Journal of Pediatric Psychology, Vol. 26, No. 2, 2001, pp. 79–91

Neurobehavioral Symptoms in Childhood Closed-Head Injuries: Changes in Prevalence and Correlates During the First Year Postinjury

Keith Owen Yeates,[1,2] PhD, ***H. Gerry Taylor,***[3,4] PhD, ***Christine T. Barry,***[3,4] PhD, ***Dennis Drotar,***[3,4] PhD, ***Shari L. Wade,***[5,6] PhD, and ***Terry Stancin,***[3,7] PhD

[1]The Ohio State University, [2]Columbus Children's Hospital, [3]Case Western Reserve University, [4]Rainbow Babies and Children's Hospital, [5]University of Cincinnati, [6]Children's Hospital Medical Center, and [7]MetroHealth Medical Center

Objective: **To examine changes in the prevalence and correlates of neurobehavioral symptoms during the first year following childhood closed-head injuries (CHIs).**

Methods: **Participants included 31 children with severe CHIs, 38 with moderate CHIs, and 53 with orthopedic injuries (OIs). Children and their families were assessed shortly after injury and at 6- and 12-month follow-ups. Parents rated 15 symptoms classified as either cognitive/somatic (C/S) or emotional/behavioral (E/B).**

Results: **Both kinds of symptoms were more common in the CHI groups than in the OI group. C/S symptoms declined in the CHI groups over time, whereas E/B symptoms became relatively more common. Measures of injury severity, children's premorbid behavioral adjustment, and concurrent cognitive functioning predicted C/S symptoms. E/B symptoms were predicted by injury severity, concurrent cognitive functioning soon after the injury, and concurrent parent and family functioning later in time. Both types of symptoms contributed to the prediction of perceived family burden, with the relationships strengthening over time.**

Conclusions: **The findings indicate that the prevalence and correlates of neurobehavioral symptoms in childhood CHIs vary as a function of symptom type and time since injury.**

Key words: *closed-head injury; children; neurobehavioral symptoms.*

Childhood closed-head injuries (CHIs) result in significant morbidity, including neurocognitive deficits, poor school performance, and declines in psychosocial adjustment and adaptive functioning (Yeates, 2000). Childhood CHIs also frequently initiate somatic, cognitive, and behavioral symptoms (Barry, Taylor, Klein, & Yeates, 1996; Rivara et al., 1994). These symptoms, commonly referred to as postconcussive in children with mild CHIs (Yeates et al., 1999), are also characteristic of children with more severe CHIs. Ratings of these symptoms may provide a more sensitive and valid outcome measure following childhood CHIs than traditional behavior rating scales, which were not constructed

All correspondence should be sent to Keith Owen Yeates, Department of Psychology, Children's Hospital, 700 Children's Dr., Columbus, Ohio 43205. E-mail: yeates.1@osu.edu.

specifically to assess children with brain impairment or physical illness (Drotar, Stein, & Perrin, 1995).

Differences in the prevalence of neurobehavioral symptoms as a function of injury severity have been described by Rivara et al. (1994) in a prospective study of childhood CHIs. In that study, parents reported that cognitive and behavioral symptoms occur more frequently among children with severe CHIs than those with mild CHIs at both 3 and 12 months postinjury. In a previous study, we also found that neurobehavioral symptoms were more common and persistent following moderate to severe CHIs than following traumatic injuries not involving the head (Barry et al., 1996). Specifically, parents reported that children with moderate to severe CHIs displayed a fourfold increase in the total number of symptoms over children with orthopedic injuries (OIs), both at a baseline assessment shortly after injury and again 6 months postinjury. In addition, we found that the total number of symptoms predicted lower performance on cognitive and achievement tests, more general adjustment problems, declines in adaptive behavior, and poorer parent and family functioning.

Our previous study (Barry et al., 1996) had two major shortcomings. First, most of our analyses relied on a summary score representing the total number of neurobehavioral symptoms, as opposed to measures of more specific classes of symptoms. Research on postconcussive symptoms in mild CHI suggests that it is important to distinguish between different kinds of symptoms. For example, factor analytic studies indicate that somatic (e.g., fatigue, headache), cognitive (e.g., inattention, forgetfulness), and psychological (e.g., moodiness, irritability) symptoms tend to cluster independently (Axelrod et al., 1996; Cicerone & Kalmar, 1995). The summary score used in our previous study might have obscured significant variation in the prevalence of different symptom types.

