5 (22.1)	93.0 (15.6)	5.0 (1.4–8.7)	0.008

SD: standard deviation

rehabilitation journey. The psychosocial functioning in PedsQL is calculated using a composite score (physical, emotional, social and school) and not through a direct scoring system, therefore more targeted psychosocial assessment is needed. In a study by Goodman et al., psychosocial assessment tools such as the Strengths and Difficulties

Questionnaire³⁰ and Loneliness and Social Dissatisfaction Scale³¹ were used in the assessment of children post-TBI, demonstrating increased difficulty in emotional regulation and social interaction.³² More rigorous methods are needed to measure and track psychosocial outcomes in trauma registries. The selected outcome measures

should align with the World Health Organization's International Classification of Functioning, Disability and Health across the age groups.³³⁻³⁴

We did not find a significant difference in parent-reported scores for school functioning between 6 and 12 months. School functioning is hard to quantify, involving variability of school environments and level of schooling.³⁵ There may also be unrecognised individualised health care needs.³⁶ Bate et al. in the UK showed that it could take up to 16 months post-TBI before readiness for return to school, highlighting the need for substantial resources in this area.³² Optimisation of school functioning following TBI is a work in progress with more needed to improve transitional services from hospital to school, support structures and teacher training.³⁷ Optimising outcomes requires a multipronged approach, affected by social factors and psychiatric status,³⁸ family functioning and community support.³⁰ With improving trauma resuscitation and increasing survival, robust longitudinal outcome measurements are needed to understand the true burden of paediatric trauma in Singapore. These data can be shared with advocacy groups and governmental agencies (including the police and social services), to facilitate multidisciplinary injury prevention efforts.

The main limitation of this study is the small study cohort, limited further by the exclusion of cases <2 years old. In our hospital, follow-up is only done for patients with major trauma (defined as ISS ≥ 16). Future studies on outcomes assessment should consider multicentre collaborations for greater power and generalisability. A follow-up period beyond a year would provide longer-term functional outcomes, including ability for higher education and employment. Ideally, PedsQL should be measured pre-injury, immediately post-injury, at discharge, and at 6 to 12 months post-injury.

Several cases could not complete the PedsQL profile due to loss to follow-up. An alternative to the parent-proxy report would be the child self-reported questionnaire. Older children may be able to answer the PedsQL questions more accurately compared to parent interviews; however, the reliability of such responses may vary more greatly. Our cohort comprised 30 cases of children ≥ 8 years old, able to provide a reliable child self-report. In assessing functional outcomes, we were unable to account for home and environmental differences contributing to recovery. We further lacked a local population comparator, since using the PedsQL Generic Core Scales may not give the most accurate comparison.

Being an observational study, we recognise that the extent and quality of neurorehabilitation differed between patients. We are currently working with the neurorehabilitation specialists in our hospital to streamline assessment tools in order that interventions can be better reviewed.

Future larger prospective research should compare functional scoring systems like WeeFIM and GOS-E Peds with HRQOL scores.^{2,14-16} This would enable a better understanding of how functional outcomes relate to HRQOL and provide comprehensive outcomes assessment for children with major trauma and TBI. We recognise that cognitive assessment is better performed using detailed neurocognitive tests instead of functional assessment tools. Non-physical domains should also be investigated in greater detail to provide a meaningful evaluation of current neurorehabilitation practices.

CONCLUSION

We described caregiver-reported HRQOL and functional outcomes in a Singapore paediatric population with major trauma associated with TBI. With current standard of care, parents of children with major trauma and TBI reported gains in quality of life, and in physical, psychosocial and overall function between 6 and 12 months post-injury.

Disclosure

The authors report no conflict of interest.

REFERENCES

1. Bradshaw CJ, Bandi AS, Muktar Z, et al. International Study of the Epidemiology of Paediatric Trauma: PAPS Research Study. *World J Surg* 2018;42:1885-94.
2. Hwang SY, Ong JW, Ng ZM, et al. Long-term outcomes in children with moderate to severe traumatic brain injury: a single-centre retrospective study. *Brain Inj* 2019;33:1420-4.
3. Chong SL, Khan UR, Santhanam I, et al. A retrospective review of paediatric head injuries in Asia – a Pan Asian Trauma Outcomes Study (PATOS) collaboration. *BMJ Open* 2017;7:e015759.
4. Akbaryan F, Derakhshanfar H, Heidari K, et al. Prognosis in children with traumatic injuries referring to the emergency department. *Chin J Traumatol* 2019;22:323-7.
5. Neumane S, Câmara-Costa H, Francillette L, et al. Functional outcome after severe childhood traumatic brain injury: Results of the TGE prospective longitudinal study. *Ann Phys Rehabil Med* 2021;64:101375.
6. Aitken ME, McCarthy ML, Slomine BS, et al. Family burden after traumatic brain injury in children. *Pediatrics* 2009; 123:199-206.
7. Bray L. Parents' experiences of hope following a child's brain injury. *Nurs Child Young People* 2015;27:22-6.
8. Graves JM, Rivara FP, Vavilala MS. Health care costs 1 year after pediatric traumatic brain injury. *Am J Public Health* 2015;105:e35-41.

