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Association of Parent Ratings of Executive Function With Global- and Setting-Specific Behavioral Impairment After Adolescent Traumatic Brain Injury

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Abstract

Objective—To determine the association of primary caregiver-rated behavioral and metacognitive aspects of executive function (EF) with impaired functioning after adolescent traumatic brain injury (TBI).

Design—Multicenter cross-sectional study.

Setting—Outpatient.

Participants—Primary caregivers and children (N = 132) aged 12 to 17 years who sustained a moderate or severe TBI within the past 1 to 6 months.

Interventions—Not applicable.

Main Outcome Measures—Primary caregiver ratings of EF, tests of memory and processing speed (PS), and a structured parent interview to assess clinical impairments in behavioral functioning were used. Logistic regression was used to examine the relation of ratings of EF with clinical ratings of impairment in global adolescent functioning and in functioning in the home,

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Supplier

school, and community settings after controlling for sex, race, socioeconomic status, injury severity, and performance on the tests of memory and PS.

Results—Caregiver ratings of poor EF were associated with impairment in both global behavioral functioning (odds ratio [OR] = 4.73; 95% confidence interval [CI], 1.54–14.52; $P < .01$) and community functioning (OR = 13.28; 95% CI, 1.94–90.87; $P < .01$).

Conclusions—Caregiver ratings of deficits in EF were associated with impaired behavioral functioning after adolescent TBI and were independent of performance on tests of memory and processing speed. Understanding the relation of EF with clinical impairments as manifested in different settings will help hone assessment batteries and focus treatments where they are needed most.

Keywords

Adolescent; Brain injuries; Executive function; Memory; Rehabilitation

Pediatric traumatic brain injury (TBI) is one of the most common causes of acquired morbidity and mortality in children.^{1,2} TBI in children results in 2,685 deaths, 37,000 hospitalizations, and 435,000 emergency room visits annually in the U.S.^{2,3} Cognitive and behavioral deficits are common after pediatric TBI,^{4,5} with problems in executive function (EF) being particularly common and persistent long-term after injury.^{6–10} EF is a complex construct and involves multiple overlapping domains, including attentional control, goal setting, cognitive flexibility, working memory, inhibition, and decision-making.^{11–13} Difficulties in cognitive and behavioral regulation aspects of EF may lead to social and behavioral problems after TBI.

Various aspects of EF are affected after TBI in children.¹³ Anderson and Catroppa⁶ found a dose response relation 24 months after injury between TBI severity and 4 components of EF: attentional control; planning, goal setting, and problem solving; cognitive flexibility; and abstract reasoning. More severe injury was associated with more executive dysfunction.⁶ Other studies have also demonstrated longer-term deficits in components of EF after TBI in children. Ten years after TBI in adolescents, individuals who sustained a severe TBI had poorer performance on goal setting and processing speed tasks compared with those with mild and moderate TBI and typically developing participants.¹⁴ Additionally, deficits in EF, memory, and verbal intelligence quotient can persist for many years after severe childhood TBI.¹⁵ These studies demonstrate that both ratings and clinical or lab-based measures of various components of EF are affected after TBI in children; however, the extent that deficits in EF relate to behavioral, emotional, and psychosocial difficulties after TBI in children is less clear. Because the ecological validity of tests of EF is not yet firmly established,^{16,17} ratings of the behavioral manifestations of EF have greater potential to predict functional outcomes than lab-based procedures. Cognitive abilities, such as memory and processing speed, are also affected by TBI and may contribute to the behavioral consequences of TBI.^{18–24}

Several recent studies evaluated the relation of functional outcomes after pediatric TBI with EF. In a small study of 28 children aged 8 to 16 years with TBI, Tonks et al²⁵ demonstrated that lab-based measures of impairments in both EF (Delis-Kaplan Executive Function System battery) and processing speed correlated with sociobehavioral difficulties assessed by the Strength and Difficulties Questionnaire. Similarly, in a study of children aged 3 to 6 years with TBI (N = 87) and orthopedic injuries (N = 119), Ganesalingam et al²⁶ found that executive dysfunction assessed by a delayed alternation task, a modified Stroop test for children (Shape School), and behavioral ratings of EF (Behavior Rating Inventory of Executive Function and Child Behavior Questionnaire) were associated with decreased

