ARTICLE

Health-Related Quality of Life During the First Year After Traumatic Brain Injury

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Objectives: To document health-related quality of life (HRQOL) of children with traumatic brain injury (TBI) and to examine the relationship between TBI severity and HRQOL during the first year after injury.

Design: Prospective cohort study.

Setting: Four pediatric level I trauma centers.

Patients: Children with TBI (n=330).

Main Exposure: Traumatic brain injury.

Main Outcome Measures: A primary caregiver completed telephone interviews at baseline, 3 months, and 12 months to measure the child's HRQOL using the Pediatric Quality of Life Inventory. The HRQOL outcomes were modeled as a function of injury, patient characteristics, and family characteristics using longitudinal, multivariable regression.

Results: A considerable proportion of children had impaired HRQOL at 3 months (42% of children) and 12 months (40% of children) after injury. Multiple dimensions of HRQOL were negatively affected among children with moderate or severe TBI (decrease of 3.7 to 17.6) ($P<.05$) and did not improve significantly over time. Concomitant lower extremity fractures and spinal injuries resulted in large declines in overall HRQOL, particularly at 3 months after injury (decrease of 12.9 and 8.1, respectively) ($P<.05$). The HRQOL scores were also reduced by preexisting psychosocial conditions (decrease of 2.9 to 12.3), impaired family functioning (decrease of 5.1 to 6.8), having Medicaid coverage or being uninsured (decrease of 3.1 to 5.5), and single-parent households (decrease of 3.2 to 3.4) ($P<.05$).

Conclusions: Moderate or severe TBI resulted in measurable declines in children's HRQOL after injury. Injury-related factors impacted HRQOL more compared with patient and family characteristics during the first year after injury.

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DURING THE PAST DECADE, a number of instruments have been developed to measure children's health-related quality of life (HRQOL).[1-9] These instruments have 3 distinguishing features: (1) they measure function at the level of the person (as opposed to the organ or organ system); (2) they measure outcome from the child's or parent's perspective (as opposed to the clinician's); and (3) they measure health as a multidimensional construct that includes physical, social, and emotional well-being. Furthermore, they can be self-administered or administered over the phone, making them practical for clinical and research applications.[10,11]

Although numerous studies have documented the neurobehavioral consequences following traumatic brain injury (TBI) in children,[12-26] only 2 have focused primarily on children's HRQOL.[27,28] Interestingly, neither found a significant relationship between the severity of TBI and HRQOL.[27,28] Stancin et al[27] used the Child Health Questionnaire to measure HRQOL at 4 years after injury among 84 subjects with moderate to severe TBI and 50 children with an orthopedic injury. Although the psychosocial health of children with severe TBI was poorer compared with those with an orthopedic injury when examined alone, no significant differences remained after controlling for socioeconomic and premorbid problems. Coster et al[28] also did not find a significant relationship between TBI severity and HRQOL using the Pediatric Evaluation of Disability Inventory among 57 young children with TBI at 6 months after injury. The findings from these 2 studies are surprising given that previous research that has

measured neuropsychological and behavioral outcomes among children with moderate to severe TBI has noted significant and persistent deficits in this patient population long after the acute injury.[13,15,17,20,24,29,30] It could be that the HRQOL instruments used in the studies by Stancin and colleagues and Coster and colleagues were not sensitive enough to discriminate among different levels of TBI severity, or it could be that HRQOL is more affected by premorbid and family characteristics than injury-related factors.

The purpose of this article is to document HRQOL among children hospitalized with TBI during the first year after injury and to examine the relationship between severity of injury and HRQOL after adjusting for premorbid, socioeconomic, and family characteristics. To do this, we compared the outcomes of children hospitalized with TBI of varying severity using the Pediatric Quality of Life Inventory (PedsQL), an instrument that we previously demonstrated to be a reliable and valid measure of HRQOL among children with TBI.[31]

METHODS

STUDY POPULATION

Children aged 5 to 15 years who were discharged alive after being hospitalized 1 or more nights at 1 of 4 level I pediatric trauma center hospitals (Johns Hopkins Hospital, Baltimore, Md; Children's Hospital of Philadelphia, Philadelphia, Pa; Harborview Medical Center, Seattle, Wash; and Arkansas Children's Hospital, Little Rock) for treatment of TBI with an Abbreviated Injury Scale (AIS) severity score of 2 or greater were eligible for the study.[32]

Children were excluded for the following reasons: (1) they or their parents were non-English speaking; (2) they had a preexisting medical condition that seriously impacted preinjury physical (eg, amputation), psychological (eg, schizophrenia or bipolar disorder), or cognitive (eg, mental retardation or prior TBI-related hospitalization) function; or (3) they were part of a suspected child abuse case. To increase the generalizability of the study and to evaluate the effects of preinjury risk factors on HRQOL, children with preinjury learning disabilities or behavioral problems were eligible.