The second major shortcoming of our previous study was its limited time frame. The study concerned only the first 6 months postinjury and relied on data from only two assessment occasions. The total number of symptoms did not change significantly during this interval in children with CHIs or those with OIs, and baseline ratings were correlated significantly with those at 6 months postinjury. However, a closer inspection revealed changes in the prevalence of individual symptoms over time, with declines in some cognitive and somatic symptoms and increases in some emotional and behavioral symptoms. Rivara et al. (1994) described a similar pattern in children with severe CHIs from 3 to 12 months postinjury but also relied on data from only two assessments and did not conduct statistical analyses to determine whether changes in prevalence rates were significant. Thus, it is unclear if the prevalence and correlates of neurobehavioral symptoms vary across time following childhood CHIs.

In this article, we address these shortcomings using data collected from the same ongoing, multisite prospective study on which our earlier research was based. We extend our previous work by focusing on specific classes of symptoms and by including data from three assessments extending across the first year postinjury. Based on previous factor analytic studies of neurobehavioral symptoms, we classify symptoms a priori as either cognitive/somatic (C/S) or emotional/behavioral (E/B). Examples of C/S symptoms include headaches, dizziness, fatigue, forgetfulness, and distractibility. Examples of E/B problems include anxiety, moodiness, impulsivity, withdrawal, depression, and aggression. We use data from three assessments extending across the first year postinjury to examine changes in the prevalence and correlates of the two symptom types.

Based on previous research (Barry et al., 1996; Rivara et al., 1994), we expected that children with CHIs would show more neurobehavioral symptoms than children with OIs. However, we hypothesized that C/S symptoms would become relatively less prevalent over time in the CHI groups, as compared to the OI group, and that E/B symptoms would become relatively more prevalent. We further hypothesized that the two classes of symptoms would show different patterns of predictors: C/S symptoms were expected to be predicted more strongly by indicators of injury severity (i.e., group membership; concurrent cognitive functioning), whereas E/B symptoms were expected to be predicted more by measures of parent and family functioning. This hypothesis was based on previous research suggesting that neurocognitive outcomes depend primarily on injury severity, whereas behavioral outcomes depend more on child and family adjustment (Rivara et al., 1994; Taylor et al., 1999; Yeates et al., 1997). Finally, we hypothesized that both types of symptoms would predict the amount of burden perceived by families as a result of the children's injuries. This hypothesis was based on studies showing that neurobehavioral symptoms and neuropsychiatric disorders are an important predictor of family stress and adaptation following childhood CHIs (Max, Castillo, Robin, et al., 1998; Rivara et al., 1992, 1996). The current research extends previous studies by comparing the contributions of C/S and E/B symptoms to family burden at multiple points in time following childhood CHIs.

Method

Participants

The sample for this study consisted of 69 children with CHIs and 53 with OIs not involving CHIs. The sample was recruited from consecutive admissions to three hospitals in northeastern Ohio. (The larger project from which the data for this study were drawn included participants from a fourth hospital in central Ohio. However, parents at this site were asked only to indicate whether the child displayed the symptoms, not whether the symptoms they endorsed were new or had worsened since the injury. Because of this procedural error, data from the fourth site is not included in this report.) All children were between 6 and 12 years of age at the time of injury and used English as their primary language at home. Children were excluded if they had a history of child abuse, previous neurological disorder, or mental retardation.

Children were eligible for the CHI group if they sustained a blunt head trauma and their lowest postresuscitation Glasgow Coma Scale (GCS; Jennett & Bond, 1975) score was 12 or less, or if the GCS score was between 13 and 15 but was associated with an intracranial lesion on neuroimaging, skull fracture, neurological deficits, or documented loss of consciousness for more than 15 minutes.

Children were eligible for the OI group if they sustained a noncranial fracture that required at least an overnight hospitalization but did not demonstrate any evidence of loss of consciousness or other indication of possible brain injury. The OI group was selected for comparison with the CHI group to equate the groups in terms of the experience of a traumatic injury and subsequent medical treatment. The selection of the OI group also helps to control for premorbid characteristics that increase a child's risk of sustaining a traumatic injury.