social competence assessed by the Adaptive Behavior Assessment System, Preschool Kindergarten Behavior Scales, and Home and Community Social Behavior Scales. Behavioral ratings of EF were more strongly correlated with social competence than other measures of EF.²⁶ Furthermore, in a study of 36 adolescents and young adults aged 16 to 22 years who sustained a TBI between ages 8 to 12 years, deficits in EF predicted less sophisticated problem-solving skills and poorer social outcomes.²⁷ Decreased self-regulation has also been correlated with poorer social and behavioral outcomes after child and adolescent TBI.^{28–31} Similarly, in other studies, slower reaction time and resistance to interference on a flanker task were correlated with long-term social outcomes,¹² and slower processing speed was associated with socioemotional difficulties after TBI in children and adolescents.²⁵ After TBI in adults, deficits in EF and memory have been associated with poorer occupational and psychosocial outcomes. In 1 study of adolescents and adults with TBI, executive dysfunction explained 13% of the variance in occupational functioning and 16% in social integration.³² In another study, the degree of working memory problems after adult TBI predicted long-term employment status, community integration, and life satisfaction.³³ Collectively, these previous studies demonstrate that both ratings of EF and cognitive aspects of EF are associated with behavioral, psychosocial, and occupational outcomes after TBI in children and adults. However, most of these studies have not evaluated associations of behavioral ratings of EF with a setting specific impairment while controlling for cognitive abilities commonly affected by pediatric TBI, such as verbal memory and processing speed. Additionally, these studies have been limited by relatively small and heterogeneous samples. Moreover, relatively few studies have targeted large samples of adolescents, the age group with the highest incidence of TBI. Thus, further research is needed to improve our understanding of the relation of behavioral and cognitive aspects of EF with functional outcomes after TBI in adolescents.

The goal of this article is to build on these previous studies by better elucidating the association of primary caregiver-rated behavioral and metacognitive aspects of EF with functional impairments globally and across multiple settings (school, home, and community) after TBI in a large cohort (N = 132) of adolescents. Specifically, we hypothesized that higher levels of primary caregiver-rated deficits in emotional and behavioral regulation, as well as in metacognitive skills (initiation, planning, organization, problem solving, and working memory), would be associated with clinical impairments in functioning across multiple real-world settings. We further hypothesized that these associations would be independent of deficits in verbal memory and processing speed. A secondary aim was to determine if functional impairments would be more closely related to the behavioral self-regulation or metacognitive components of EF. A better understanding of the relation of behavioral and cognitive aspects of EF with functional impairment in various settings after adolescent TBI would help in targeting interventions to individuals at risk and identifying settings where there is an increased risk for these problems.

Methods

Participants

The current study is part of a larger clinical trial comparing the efficacy of 2 Internet-based interventions. Study sites included 4 tertiary pediatric hospitals, 2 tertiary general medical centers, and 1 specialized children's hospital. Prior to initiation of the study, institutional review board approval was obtained from all participating institutions. Only the baseline data collected as part of the initial assessment are presented here. Participants included adolescents aged 12 to 17 years who sustained a moderate or severe TBI. Children were considered eligible for study participation if they were admitted to the hospital for at least 1 night for a moderate or severe TBI, they completed all inpatient medical and inpatient rehabilitation clinical care, and were within 1 to 6 months postinjury. The Glasgow Coma

Scale (GCS) was used to characterize TBI severity.³⁴ Moderate TBI was defined as a GCS score of 9 to 12 or a higher score accompanied by evidence of neurologic insult on neuroimaging. Severe TBI was defined as a GCS score <9 with or without evidence of neuroimaging findings. Exclusion criteria included nonblunt trauma (eg, penetrating head injury), primary language other than English, history of moderate or severe intellectual disability prior to injury, history of child abuse as documented in the medical record or reported by parents, active inpatient medical or rehabilitation care, inability to perform study measures, and history of participant or parental psychiatric hospitalization 1 year previous to enrollment. Participants were enrolled 1 to 6 months after initial injury into the multicenter cross-sectional study.