The sample was stratified by AIS severity to enroll adequate numbers of children with more severe TBI. Consecutive children within each study group were enrolled until there were approximately 95 children with head injuries with AIS scores of 2, 3, and 4. The target number for children with head injuries with AIS scores of 5 was 50 because they are less frequent.

PROCEDURES

The institutional review boards of all of the 4 participating sites approved the study. Between January 15, 2002, and July 31, 2003, the study coordinators identified 536 children with an eligible injury. However, 98 (18%) of the children were deemed ineligible on full review of all of the demographic and injury characteristics. The study coordinators approached all of the eligible children and their families. Those who consented agreed to complete 3 telephone interviews over a 1-year period and to allow pertinent injury and treatment information to be abstracted from the child's medical record.

All of the interviews were conducted by a professional survey research firm with a primary caregiver of the injured child. The first, or baseline, interview conducted within 3 weeks of the initial hospitalization (median, 16 days) was designed to measure the child's preinjury HRQOL and to obtain background information on the child and his or her family. During the baseline interview, the respondent was instructed to think of the child 1 month prior to the injury when answering the HRQOL questions. During the follow-up interviews, the respondent was asked to rate the child's HRQOL during the previous month.

MEASUREMENT

Health-related quality of life was measured with the PedsQL.[1,33] The PedsQL was selected over other pediatric HRQOL instruments primarily because it advocates a modular assessment strategy that allows for the integration of generic and disease-specific scales. For this study, the PedsQL generic instrument was supplemented with a cognitive function scale since cognitive dysfunction is a common and serious impairment following TBI.[34] Numerous studies[31,35-42] have confirmed the PedsQL to be a reliable and valid instrument for measuring HRQOL among children with different types of illnesses or injuries, including TBI.

The PedsQL generic core comprises 23 items that measure 4 health domains: (1) physical functioning, (2) emotional functioning, (3) social functioning, and (4) school functioning. The scales can be aggregated into summary scales of physical health (same as the physical functioning scale), psychosocial health (emotional, social, and school functioning scales), and total health (all of the 4 scales). The PedsQL cognitive function scale comprises 6 items. All of the PedsQL scales have a possible range from 0 (poor health) to 100 (excellent health). Scale scores more than 1 SD below the healthy sample mean are considered impaired.[34,40]

The child's age, race, health insurance coverage, and the presence of preexisting physical or psychosocial health conditions were obtained from the respondent during the baseline interview. The most prevalent preexisting physical conditions were asthma (18%) and allergies (17%) whereas the most common psychosocial conditions were an attentional problem (12%), a learning disability (11%), and a behavioral problem (7%). The respondent was also queried about his or her age, race, marital status, highest grade in school completed, total annual income of the household, and relationship to the child. Finally, the general functioning scale of the Family Assessment Device was administered to the respondents.[43,44] This 12-item scale is a self-reported measure of overall family functioning.[43-45] The scale has a possible range of 1 to 4, and scores of 2 and higher are considered unhealthy family functioning.

The nature and severity of all of the injuries sustained were characterized according to the AIS.[32,46] This scale classifies more than 2000 injuries according to the body region of injury (eg, head, chest, lower extremity), type of structure involved (eg, nerve, vessel, bone), location of injury within the body region (eg, femur, tibia), and nature of injury (eg, abrasion, crush). The AIS grades each injury according to its associated threat to life on an ordinal scale from 1 (minor) to 6 (unsurvivable). Typical head injuries sustained by the study sample included a closed vault fracture (AIS score = 2), comminuted vault fracture or subarachnoid hemorrhage (AIS score = 3), epidural or subdural hematoma (AIS score = 4), or a diffuse axonal injury (AIS score = 5). To reflect overall injury severity, the New Injury Severity Scale score was computed. The New Injury Severity Scale score is the sum of the squares of the 3 most severe injuries sustained.[47] The New Injury Severity Scale score ranges from 0 to 75, and higher scores reflect greater severity. Finally, the mechanism of injury, hospital length of stay, and disposition were recorded for all of the subjects.