Following established conventions (Yeates, 2000), the CHI group was divided into two groups based on injury severity. Children whose lowest postresuscitation GCS scores were 8 or less were considered to have severe injuries, and children with scores of 9 or more were considered to have moderate injuries. Many of the children in the moderate injury group had GCS scores ranging from 13 to 15, but they all demonstrated additional complications indicative of a more severe injury (e.g., intracranial lesion on neuroimaging, skull fracture, neurological deficits, or sustained loss of consciousness). Thus, their injuries were considered moderate rather than mild.

Descriptive information about the three groups is summarized in Table I. The groups did not differ in gender, race, family structure, maternal education, annual family income, or Duncan occupational status index (Stevens & Featherman, 1981). Virtually all of the minority participants were African American. The groups also did not differ on children's age at injury or their pre-injury behavioral adjustment or academic performance, based on retrospective parent and teacher ratings. As anticipated, the groups differed in injury severity. The Injury Severity Score (ISS; Mayer, Matlack, Johnson, & Walker, 1980) presented in Table I is based on all injuries the children sustained, whereas the partial ISS is calculated based only on injuries unrelated to CHI. The severe CHI group had the most severe injuries overall but did not differ from the OI group in the severity of injuries not involving the brain.

Procedure

The study was approved by the institutional review boards at all participating institutions. All age-appropriate hospital admissions were monitored for potential eligibility. Once children meeting entry criteria were deemed medically stable, their parents or legal guardians were invited to participate in the study. After informed consent was obtained, the children's primary caregivers were asked to provide demographic information. They also provided retrospective ratings of pre-injury family functioning and children's premorbid behavioral adjustment. In almost all cases (93%), the child's biological mother was the primary caregiver and respondent throughout the study.

Consent was obtained at the time of hospitalization to request ratings of the child's classroom behavior and school performance from school personnel, and arrangements were made to complete

Table I. Demographic Features of Participants

Variable	Orthopedic Injury	Moderate CHI	Severe CHI
n	53	38	31
Child's gender (% male)	58	68	81
Maternal ethnic status (% white)	47	66	68
Single-parent homes (%)	39	37	49
Maternal education (%)			
Did not complete high school	13	5	19
High school graduate	32	54	42
1–2 years college	36	24	26
≥4 years college	19	16	13
Family income (%)			
<$20,000	45	43	55
$20,000–$39,000	19	24	20
$40,000–$59,000	16	14	14
≥$60,000	19	19	10
Duncan occup. status index (*M, SD*)	30.65, 19.51	31.90, 18.64	37.29, 22.44
Age at injury (yrs) (*M, SD*)	9.29, 2.07	10.02, 1.89	9.43, 2.05
Glasgow Coma Scale score (*M, SD*)*	—, —	14.03, 1.76	4.97, 1.85
Injury Severity Score (*M, SD*)*	7.37, 3.44	12.61, 5.82	22.39, 12.80
Partial Injury Severity Score (*M, SD*)*	7.37, 3.44	2.24, 3.37	10.03, 11.21
Child's pre-injury behavioral adjustment (*M, SD*)[a]	50.29, 9.74	54.08, 11.23	49.77, 10.89
Child's pre-injury academic performance (*M, SD*)[b]	50.15, 10.06	47.89, 9.17	47.76, 10.03

[a]Child Behavior Checklist total *T* score.
[b]Teacher Report Form *T* score based on ratings of classroom performance. Data were available for 92 of 112 children.
*Groups differ significantly, $p < .05$.

an initial, or baseline, postinjury assessment. During baseline assessments, caregivers were interviewed regarding children's neurobehavioral symptoms. They also completed ratings of postinjury parent adjustment and family characteristics, as well as family burden associated with the children's injuries.

The baseline assessments included neuropsychological testing of the children. Prior to testing, children in the CHI groups were screened for posttraumatic amnesia using the Children's Orientation of Amnesia Test (COAT; Ewing-Cobbs, Levin, Fletcher, Miner, & Eisenberg, 1990). Children were tested only after they scored within broad normal limits on the COAT on two consecutive days. No children were omitted from the study based on this criterion, but assessment was delayed somewhat for some of the children in the severe CHI group. As a result, the groups differed significantly in the interval between the injury and the initial postinjury assessment, although the mean difference between the severe CHI and OI groups was only about 9 days. In almost all cases, baseline assessments occurred within 4 weeks of injury.