Of the 308 families initially identified as potential participants in the study, 52 did not meet inclusion criteria, 52 refused participation, 5 were unable to be contacted, and 67 were unable to be recruited during the initial 6 months postinjury. The final study population evaluated consisted of 132 participants (65.2% boys, 19.7% nonwhites, and 38.6% with severe TBIs). The mean age of injury $\pm$ SD was 14.54 ± 1.74 years, and the mean time since injury $\pm$ SD was 3.56 ± 1.74 months. There were no differences between participants and nonparticipants in age (mean $\pm$ SD, 14.54 ± 1.74 for participants; 14.68 ± 1.74 for nonparticipants). However, nonparticipants were significantly more likely than participants to be nonwhite (24.4% vs 19.7%, respectively) and to have less severe TBI as measured by the GCS (mean GCS $\pm$ SD, 11.9 ± 3.89 vs 10.03 ± 4.56).

Measures

Measures were collected during home visits by trained research coordinators. All measures used in this study were collected as part of the baseline visit prior to treatment group assignment. Clinical impairments in functioning were assessed using the Child and Adolescent Functional Assessment Scale (CAFAS). The CAFAS is a structured clinical interview of parents/primary caregivers that identifies clinical impairment in behavioral functioning in adolescents across different settings. It has been used widely to assess clinical outcomes in children with serious emotional disturbances.^{35,36} The CAFAS generates a total score as well as clinical ratings of functional impairment in 8 domains: school, home, community, behavior toward others, moods/emotions, self-harmful behaviors, substance abuse, and thinking.³⁷ The rating is ordinal: 0 (no impairment), 10 (mild impairment), 20 (moderate impairment), and 30 (severe impairment). Additionally, a total score (range, 0–240) is generated by adding the scores for each of the 8 domains. The CAFAS has been well validated and has excellent interrater reliability with correlation coefficients ranging from .74 to .99.³⁵ In prior studies of children with severe emotional disturbance, the CAFAS total score was dichotomized into 2 levels of impairment: no/mild and at risk.^{38,39} To insure high interrater reliability for administration of the CAFAS for this study, a PhD level psychologist and Master's level counselor attended a 2-day training session provided by the creator of the CAFAS that certified them as CAFAS trainers.³⁷ The certified trainers then provided subsequent training to site raters until they were able to pass the necessary tests to achieve 80% interrater reliability, as recommended by the creator of the CAFAS. Trainers and raters participated in monthly reliability calls throughout the course of the study to discuss recently administered CAFAS interviews, answer questions that had arisen, and ensure that each site continued to rate the CAFAS in a standard manner. Ratings of recordings of 10% of the CAFAS interviews by a certified trainer yielded an interrater reliability of 95%.

The Behavior Rating Inventory of Executive Function (BRIEF) was completed by the participant's family-identified primary caregiver to assess EF.^{40–44} The measure has good internal consistency, interrater reliability, and test-retest reliability and has been validated in pediatric TBI.^{40,44} The Behavioral Regulation Index (BRI) and the metacognition index

(MI) were used to measure behavioral and metacognitive aspects of EF. The BRI represents the child's ability to modulate emotions and behavior with inhibitory control, and the MI represents the child's ability to initiate, plan, organize, and sustain future oriented problem solving in working memory.⁴³ Higher scores indicate more problems in EF, with a score of 65 or greater indicating significant executive dysfunction.^{42,43} Dichotomized scores were used in the analysis to identify individuals with potential clinical impairment.

Although our primary aim was to examine the BRIEF as a predictor of impaired behavioral functioning, tests of verbal memory and processing speed were also administered to assess these cognitive skills that subserve EF. The California Verbal Learning Test (CVLT) was used to assess verbal learning and memory.^{45,46} The CVLT child version⁴⁶ was used in participants aged 16 years and younger; the adult version⁴⁵ was used in children aged 17 years and older. The CVLT has been used previously in pediatric TBI studies and has sound psychometric properties.^{18,23,47} The T score for the total number of items recalled during the initial 5 learning trials was used in the analysis,⁴⁸ with lower scores indicating greater verbal learning and memory impairment. Age standardized scores for the child or adult version of the CVLT were used for the analysis. The Wechsler Processing Speed Index (PSI) was used to assess processing speed.^{49,50} The Wechsler Intelligence Scale for Children, 4th edition PSI⁴⁹ was used in participants aged 16 years and younger; the Wechsler Adult Intelligence Scale, 4th edition PSI⁵⁰ was used in participants aged 17 years and older. The PSI is sensitive to the effects of TBI.^{24,47,51} The PSI standard score was used in the analysis with lower scores indicating slower processing speed. Age standardized scores for the child or adult version of the Wechsler PSI were used in the analysis.