Table 1. Percentage Distribution of Patient Characteristics of Subjects by Traumatic Brain Injury Severity

Patient Characteristic	Overall, % (n = 330)	Mild TBI, % (n = 185)	Moderate TBI, % (n = 103)	Severe TBI, % (n = 42)
Age, y				
5-7	28.4	27.0	35.9	16.7
8-10	26.4	28.7	26.2	16.7
11-12	20.3	20.5	15.5	30.9
13-15	24.9	23.8	22.4	35.7
Sex, male	69.4	69.2	68.9	71.4
Race				
White	68.5	65.4	68.9	81.0
Nonwhite	31.5	34.6	31.1	19.0
Health insurance				
Uninsured	0.3	0.5	0.0	0.0
Commercial	73.3	71.9	77.7	69.1
Medicaid	26.4	27.6	22.3	30.9
Preexisting physical condition	37.9	35.1	41.7	40.5
Preexisting psychosocial condition	25.1	22.7	27.2	30.9
Normal total PedsQL score at baseline	89.1	88.1	89.3	92.9

Abbreviations: PedsQL, Pediatric Quality of Life Inventory; TBI, traumatic brain injury.

DATA ANALYSIS

First, we compared those who enrolled with those who did not by different patient and injury characteristics using a χ^2 test of homogeneity. We also compared the distribution of different patient, respondent, and family characteristics by the severity of TBI sustained among those who enrolled. Second, we compared the mean PedsQL scale scores among the TBI severity groups by analysis of variance, and we examined the percentage of subjects with HRQOL outcomes that were 1 and 2 SDs lower than general population norms.[1,40] Because the PedsQL scale scores of children who sustained head injuries with AIS scores of 2 and 3 were similar, these 2 groups were combined. Throughout this article, head injuries with AIS scores of 2 and 3 are referred to as mild TBI, head injuries with AIS scores of 4 as moderate TBI, and head injuries with AIS scores of 5 as severe TBI.

Finally, to examine the impact of TBI on HRQOL over time controlling for the influence of other factors, generalized estimating equation modeling was used.[48] Selected PedsQL scale scores of all of the enrolled subjects were modeled separately as a function of time, head injury severity (maximum AIS score of the head-body region), the presence of an injury with an AIS score of 2 or higher to each other body region, mechanism of injury, Glasgow Coma Scale score, patient characteristics (ie, age, race, sex, preexisting conditions), respondent characteristics (ie, age, race, sex, relationship to child, education), and family characteristics (ie, family functioning, marital status, total household income, health insurance coverage). All of the independent variables were initially forced into the models and dropped sequentially based on their association with the outcomes. Possible interactions were tested and regression diagnostics were examined to evaluate multicollinearity and goodness of fit. Variables were considered statistically significant at $P \leq .05$ and were noted as borderline significant at $.05 < P \leq .10$. Only variables that were significant at $P \leq .10$ were included in the final models.

RESULTS

Of the 438 children eligible for the study, 381 (87%) consented and 330 (75%) enrolled. Children who did not enroll were more likely to lack health insurance (10%) than those who enrolled (<1%) ($P < .05$). In addition, children who did not enroll were hospitalized longer than those who enrolled (8.3 vs 5.3 days, respectively) ($P \leq .01$). Of the 330 who enrolled, 302 (92%) completed the interview at 3 months and 288 (87%) completed the interview at 12 months. Seventeen subjects (5%) did not complete either follow-up interview. Those who were not followed up were more likely to be younger, nonwhite, and part of a single-parent household compared with those who were followed up ($P \leq .05$) (data not shown).

Table 1 and **Table 2** display the patient, respondent, and family characteristics of the sample by the severity of TBI sustained. The mean age of all of the enrolled subjects was 10.4 years (range, 5.1-15.9 years). Subjects were more likely to be male (69%), white (69%), and in good health prior to the injury (89%). There were no significant differences in patient characteristics by the severity of TBI sustained (all $P > .10$). The respondents for children with severe TBI were more likely to be the father (31%) compared with respondents for children with mild (12%) or moderate (13%) TBI ($P \leq .05$). A greater proportion of respondents for children with mild TBI had not completed high school (24%) than respondents for children with moderate (11%) or severe (10%) TBI ($P = .001$). Finally, the respondents for children with moderate and severe TBI reported better preinjury family functioning (94% and 93%, respectively) than respondents for children with mild TBI (79%) ($P < .05$) (Table 2).

Traffic-related injuries (39%) and falls (36%) were the most common injuries (**Table 3**). The mean New Injury Severity Scale score was 21 (range, 4-66). Subjects with severe TBI were significantly more likely to sustain a thoracic (33%), abdominal (17%), spinal (17%), or upper extremity (26%) fracture than subjects with mild TBI (AIS score = 2) (4%, 3%, 3%, and 9%, respectively) ($P < .01$).

Children with severe TBI had significantly poorer HRQOL scores after injury ($P \leq .05$) than children with mild TBI, except for social functioning (not significantly different at 3 months only [$P = .15$]) and emotional functioning (not significantly different at 3 or 12 months [$P = .51$ and $P = .15$, respectively]) (**Table 4**).