Baseline assessment procedures were repeated approximately 6 and 12 months later. All follow-up assessments of child and family variables were based on concurrent child and family status.

Measures

Neurobehavioral Symptoms. Neurobehavioral symptoms were assessed by asking the child's caregiver to complete the 30-item Post-Injury Symptom Checklist (Barry et al., 1996). The authors developed the checklist specifically for this study. Potential symptoms were selected based on our clinical experience and the existing literature (e.g., Rivara et al., 1994). In previous research (Barry et al., 1996), the total score on the checklist demonstrated acceptable reliability over a 6-month period (mean within-group correlation = .55) and predicted a variety of child and family outcomes.

The interviewer read the symptoms to the caregiver one at a time and asked him or her to indicate whether the child displayed the symptom. For each symptom endorsed by the caregiver, the interviewer then asked whether the symptom was new or had worsened since the injury. Only symptoms reported as changed relative to the child's pre-injury status were counted as present.

For this study, we focused on 15 symptoms that the two senior authors (KOY, HGT) classified as either cognitive/somatic (i.e., headaches/dizziness, fatigue, memory problems, attention problems, difficulty concentrating, difficulty following directions, confusion) or emotional/behavioral (i.e., anxious, quick to anger, moody, impulsive, over- or underactive, withdrawn, depressed, aggressive). The classification followed previous factor analytic studies of neurobehavioral symptoms (Axelrod et al., 1996; Cicerone & Kalmar, 1995). The remaining 15 symptoms on the Post-Injury Symptom Checklist did not fall clearly in either of the two categories and generally reflected physical problems likely to arise as a result of severe CHIs (e.g., poor bladder control, difficulties swallowing, problems in coordination and clumsiness). They were rarely reported in either the CHI or OI groups.

Premorbid Behavioral Adjustment. Children's premorbid behavioral adjustment was assessed during the initial hospital interview by obtaining retrospective ratings on the Child Behavior Checklist (CBC). The CBC is a well-known rating scale standardized on a large sample of community and clinic-referred children between the ages of 4 and 18. It has demonstrated satisfactory reliability and validity in previous research (Achenbach, 1991), although it has not always been sensitive to the effects of childhood CHIs (Fletcher, Ewing-Cobbs, Miner, Levin, & Eisenberg, 1990; Fletcher et al., 1996). The total *T* score from the CBC was used to measure premorbid behavioral adjustment. As Table I shows, the CHI and OI groups did not differ on the total *T* score.

Postinjury Cognitive Functioning. Cognitive outcomes were assessed at all three occasions using a neuropsychological test battery. We selected two measures of cognitive functioning from the larger test battery (Taylor et al., 1995) as possible predictors of neurobehavioral symptoms.

The first measure was an estimated Verbal IQ (VIQ) derived from a short form of the third edition of the Wechsler Intelligence Scale for Children (WISC-III; Wechsler, 1991). The short form included the Similarities and Vocabulary subtests, from which the estimated VIQ was derived (Sattler, 1992). The estimated VIQ has a validity coefficient of .88. In previous research, we found that the estimated VIQ distinguished between the CHI and OI groups (Taylor et al., 1999) and that it was correlated with the total number of neurobehavioral symptoms at the baseline assessment (Barry et al., 1996). We also chose the estimated VIQ because many children were unable to complete the subtests used to estimate Performance IQ (i.e., Block Design, Object Assembly) at the baseline assessment because of upper extremity fractures.

The second measure of cognitive functioning was the total number of words recalled across five learning trials on a shortened, preliminary version of the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1994). Age-adjusted *z* scores for total recall were computed using the OI group for normative purposes. We have found that total recall on the CVLT discriminates between the CHI and OI groups (Taylor et al., 1999) and is correlated with the total number of neurobehavioral symptoms at the baseline assessment (Barry et al., 1996).

Premorbid Family Adjustment. Premorbid family adjustment was assessed during the initial hospital interview by obtaining retrospective ratings on the General Functioning scale from the McMaster Family Assessment Device (FAD). The FAD is a 60-item rating scale that has shown satisfactory reliability and validity in previous research (Byles, Bryne, Boyle, & Oxford, 1988; Miller, Bishop, Epstein, & Keitner, 1985). It is designed to assess family functioning across a variety of domains and generates scores on seven subscales. The 12-item General Functioning Scale provides an overall measure of family functioning. The CHI and OI groups did not differ at baseline on the General Functioning Scale (Wade et al., 1998).