Data analysis

All data analysis was performed using SAS enterprise guide version 5.1^a or JMP genomics 5.0.^a The moderate and severe TBI groups were compared on demographic factors and behavioral and neuropsychologic outcome measures using *t* tests or chi-square analysis. The CAFAS total score, consistent with previous studies^{38,39} of adolescents, was also dichotomized into 2 levels of impairment: no/mild (score range, 0–50) and at risk (score range, >50). Logistic regression was performed for the dichotomized CAFAS total score (primary analysis) and each domain score (secondary analyses). Three series of regressions were conducted: one that included only the BSI as the primary predictor (BRI models), one that included only the MI (MI models), and a third that included both the BRI and MI (combined models). *P* < .05 was considered significant for the primary analysis. For the secondary analyses, a corrected *P* was calculated by dividing .05 by 3 (the number of domain scores on the CAFAS used in the secondary analysis: school, home, and community); therefore, *P* = .017 was used as the threshold for significance in the secondary analysis. To identify individuals with at least mild clinical impairment, the CAFAS domain scores were dichotomized into no impairment (score = 0) versus any impairment (score > 0).^{37,39} BRI and MI T scores for primary caregiver ratings on the BRIEF were dichotomized into impaired (T score ≥ 65) versus nonimpaired (T score < 65), as used previously,^{42,43} and were the primary predictors of interest.

Covariates included in the regression models included age at injury, months since injury, sex, socioeconomic status estimated by the primary caregiver's highest grade of school completed (<high school or high school), race (white or nonwhite), and injury severity (severe or nonsevere TBI). Sex, race, and socioeconomic status have been included as covariates in prior pediatric TBI research.^{31,52,53} TBI severity was included as a covariate because of its associations with neurobehavioral outcomes after pediatric TBI.^{4,54}

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Standardized scores for the CVLT and PSI were also included as covariates to determine if associations between ratings of EF and the CAFAS were independent of any effects of TBI on these cognitive skills. Because poor memory skills and slowed processing could potentially contribute to the behavioral manifestations of impaired EF, controlling for these skills increased our confidence in interpreting associations of the BRIEF with behavioral functioning as reflecting the influences of EF rather than of cognitive skills.

Correlations between age at injury ($r = .06$, $P = .49$) and time since injury ($r = .09$, $P = .30$) with the CAFAS total score were examined. The correlations were not significant at $P < .15$; therefore, age at injury and time since injury were excluded from the final models.

Results

Demographics and distribution of outcome measures in the study population

The moderate and severe TBI groups did not differ significantly in age at injury, time since injury, race, sex, or primary caregiver education (table 1). Consistent with the assignment to severity groups, the GCS, PSI, and CVLT scores were significantly lower for the severe group than for the moderate group (see table 1). However, the moderate and severe groups did not differ on the behavioral or neuropsychologic outcome measures (see table 1).

Logistic regression models examining predictors of the CAFAS

Impairments on both the BRI and MI were associated with global impairment of the CAFAS total score (table 2): for the BRI model, the odds ratio (OR) was 5.20 (95% confidence interval [CI], 2.00–13.54; $P < .001$); and for the MI model, the OR was 7.31 (95% CI, 2.63–20.33; $P < .001$). Only impairment on the MI was associated with global functional impairment in the combined regression model (OR = 4.73; 95% CI, 1.54–14.52; $P < .01$).

In the secondary analysis (table 3), impairments on both the BRI and MI were associated with functional behavioral impairments in school: for the BRI model, the OR was 3.50 (95% CI, 1.41–8.69; $P < .01$), and for the MI model, the OR was 3.93 (95% CI, 1.58–9.79; $P < .01$). Neither the BRI nor MI predicted the CAFAS school score when both variables were included as predictors (combined model), though the association of impairment on the MI approached significance (OR = 2.96; 95% CI, 1.06–8.30; $P = .04$). Impairment on the MI was also associated with community dysfunction in both the MI model (OR = 17.53; 95% CI, 3.06–100.56; $P < .01$) and the combined model (OR = 13.28; 95% CI, 1.94–90.87; $P < .01$). Of the several covariates included in the analysis, sex was the only variable significantly associated with impairment on the CAFAS, with higher rates of dysfunction at school for boys than girls. Marginally significant ($P < .10$) associations were also found between scores on the noncognitive measures and impairments on the CAFAS (see tables 2 and 3).