Table 2. Percentage Distribution of Respondent and Family Characteristics of Subjects by Traumatic Brain Injury Severity

Respondent or Family Characteristic	Overall, % (n = 330)	Mild TBI, % (n = 185)	Moderate TBI, % (n = 103)	Severe TBI, % (n = 42)
Respondent*				
Mother	80.3	81.1	83.5	69.0
Father	14.6	11.9	12.6	31.0
Other	5.1	7.0	3.9	0.0
Respondent age, y				
21-34	33.3	36.2	31.1	26.2
35-40	30.9	30.8	32.0	28.6
≥41	35.8	33.0	36.9	45.2
Educational level of respondent*				
<High school graduate	18.2	24.3	10.7	9.5
High school graduate	33.3	31.9	36.9	31.0
Some college	26.7	22.2	32.0	33.3
College graduate	21.8	21.6	20.4	26.2
Marital status of respondent				
Married or partner	63.6	66.0	62.1	57.1
Not married or no partner	36.4	34.0	37.9	42.9
Total household income, $†				
<20 000	18.3	18.8	16.7	20.0
20 000-49 999	36.0	35.9	38.5	30.0
50 000-99 999	34.0	34.3	36.5	27.5
≥100 000	11.7	11.0	8.3	22.5
Healthy family functioning before injury*	85.5	78.9	94.2	92.9

Abbreviation: TBI, traumatic brain injury.
*Difference is significant between study groups ($P \leq .05$).
†Data were missing for 10 subjects.

Table 3. Percentage Distribution of Injury Characteristics of Subjects by Traumatic Brain Injury Severity

Injury Characteristic	Overall, % (n = 330)	Mild TBI, % (n = 185)	Moderate TBI, % (n = 103)	Severe TBI, % (n = 42)
Mechanism of injury*				
Traffic related	38.8	33.0	35.0	73.8
Fall	36.1	36.8	42.7	16.7
Other	25.1	30.2	22.3	9.5
New Injury Severity Scale score*				
4	13.6	24.3	0.0	0.0
5-9	26.4	47.0	0.0	0.0
10-24	23.0	21.1	35.9	0.0
≥25	37.0	7.6	64.1	100.0
Hospital length of stay, d*				
1-2	31.8	47.0	17.5	0.0
3	20.9	22.2	25.2	4.7
4-7	24.9	21.1	35.0	16.7
≥8	22.4	9.7	22.3	78.6
Disposition*				
Home	84.2	94.6	84.5	19.1
Rehabilitation hospital	15.8	5.4	5.5	80.9
Location of injury with AIS score ≥2				
Face	12.7	11.9	9.7	3.8
Thorax*	8.2	3.8	5.8	33.3
Abdomen*	5.5	3.2	4.8	16.7
Spine*	5.2	3.2	3.9	16.7
Upper extremity*	11.2	8.6	9.7	26.2
Lower extremity*	16.1	15.1	12.6	28.6

Abbreviations: AIS, Abbreviated Injury Scale; TBI, traumatic brain injury.
*Difference is significant between study groups ($P \leq .05$).

When comparing children with severe TBI with those with moderate TBI, physical functioning was the only significant difference at both 3 and 12 months after injury ($P \leq .05$).

Using the total PedsQL score as an overall measure of HRQOL, **Figure 1** displays the proportion of children with impaired HRQOL by TBI severity. Overall, a considerable proportion of children had impaired HRQOL at 3 months

Table 4. Mean Pediatric Quality of Life Inventory Scores by Traumatic Brain Injury Severity*

PedsQL Scale	PedsQL Score Overall, Mean (n = 330)	PedsQL Score for Mild TBI, Mean (n = 185)	PedsQL Score for Moderate TBI, Mean (n = 103)	PedsQL Score for Severe TBI, Mean (n = 42)
Total				
At baseline	88.9	88.3	89.1	90.8
At 3 mo†	74.8	77.4	73.4	67.4
At 12 mo†	77.7	80.0	76.4	70.3
Physical function				
At baseline	95.0	94.3	95.4	96.7
At 3 mo†	78.1	81.5	77.8	65.2
At 12 mo†	84.7	87.3	83.4	75.5
Emotional function				
At baseline	86.0	85.4	86.7	87.0
At 3 mo	71.0	72.0	69.8	69.6
At 12 mo	73.1	74.9	70.9	70.1
Social function				
At baseline	90.4	90.0	90.0	93.6
At 3 mo	78.7	80.3	77.5	75.4
At 12 mo‡	80.9	83.2	79.1	75.1
School function				
At baseline	84.1	83.6	84.1	86.0
At 3 mo†	71.2	75.4	68.7	59.1
At 12 mo†	72.2	74.2	72.3	62.9
Psychosocial function				
At baseline	86.8	86.3	87.0	88.9
At 3 mo	73.7	76.0	72.0	68.2
At 12 mo	75.3	77.4	74.1	68.8
Cognitive function				
At baseline	86.2	85.6	85.7	90.0
At 3 mo†	68.2	72.3	66.1	56.4
At 12 mo†	68.4	71.2	66.0	61.4