Postinjury Parent Adjustment and Family Characteristics. Postinjury parent adjustment was assessed at all three occasions using the General Severity Index from the Brief Symptom Inventory (BSI; Derogatis & Melisaratos, 1983). The BSI is a 53-item rating scale with satisfactory reliability and validity designed to assess a range of psychiatric symptoms. The General Severity Index is a global index that reflects the total score divided by the total number of items. We have found previously that it distinguishes between the CHI and OI groups (Wade, Taylor, Drotar, Stancin, & Yeates, 1998).

Postinjury family characteristics were assessed at all three occasions using the Life Stressors and Social Resources Inventory (LSSRI; Moos & Moos, 1988). The LSSRI (Moos, Fenn, Billings, & Moos, 1989) is an interview measure that generates standard scores for stressors and resources across a variety of domains. It has demonstrated satisfactory reliability and validity in prior research (Wade et al., 1996). For this study, we averaged standard scores across domains to provide global measures of family stressors and resources. Child stressor and resource subscales were omitted because they included ratings of behavior and were potentially confounded with the neurobehavioral symptom measures. We omitted the negative life events stressor subscale because it was potentially confounded with injury severity.

Postinjury Family Burden. The families' postinjury perceptions of burden were measured with the Family Burden of Injury Interview (FBII; Burgess et al., 1999). The FBII was developed for this study to assess the unique burdens that families face following childhood CHIs. During the interview, parents are asked if they are experiencing a variety of possible sources of burden or distress. For any item that they endorse, they are asked to rate an associated level of stress on a 5-point scale. The FBII includes questions relating to concerns about the injured child, about the spouse's reaction to the injury, and about reactions of extended family and friends. We used a total score from the FBII derived by averaging the ratings on these questions. We found previously that scores on the FBII distinguished between the CHI and OI groups (Burgess et al., 1999; Wade et al., 1998).

Postinjury family burden also was measured with the Impact on Family scale, Version G (IOF-G; Stein & Jessop, 1985). This 34-item questionnaire assesses parental perceptions of the negative impact of the child's health on the family. Because the children in this study had all sustained a recent injury, the perceived effect of their injury, rather than of the child's general health, was assessed using the IOF-G. The scale generates a total score that summarizes the negative impact of the injury. The IOF-G has been validated in previous studies of children with chronic health conditions (Stein & Jessop, 1985), and we have found it to differentiate between the CHI and OI groups (Wade et al., 1998).

Attrition and Missing Data

Of a total of 122 children, 102 completed all three assessments and 7 others completed two of the three assessments. Because of a delay in the administration of the Post-Injury Symptom Checklist, data regarding neurobehavioral symptoms were unavailable for the first 24 children who entered the study, all of whom had complete data otherwise. Eleven children completed only the baseline assessment. One child had symptom ratings available at all three occasions but participated in neuropsychological testing only at baseline, and one child had only baseline symptom ratings available and did not complete any neuropsychological testing. In this study, cross-sectional analyses at each assessment included data from all available participants. Longitudinal analyses included only participants with the requisite data from all three assessments.

The OI and CHI groups did not differ in the proportion of families completing at least two of the three assessments. Dropouts demonstrated lower socioeconomic status than participants remaining in the study and also were more likely to be African American. These differences did not vary across the three groups. Among the severe CHI group, dropouts had more severe injuries (i.e., lower GCS scores) than participants remaining in the study. Thus, attrition and missing data may have reduced the generalizability of the findings but did not differentially affect the OI and CHI groups.

Data Analysis

The first set of analyses focused on the prevalence of neurobehavioral symptoms. Chi-square analyses were used first to examine group differences in the prevalence of each individual symptom at each occasion. Repeated-measures multivariate analyses of variance (MANOVA) were then used to examine changes in the prevalence of individual symptoms over time, with group and occasion as independent variables. The dependent variable in these analyses was the presence/absence of each symptom (scored 0 or 1). Significance tests were adjusted to reflect the use of dichotomous dependent variables (Myers, DiCecco, White, & Borden, 1982). Finally, we also used repeated-measures MANOVA to examine changes in the total number of C/S and E/B symptoms, again with group and occasion as independent variables. In tests for the effect of time, the single-degree-of-freedom linear polynomial and the interactions involving it were examined for significance rather than the main effect for occasion and its interactions, because study hypotheses specified different group trends in linear change. Statistical power for the analyses of variance, based on a p of .05, was approximately .50 for medium-effect sizes and .90 for large-effect sizes (Cohen, 1988).