Discussion

This study demonstrated that primary caregiver ratings of deficits in the metacognition (MI) and behavior regulation (BRI) aspects of EF, as measured by the BRIEF, were associated with functional behavioral impairments on the CAFAS after controlling for sex, race, socioeconomic status, injury severity, and performance on tests of memory and processing speed. Deficits in metacognition (MI) were associated with impaired functioning globally (CAFAS total score) and in the community. There was a trend for an association between metacognitive dysfunction and school impairment. Because we controlled for measures of memory and processing speed, associations of primary caregiver ratings of problems in EF with clinical impairments are interpreted as reflecting weaknesses in EF skills rather than in cognitive abilities, which can be adversely affected by pediatric TBI.

Previous studies have demonstrated an association between neuropsychologic measures of EF and occupational, social, and cognitive outcomes.^{12,27,32–34,55} However, this study adds to the literature by better elucidating the association of metacognitive and behavior regulation ratings of EF with impaired functioning in a large cohort of adolescents who sustained a moderate or severe TBI. In agreement with other research,^{16,17,25} our findings also indicate that ratings of EF are associated with functioning globally and across various settings. To our knowledge, this is the first study to evaluate the association of ratings of EF with clinical functioning after TBI in adolescents assessed by the CAFAS. The CAFAS reliably determines the need for intensive services, assesses clinical changes, and can be used to monitor response to interventions for children with serious emotional disturbances.³⁶ It also predicts use of services better than either the Child Behavior Checklist or psychiatric diagnoses.^{35,36} Identifying neuropsychologic measures that predict impairments in clinical functioning in children with TBI is important, because it will potentially help hone screening and assessment batteries to include tests that are more sensitive to clinical levels of impairment in thinking and behavior in specific settings. Identifying predictors of poor functioning also allows clinicians to focus treatments where they are needed most.

This study focused on the evaluation of adolescents within 6 months after injury. This is an important time point, because children are commonly transitioning back to home, school, and the community during this time. Executive dysfunction is known to persist long term after injury.^{7,56} Identification of deficits as early as possible would allow interventions to be initiated early and potentially minimize the detrimental effect of executive dysfunction on long-term behavioral impairments after injury. Future research will need to clarify the impact of executive dysfunction longitudinally on behavioral impairment across multiple settings.

In this study, 34% of adolescents with moderate and severe TBI scored in the at risk range on the total CAFAS score (>50). The mean score $\pm$ SD for the at risk group was 85.56 ± 26.25 , which is similar to scores for individuals with severe emotional disturbances receiving community mental health services (mean $\pm$ SD, 89.35 ± 32.35).³⁸ Additionally, a high proportion of the study population had some impairment in the school, home, behavior toward others, moods and emotions, and thinking domains on the CAFAS. However, a low proportion of the study population evidenced impairment in the community, self-harm, and substance abuse domains, suggesting that cognitive and behavioral problems are more common than self-injurious behavior or substance abuse disorders in the study population. Given that behavioral and emotional problems are common after pediatric TBI, further elucidation of the role of the CAFAS in the evaluation of clinical impairment in behavior after injury is needed. Covariate effects indicated the need to take sex differences into account when assessing risk for clinical impairment. Further research is needed to define the conjoint effects of injury-related variables, demographic variables, and performance-based cognitive measures to better identify individuals potentially at risk for poorer behavioral outcomes after injury.

Study limitations

The study benefitted from use of a structured clinical interview that assessed functioning across several domains and settings. However, this information was obtained only from parents, which may have artificially increased the association of primary caregiver ratings of EF with our clinical ratings based on the CAFAS. Collections of ratings from teachers or broader lab-based measures of EF may be useful in obtaining less biased estimates of associations of behavioral indications of poor EF with findings from the CAFAS. Evaluating the association of EF tasks^{57,58} with CAFAS ratings may also provide further insight into the utility of the CAFAS for the evaluation of functioning after TBI in adolescents. Another limitation of this study is the lack of a non-TBI control group, which would have clarified