Abbreviations: PedsQL, Pediatric Quality of Life Inventory; TBI, traumatic brain injury.

*There were 433 subjects at baseline, 391 at 3 months after injury, and 377 at 12 months after injury.

†Difference is significant between at least 2 of the study groups ($P \leq .05$).

‡Difference is borderline significant between at least 2 of the study groups ($.05 < P < .10$).

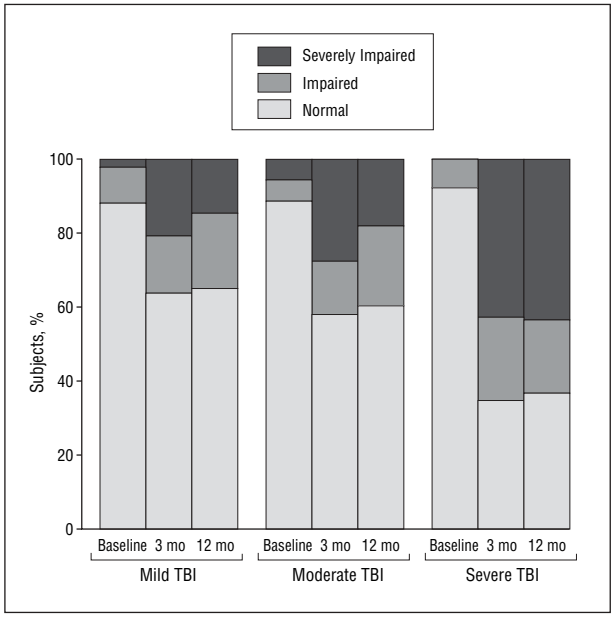

Figure 1. Percentage of subjects with impaired health-related quality of life by traumatic brain injury (TBI) severity at baseline, 3 months after injury, and 12 months after injury. The health-related quality of life is measured by the total Pediatric Quality of Life Inventory score. Severely impaired indicates 2 SDs below the general population norm; impaired, 1 SD below the general population norm.

(42%) and 12 months (40%) after injury. At 3 months after injury, more children with mild TBI (64%; relative risk = 1.3; 95% confidence interval, 1.1-1.5) or moderate TBI (58%; relative risk = 1.3; 95% confidence interval, 1.1-1.7) had normal HRQOL compared with children with severe TBI (35%). Similarly, at 12 months after injury, HRQOL of a relatively small proportion of children with severe TBI was normal (37%) compared with the other TBI groups (relative risk = 0.4; 95% confidence interval, 0.2-0.7).

Figure 2 compares the mean total PedsQL scores of the different study groups at 12 months after injury with scores for children with different medical conditions.[1,34-38,40-42,49,50] Health-related quality of life of children with mild TBI is similar to that of children with type 1 diabetes mellitus.[49] Health-related quality of life of children with moderate TBI is most similar to that of children who survived acute lymphoblastic leukemia whereas HRQOL of children with severe TBI most resembled that of children who were seen at a rheumatology or oncology clinic.[34,42,50]

Table 5 displays the changes in HRQOL scores associated with different risk factors. Of note, the type and severity of injuries sustained are associated with the greatest reductions in HRQOL at 3 and 12 months after injury. Children with moderate or severe TBI had significantly poorer physical, cognitive, psychosocial, and overall HRQOL scores compared with children with mild TBI (all $P < .10$). Furthermore, there is a significant interaction effect between type and severity of injury and time. At 3 and 12 months after injury, the presence of a concomitant lower extremity fracture (decrease of 24.1 and 7.3, respectively), upper extremity fracture (decrease of 8.9 and 7.8, respectively), concomitant spinal injury (decrease of 13.2 and 7.7, respectively), or severe TBI (decrease of 11.7 and 9.6, respectively) ($P < .05$) was associated with the largest decrements in physical function. Although the impact of a concomitant lower extremity fracture and a concomitant spinal injury (ie, spinal fracture or dislocation) on physical function lessened over time, the impact of a concomitant upper extremity fracture or severe TBI did not. A similar pattern was noted for psychosocial function and overall HRQOL; however, the magnitude of the impact was not as strong (except for TBI), and only the impact of the concomitant lower extremity fracture lessened over time. None of the associated injuries to other body regions significantly influenced HRQOL (all $P > .10$). There was also a strong dose-response relationship noted between the severity of TBI and cognitive function (**Figure 3**).