The next set of analyses focused on the prediction of neurobehavioral symptoms. We used regression analyses to examine the prediction of the total number of C/S and E/B symptoms at each occasion.

Table II. Percentage of Children Reported to Display Onset of Neurobehavioral Symptoms at Each Occasion

	Orthopedic Injury			Moderate CHI			Severe CHI		
	Baseline (n = 43)	6 Mos. (n = 42)	12 Mos. (n = 44)	Baseline (n = 31)	6 Mos. (n = 37)	12 Mos. (n = 37)	Baseline (n = 24)	6 Mos. (n = 28)	12 Mos. (n = 27)
Cognitive/somatic symptoms									
Headaches/dizziness[a]	9	10	2	61	62	57	71	57	33
Fatigue[a]	14	10	5	68	43	22	79	50	37
Mem. prob.[a]	2	5	2	23	27	35	58	50	56
Atten. prob.[a]	2	2	0	29	24	27	33	46	48
Difficulty concentrating[a]	2	7	0	29	30	19	46	39	56
Difficulty following directions[a]	0	5	2	13	32	27	50	43	48
Confusion[a]	0	2	2	19	16	14	54	29	30
Emotional/behavioral symptoms									
Anxious[a]	12	10	0	23	16	24	38	36	30
Quick to anger[b]	26	14	5	45	35	35	29	57	44
Moody[b]	30	10	2	52	57	41	29	50	52
Impulsive[a]	7	10	2	13	41	32	29	43	52
Over- or underactive[a]	9	12	0	48	30	24	63	57	30
Withdrawn[c]	7	5	0	6	11	8	17	14	22
Depressed[b]	16	2	0	19	22	14	25	18	19
Aggressive[b]	9	17	5	26	32	30	25	46	37

[a]Group differences significant, $p < .05$, at all three occasions.
[b]Group differences significant, $p < .05$, at 6 and 12 months only.
[c]Group differences significant, $p < .05$, at 12 months only.

Predictors included injury severity (i.e., group membership) and concurrent child cognitive functioning (estimated WISC-III VIQ, CVLT total recall z score), both potential indicators of underlying brain impairment; premorbid child adjustment (CBC total T score) and family functioning (FAD General Functioning Scale total score), both possible preinjury determinants of symptom complaints; and concurrent parent psychological adjustment (BSI General Severity Index) and family stressors and resources (LSSRI total stressors and resources scales), possible postinjury determinants of neurobehavioral symptoms. All predictors were entered simultaneously into the regression equations. Measures of injury-related family burden were not included in these analyses because they were considered more likely to result from, rather than give rise to, neurobehavioral symptoms. Statistical power for these regression analyses was approximately .75 for medium-effect sizes and .90 for large-effect sizes.

The final set of analyses focused on the prediction of family burden from neurobehavioral symptoms. We used hierarchical regression analyses to examine the prediction of the FBII total score and the IOF total score at each occasion from the total number of C/S and E/B symptoms. The two symptom scores were entered into the regression analyses simultaneously after first entering two dummy variables that represented group membership, to control for injury severity. Statistical power for these regression analyses was greater than .90 for both medium- and large-effect sizes.

Results

Prevalence of Neurobehavioral Symptoms

Table II summarizes group differences in the prevalence of individual symptoms at each assessment. Chi-square analyses indicated that the three groups differed significantly in the prevalence of all seven C/S symptoms at all three occasions. The groups differed in the prevalence of three out of eight E/B symptoms at baseline, seven out of eight at 6 months postinjury, and all eight at 12 months postinjury. In all instances, significant differences reflected more prevalent symptoms in the CHI groups than in the OI group. In most cases, the severe CHI group also displayed more symptoms than the moderate CHI group.