the relative risk of functional behavior impairment in the TBI group. Nevertheless, the CAFAS is a well-validated measure, which has been used to assess setting-specific clinical impairments in adolescents with emotional problems, and impairments on this interview measure are considered rare in nonclinical populations. It is thus likely that many of these functional impairments were consequences of TBI. Moreover, our study is the first, to our knowledge, to document these impairments using the CAFAS. Our findings also confirm associations of ratings of EF with impaired functioning across several domains in a large cohort of adolescents with moderate to severe TBI. Another limitation is our focus on cross-sectional differences between TBI severity groups rather than on the effect of severity on longitudinal changes postinjury. Because EF skills are known to continue to develop throughout adolescence, it will be important to further characterize how TBI affects this process. Failure to examine levels of clinical impairment prior to injury also precluded identification of postinjury changes in behavioral adaptation, including de novo clinical impairments. Additionally, the secondary analysis of setting-specific findings should be interrupted cautiously, because larger studies will need to be performed to better characterize setting specific trends. Finally, participants were more likely to be white and to have more severe TBI than nonparticipants. Although these differences were small, caution is thus advised in generalizing findings to the broader population of children with TBI.

Conclusions

Our study demonstrated that primary caregiver ratings of EF are associated with functional impairments in behavior, as assessed by the CAFAS. Future research should continue to better define the relation of behavioral, metacognitive, and cognitive measures with behavioral functioning after adolescent TBI. Larger longitudinal studies would also be useful in examining how functional impairments emerge after TBI and the behavioral, cognitive, and environmental factors that contribute to these impairments. Understanding the ability of EF measures to predict clinical impairment is important, because it will potentially help hone screening and assessment batteries and allow clinicians to focus treatments where they are needed most.

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List of abbreviations

BRI	Behavioral Regulation Index
BRIEF	Behavior Rating Inventory of Executive Function
CAFAS	Child and Adolescent Functional Assessment Scale
CI	confidence interval
CVLT	California Verbal Learning Test
EF	executive function
GCS	Glasgow Coma Scale
MI	Metacognition Index

OR	odds ratio
PSI	Processing Speed Index
TBI	traumatic brain injury

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Table 1

Demographics and distribution of outcome measures in the study population

Demographics and Measures	Total Population	Moderate Group	Severe Group
Demographics			
GCS *	10.03±4.56	13.41±1.85	4.96±1.93
Age at injury	14.54±1.74	14.41±1.74	14.73±1.71
Months since injury	3.56±1.74	3.34±1.74	3.92±1.70
Race (% nonwhite)	19.70	24.70	11.80
Sex (% boy)	65.20	66.70	62.80
Primary caregiver education (% <high school)	44.70	43.20	47.10
Study measures			
BRIEF-BRI	58.13±11.50	57.55±11.59	59.00±11.41
BRIEF-MI	59.97±9.80	59.53±10.33	60.64±8.97
PSI *	90.56±16.27	95.57±14.62	82.84±15.76
CVLT score *	44.27±12.61	46.50±12.84	40.78±11.53
CAFAS total score	45.76±35.02	42.35±34.03	51.18±36.20
CAFAS domains			
School	7.12±9.37	7.65±9.65	6.27±8.94
Home	10.68±9.51	9.88±8.73	11.96±0.59
Community	1.36±4.75	1.36±4.94	1.37±4.48
Behavior toward others	6.06±7.89	5.43±7.42	7.06±8.55
Moods and emotions	9.02±8.81	8.15±9.10	10.39±8.24
Self-harm	0.68±3.54	0.49±3.12	0.98±4.13
Substance use	0.91±4.00	0.37±1.90	1.76±5.90
Thinking	9.92±8.95	9.01±9.03	11.37±8.72
CAFAS domains (% any impairment)			
School	43.20	45.70	39.20
Home	68.90	67.90	70.60
Community	9.10	8.60	9.80
Behavior toward others	43.20	40.70	47.10
Moods and emotions	59.10	53.09	68.63
Self-harm	3.80	2.50	5.90
Substance use	6.10	3.70	9.80
Thinking	60.60	54.30	70.60
Total	34.10	30.70	39.20

NOTE. Values are mean ± SD or %.

* Significant difference at $P<.05$ between moderate and severe groups.