The only patient characteristic to demonstrate a significant relationship to HRQOL was the presence of a preexisting psychosocial condition, which was associated with a significant reduction in all of the dimensions of HRQOL (range of decrease, 2.9-12.3) ($P \leq .05$).

Although none of the respondent characteristics significantly influenced HRQOL, several family character-

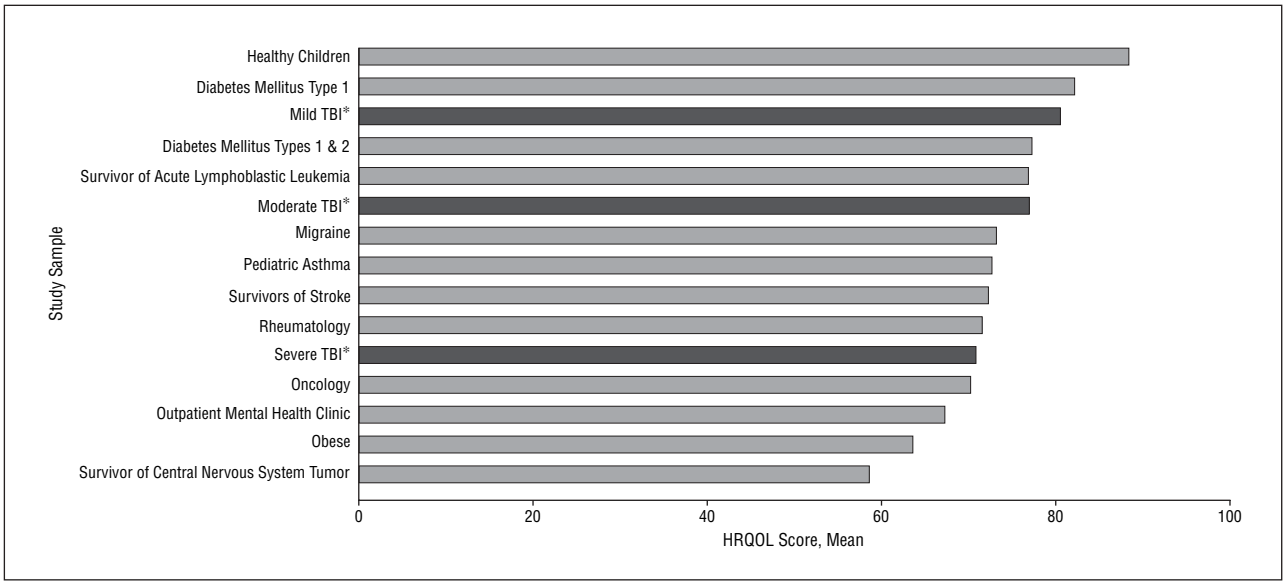

Figure 2. Mean health-related quality of life (HRQOL) scores among different study samples. The HRQOL is measured by the total Pediatric Quality of Life Inventory score. TBI indicates traumatic brain injury; asterisk, the HRQOL was measured at 12 months after injury.

istics did. The HRQOL scores of children who came from single-parent households were significantly lower than those of children who lived with both parents or 1 parent and a partner (range of decrease, 3.2-3.4) ($P \leq .05$). Similarly, unhealthy family functioning was associated with a significant reduction in HRQOL (range of decrease, 5.1-6.8) ($P \leq .05$). Finally, children who were covered by Medicaid or were uninsured had poorer HRQOL outcomes compared with children with private health insurance (range of decrease, 3.1-5.5) ($P \leq .05$). Family income was significantly related to HRQOL when examined alone (subjects with lower family income had poorer HRQOL outcomes compared with subjects from higher income households), but because of its strong correlation to health insurance coverage and marital status, it did not remain significant in the multivariable model (all $P > .10$; data not shown).

COMMENT

This is the first study to our knowledge to document the HRQOL outcomes during the first year after injury of a cohort of children who sustained TBI severe enough to warrant hospitalization, and we found that the severity of injury significantly impacted HRQOL. Our findings are consistent with other studies[12-20,22-26] that have examined neuropsychological and behavioral outcomes following TBI. All of the dimensions of HRQOL measurably declined among children who sustained severe TBI and did not improve over time. With the exception of physical function, multiple dimensions of HRQOL were also negatively impacted among children who sustained moderate TBI.