9. Epidemiology & Disease Control Division, Ministry of Health, Singapore; Institute for Health Metrics and Evaluation. The Burden of Disease in Singapore, 1990–2017: An overview of the Global Burden of Disease Study 2017 results. Seattle, WA: IHME; 2019.
10. Naqvi G, Johansson G, Yip G, et al. Mechanisms, patterns and outcomes of paediatric polytrauma in a UK major trauma centre. *Ann R Coll Surg* 2017;99:39-45.
11. Huisman TAGM, Poretti A. Chapter 62 - Trauma. *Handbook of Clinical Neurology*. Elsevier 2016;136:1199-220.
12. Coulthard MG, Varghese V, Harvey LP, et al. A review of children with severe trauma admitted to pediatric intensive care in Queensland, Australia. *PLOS ONE* 2019;14:e021153.
13. Goh MSL, Looi DSH, Sultana R, et al. The Impact of Traumatic Brain Injury on Neurocognitive Outcomes in Children: a Systematic Review and Meta-Analysis. *J Neurol Neurosurg Psychiatry* 2021;92:847-53.
14. Beers SR, Wisniewski SR, Gracia-Filion P, et al. Validity of a Pediatric Version of the Glasgow Outcome Scale–Extended. *J Neurotrauma* 2012;29:1126-39.
15. Wong V, Wong S, Chan K, et al. Functional Independence Measure (WeeFIM) for Chinese Children: Hong Kong Cohort. *Paediatrics* 2002;109:e36.
16. Grilli L, Feldman DE, Majnemer A, et al. Associations between a functional independence measure (WeeFIM) and the pediatric quality of life inventory (PedsQL4.0) in young children with physical disabilities. *Qual Life Res* 2006;15:1023-31.
17. Beverung LM, Varni JW, Panepinto JA. Clinically meaningful interpretation of pediatric health-related quality of life in sickle cell disease. *J Paediatr Hematol Oncol* 2015; 37:128-33.
18. Kamm CP, Bohlhalter S, Pflugshaupt T, et al. Patient-tailored multimodal neurorehabilitation: The Lucerne model. *Clinical Translational Neuroscience* 2019;3:1-7.
19. Jain S, Iverson LM. Glasgow Coma Scale. Updated 12 June 2023. StatPearls. <https://www.ncbi.nlm.nih.gov/books/NBK513298/>. Accessed 12 October 2023.
20. Baker SP, O'Neill B. The Injury Severity Score: An Update. *J Trauma* 1976;16:882-5.
21. Association for the Advancement of Automotive Medicine. The Abbreviated Injury Scale, 2015. <https://www.aaam.org/abbreviated-injury-scale-ais/>. Accessed 12 October 2023.
22. Petridou ET, Antonopoulos CN. Injury Epidemiology. In Quah SR (Ed), *International Encyclopedia of Public Health* (2nd Edition), Oxford: Elsevier; 2017.
23. Varni JW. Pediatric Quality of Life Inventory™ (PedsQL™). Mapi Research Trust. <https://eprovide.mapi-trust.org/instruments/pediatric-quality-of-life-inventory>. Accessed 12 October 2023.
24. Varni JW, Burwinkle TM, Seid M, et al. The PedsQL 4.0 as a Pediatric Population Health Measure: Feasibility, Reliability, and Validity. *Ambul Pediatr* 2003;3:329-41.
25. Stephens JA, Williamson KC, Berryhill ME. Evidence-Based Practice for Traumatic Brain Injury A Cognitive Rehabilitation Reference for Occupational Therapists. *OTJR* 2015;35:5-22.
26. IBM Corp. IBM SPSS Statistics for Windows, Version 26.0. Armonk; 2019.
27. Huang YT, Huang YH, Hsieh CH, et al. Comparison of Injury Severity Score, Glasgow Coma Scale, and Revised Trauma Score in Predicting the Mortality and Prolonged ICU Stay of Traumatic Young Children: A Cross-Sectional Retrospective Study. *Emerg Med Int* 2019;54:53624.
28. Levi R. Neurological Rehabilitation. In Brahme A (Ed), *Comprehensive Biomedical Physics*. Elsevier 2014;10:401-9.
29. Yeates G. Social Cognition Interventions in Neuro-Rehabilitation: An Overview. *Adv Clin Neurosci Rehabil* 2014. doi: 10.47795/ALUA9018.
30. Goodman R. The extended version of the Strengths and Difficulties Questionnaire as a guide to child psychiatric caseness and consequent burden. *J Child Psychol Psychiatry* 1999;40:791-9.
31. Asher S, Wheeler V. Children's loneliness: A comparison of rejected and neglected peer status. *Journal of Consulting and Clinical Psychology* 1985;53:500-5.
32. Bate C, Turner K, Fricke S. Return to school after acquired brain injury in the UK – the educators' perspectives. *J Res Spec Educ Needs* 2021;21:242-53.
33. Rosenbaum PL. The F-words for child development: functioning, family, fitness, fun, friends, and future. *Dev Med Child Neurol* 2022;64:141-2.
34. Rosenbaum P, Gorter JW. The 'F-words' in childhood disability: I swear this is how we should think! *Child Care Health Dev* 2012;38:457-63.
35. Ross KA, McMillian T, Kelly T, et al. Friendship, loneliness and psychosocial functioning in children with traumatic brain injury. *Brain Inj* 2011;25:1206-11.
36. Slomine BS, McCarthy ML, Ding R, et al. Health Care Utilization and Needs After Pediatric Traumatic Brain Injury. *Pediatrics* 2006;117:e663-74.
37. Todis B, McCart M, Glang A. Hospital to school transition following traumatic brain injury: A qualitative longitudinal study. *NeuroRehabilitation* 2018;42:269-76.
38. Ponsford J. Factors contributing to outcome following traumatic brain injury. *NeuroRehabilitation* 2013;32:803-15.