Table 2

Logistic regression models for CAFAS total scores with BRI and MI as predictor variables

Variable	BRI Model		MI Model		Combined Model	
	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P
Sex	1.60 (0.618–4.15)	.330	2.72 (0.94–7.93)	.070	2.58 (0.87–7.69)	.09
Race	1.33 (0.41–4.25)	.640	2.19 (0.68–7.08)	.190	2.01 (0.60–6.76)	.26
SES	0.72 (0.27–1.92)	.510	0.93 (0.35–2.42)	.880	0.743 (0.27–2.08)	.57
Injury severity	1.30 (0.50–3.40)	.590	1.20 (0.46–3.14)	.700	1.19 (0.45–3.18)	.72
PSI	0.97 (0.94–1.00)	.060	0.97 (0.94–1.00)	.050	0.97 (0.94–1.00)	.34
Memory	0.97 (0.93–1.01)	.180	0.98 (0.94–1.02)	.280	0.98 (0.94–1.02)	.19
BRI	5.20 (2.00–13.54)	<.001	NA	NA	2.74 (0.95–7.94)	.06
MI	NA	NA	7.31 (2.63–20.33)	<.001	4.73 (1.54–14.52)	<.01

Abbreviations: NA, not applicable; SES, socioeconomic status estimated by primary caregiver education.

Table 3

Logistic regression models for CAFAS school, home, and community domain scores with BRI and MI as predictor variables

Domain	Variable	BRI Model		MI Model		Combined Model	
		Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P	Odds Ratio (95% CI)	P
School	Sex	2.44 (1.04–5.73)	.04	3.42 (1.34–8.72)	.01	3.39 (1.31–8.76)	.01
	Race	0.74 (0.26–2.10)	.57	1.06 (0.38–2.96)	.92	0.93 (0.32–2.68)	.89
	SES	1.69 (0.71–4.02)	.23	2.22 (0.94–5.22)	.07	1.81 (0.74–4.41)	.19
	Injury severity	1.32 (0.55–3.17)	.53	1.18 (0.50–2.77)	.71	1.28 (0.53–3.08)	.58
	PSI	1.01 (0.98–1.03)	.70	1.01 (0.98–1.04)	.62	1.01 (0.98–1.04)	.64
	Memory	1.01 (0.98–1.05)	.44	1.02 (0.99–1.06)	.21	1.02 (0.98–1.06)	.25
	BRI	3.50 (1.41–8.69)	<.01	NA	NA	2.15 (0.78–5.93)	.14
	MI	NA	NA	3.93 (1.58–9.79)	<.01	2.96 (1.06–8.30)	.04
Home	Sex	1.84 (0.77–4.37)	.17	2.25 (0.91–5.56)	.08	2.16 (0.87–5.37)	.10
	Race	1.03 (0.34–3.14)	.97	1.25 (0.41–3.84)	.69	1.14 (0.37–3.56)	.82
	SES	1.30 (0.52–3.21)	.57	1.46 (0.59–3.57)	.41	1.33 (0.53–3.31)	.55
	Injury severity	1.18 (0.47–2.95)	.72	1.22 (0.49–3.04)	.67	1.18 (0.47–2.98)	.73
	PSI	0.97 (0.95–1.00)	.07	0.97 (0.94–1.00)	.05	0.97 (0.95–1.00)	.07
	Memory	1.03 (0.99–1.07)	.11	1.03 (0.99–1.07)	.10	1.04 (1.00–1.08)	.08
	BRI	3.08 (1.05–9.02)	.04	NA	NA	2.20 (0.66–7.28)	.20
	MI	NA	NA	2.86 (1.07–7.67)	.04	1.96 (0.65–5.93)	.23
Community	Sex	2.47 (0.53–11.47)	.25	8.16 (1.21–55.23)	.03	7.35 (1.08–50.26)	.04
	Race*	NA	NA	NA	NA	NA	NA
	SES	0.75 (0.16–3.41)	.70	1.18 (0.26–5.28)	.83	1.03 (0.21–4.96)	.98
	Injury severity	0.54 (0.13–2.31)	.41	0.47 (0.11–2.08)	.32	0.52 (0.11–2.35)	.39
	PSI	1.02 (0.97–1.07)	.52	1.03 (0.98–1.08)	.33	1.02 (0.974–1.08)	.36
	Memory	1.05 (0.98–1.12)	.21	1.07 (1.00–1.15)	.06	1.07 (0.99–1.12)	.07
	BRI	5.38 (1.34–21.64)	.02	NA	NA	1.68 (0.33–8.57)	.53
	MI	NA	NA	17.53 (3.06–100.56)	<.01	13.28 (1.94–90.87)	<.01

Abbreviations: NA, not applicable; SES, socioeconomic status estimated by primary caregiver education.

* Race was not used as a covariate in the community analysis, because the maximum likelihood ratio did not exist for this variable because of the small percentage (9.1%) of individuals with community impairment on the CAFAS in the study population.