Our results suggest that there is a strong relationship between the severity of TBI and HRQOL during the first year after injury. Coster et al[28] may not have found a significant association between TBI severity and HRQOL during the first 6 months after injury because the majority of their patients sustained mild TBI. In a multivariable analysis, Stancin et al[27] also did not find a relationship between TBI severity and HRQOL as measured by the Child Health Questionnaire. Although it could be that the Child Health Questionnaire is not sufficiently sensitive for children with TBI, it seems more likely that the relationship between TBI severity and HRQOL weakens over time. Since numerous studies[16,17,20,22-24] have demonstrated that children with severe TBI have persistent long-term deficits that should negatively impact HRQOL, it will be important in future research to measure HRQOL outcomes multiple times over a long follow-up period to determine how HRQOL and the factors that influence it change over time.

The results of this study demonstrate the importance of measuring the impact of associated injuries on children's health. The poorest HRQOL outcomes were among children who sustained TBI and an associated extremity fracture or spinal injury (ie, spinal fractures or dislocations). These results concur with earlier studies[51,52] that noted that a significant proportion of children who sustained an extremity injury had physical and role limitations 1 year later. We also found that a small but significant proportion of children with extremity fractures, particularly lower extremity fractures, had impaired HRQOL at 1 year after injury.[53] MacKenzie et al[54] also found that among adult trauma patients, injuries to the head, spine, or extremities (particularly lower extremities) were more frequently associated with functional limitations after injury compared with injuries to other body regions.

Children with moderate or severe TBI had worse physical and psychosocial functioning during the first year after injury compared with children with mild TBI. Evidence that children who sustain moderate to severe TBI are at higher risk of developing a psychiatric disorder after injury is beginning to accumulate.[55,56] Other researchers[13,15,29,57,58] have also found that children who sustain moderate to severe TBI exhibit more depressive symptoms, behavioral problems, and difficulties at school compared with children with an orthopedic injury.

Table 5. Estimated Change in Health-Related Quality of Life Scores Associated With Each Characteristic*

Characteristic†	Physical Function, Change in Scale Score	Cognitive Function, Change in Scale Score	Psychosocial Function, Change in Scale Score	Total PedsQL, Change in Scale Score
Intercept	99.2	91.9	92.9	94.4
Time				
3 mo (baseline)	−7.9‡	−11.6‡	−8.2‡	−8.1‡
12 mo (baseline)	−5.5‡	−13.2‡	−8.2‡	−7.5‡
Head injury severity				
Moderate TBI (mild TBI)	0.4	−0.3	0.2	0.2
Severe TBI (mild TBI)	2.7‡	5.4‡	3.3§	3.2‡
Head injury severity and time				
Moderate TBI at 3 mo (mild TBI at 3 mo)	−5.8‡	−7.1‡	−5.2‡	−5.3‡
Severe TBI at 3 mo (mild TBI at 3 mo)	−11.7‡	−17.6‡	−7.2§	−8.2‡
Moderate TBI at 12 mo (mild TBI at 12 mo)	−4.7‡	−4.7§	−3.3§	−3.7‡
Severe TBI at 12 mo (mild TBI at 12 mo)	−9.6‡	−10.7‡	−6.5‡	−7.3‡
Concomitant LE fracture				
LE fracture (no LE fracture)	1.4	1.9	2.5	2.2
Concomitant LE fracture and time				
LE fracture at 3 mo (no LE fracture at 3 mo)	−24.1‡	−5.9	−9.2‡	−12.9‡
LE fracture at 12 mo (no LE fracture at 12 mo)	−7.3§	−0.9	−2.0	−3.3
Concomitant UE fracture				
UE fracture (no UE fracture)	1.9	4.0	0.2	0.7
Concomitant UE fracture and time				
UE fracture at 3 mo (no UE fracture at 3 mo)	−8.9§	−6.3	−5.2	−6.1§
UE fracture at 12 mo (no UE fracture at 12 mo)	7.8‡	−11.1‡	−9.0‡	−8.7‡
Concomitant spinal injury				
Spinal injury at baseline (no spinal injury at baseline)	0.3	0.5	0.8	0.7
Concomitant spinal injury and time				
Spinal injury at 3 mo (no spinal injury at 3 mo)	−13.2§	−5.2	−6.3§	−8.1‡
Spinal injury at 12 mo (no spinal injury at 12 mo)	−7.7	−9.8§	−6.3§	−6.5§
Mechanism of injury				
Traffic-related (fall)	−2.7§	−3.6§	−2.7§	−2.5§
Other (fall)	−1.1	−0.4	−0.2	−0.2
Patient characteristics				
Preexisting psychosocial condition (no preexisting psychosocial condition)	−2.9‡	−12.3‡	−8.0‡	−6.7‡
Preexisting physical condition (no preexisting physical condition)	−1.0	0.7	−2.0§	−1.9§
Family characteristics				
Single or no partner (married or partner)	−3.4‡	−1.6	−3.2‡	−3.2‡
Poor family functioning (good family functioning)	−5.1‡	−4.8§	−6.8‡	−6.5‡
Medicaid or uninsured (commercial insurance)	−3.1‡	−5.5‡	−3.7‡	−3.6‡

Abbreviations: LE, lower extremity; PedsQL, Pediatric Quality of Life Inventory; TBI, traumatic brain injury; UE, upper extremity.

*These estimates reflect the increase or decrease in the PedsQL scale scores associated with a given characteristic compared with the reference group adjusted for all of the other covariates in the tables.

†Reference group is in parentheses for each parameter.

‡Parameters are significant ($P \leq .05$).

§Parameters are borderline significant ($.05 < P < .10$).

With increasing TBI severity, parents reported more cognitive dysfunction. Moreover, the cognitive dysfunction persisted over time. Our results concur with numerous other studies[14,16,20,30,59,60] that have described cognitive deficits at 1 year after injury among children who sustain moderate to severe TBI.

The presence of a preexisting psychosocial condition was associated with a reduction in many domains of HRQOL, even after adjusting for preinjury function. Other studies[19,61,62] involving trauma patients have also noted the importance of controlling for the presence of comorbidities when examining the impact of an injury on HRQOL.

During the first year after injury, unhealthy family functioning, single-parent households, and being uninsured or covered by Medicaid all had a small but negative impact on children's HRQOL. These results are consistent with those of other studies[15,18] that have also found that preinjury family functioning influences different health outcomes after TBI. It could be that single-parent households have fewer resources (ie, financial and/or social) available to devote to a child's recovery compared with 2-parent households. Similarly, financial resources could also explain why the HRQOL outcomes were poorer among children covered by Medicaid or who were uninsured. Stancin et al[27] noted a significant association between socioeconomic status and HRQOL. Contrary to the results of other studies,[15,29,63] we did not find a significant interaction effect between family characteristics and the severity of TBI sustained.

The results of this study must be considered in the context of several limitations. First, preinjury HRQOL scores were obtained shortly after injury, which could have bi-

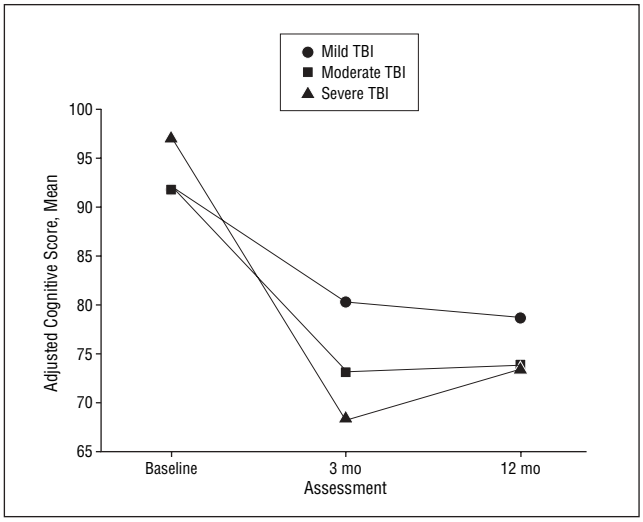

Figure 3. Adjusted mean cognitive score by traumatic brain injury (TBI) severity. Scores were adjusted for associated injury, mechanism of injury, patient characteristics, and family characteristics.

ased the respondent's perceptions. Although the preinjury HRQOL scores were not significantly different among the study groups when examined alone, the multivariable regression results showed that the parents of children with severe TBI reported better preinjury HRQOL compared with that which the parents of the children with an extremity fracture reported. While this may reflect a small overestimation of preinjury function, an estimate is important to have when evaluating injury sequelae.[15] Second, HRQOL was based on a primary caregiver's perspective; future research should incorporate the child's perceptions of his or her HRQOL. Finally, we may have underestimated the reduction in HRQOL as a result of severe TBI or a lack of health insurance since children with either of these characteristics were less likely to participate.

Despite these limitations, this study illustrates that it is possible to use a brief instrument to assess a child's physical and psychosocial health following TBI. While it is not feasible to conduct in-depth follow-up assessments on all children who sustain TBI severe enough to warrant hospitalization, it may be that an instrument such as the PedsQL can help clinicians to monitor the recovery of children following different types of injuries and to systematically identify those in need of further evaluation and services.

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