In repeated-measures MANOVAs, group main effects were significant for all C/S symptoms and six out of eight E/B symptoms (i.e., not for withdrawn or depressed). Significant group by linear trend interactions were obtained for two C/S symptoms

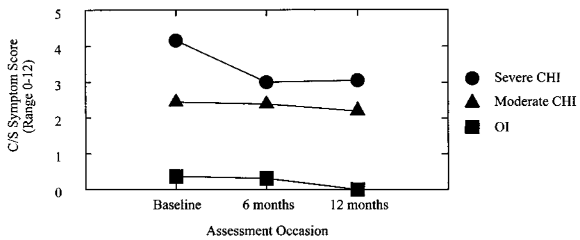

Figure 1. C/S symptom scores at three occasions by group.

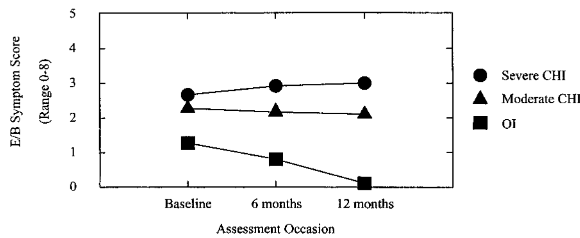

Figure 2. E/B symptom scores at three occasions by group.

(i.e., fatigue, confusion) and three E/B symptoms (i.e., quick to anger, moody, impulsive). Group differences became less pronounced over time for the two C/S symptoms, because of declines in the two CHI groups. In contrast, group differences became more pronounced for the three E/B symptoms, because of increases in the severe CHI group and decreases in the OI group over time.

A repeated-measures MANOVA with the total number of C/S symptoms as the dependent variable revealed a significant group main effect, $F(2, 78) = 31.85$, $p < .001$. As Figure 1 shows, the CHI groups displayed more C/S symptoms than the OI group, although the severe CHI group showed a modest decline in C/S symptoms over time. A repeated-measures MANOVA with the total number of E/B symptoms as the dependent variable revealed a significant group main effect, $F(2, 78) = 11.08$, $p < .01$, as well as a significant group by linear trend interaction, $F(2, 78) = 3.16$, $p < .05$. Figure 2 shows that the CHI groups displayed more E/B symptoms than the OI group and that the differences increased over time because of a modest increase in symptoms in the severe CHI group and a larger decrease in the OI group.

Prediction of Neurobehavioral Symptoms

In regression analyses predicting C/S symptoms, the total model was significant at all three occasions, $F(9, 77) = 12.27$, $p < .001$, at baseline; $F(9, 88) = 5.88$, $p < .001$, at 6 months; and $F(9, 92) = 8.76$, $p < .001$, at 12 months. The total amount of variance accounted for was 59% at baseline, 38% at 6 months, and 68% at 12 months. Injury severity (i.e., group membership) accounted for unique variance in C/S symptoms at all three occasions, consistent with prior analyses. Concurrent memory functioning accounted for unique variance at baseline and 12-months postinjury, with more C/S symptoms related to lower CVLT total *z* scores. Premorbid child adjustment accounted for unique variance at baseline only, with more C/S symptoms related to higher CBC total *T* scores. None of the other predictors contributed independently to the prediction of C/S symptoms at any occasion.

The total model also was significant at all three occasions in regression analyses predicting E/B symptoms, $F(9, 77) = 3.94$, $p < .001$, at baseline; $F(9, 88) = 8.75$, $p < .001$, at 6 months; and $F(9, 92) = 10.00$, $p < .001$, at 12 months. The total amount of variance accounted for was 32% at baseline, 47% at 6 months, and 49% at 12 months. Injury severity (i.e., group membership) accounted for unique variance in E/B symptoms at all three occasions, again consistent with prior analyses. Concurrent child intellectual functioning accounted for unique variance at baseline and 6 months, with more E/B symptoms related to lower estimated VIQ. Concurrent family resources were a significant predictor at 6 months, such that fewer E/B symptoms were related to higher scores on the LSSRI resources scale. Concurrent parent psychological adjustment was a significant predictor at 12 months, with more E/B symptoms related to higher BSI General Severity Index scores. None of the other predictors independently contributed to the prediction of E/B symptoms at any occasion.

Prediction of Family Burden

In regression analyses predicting injury-related family burden, the total model was significant for both dependent variables at all three occasions, with the relationships strengthening over time: for the FBII, $F(4, 92) = 7.64$, $p < .001$, at baseline; $F(4, 102) = 40.64$, $p < .001$, at 6 months; and $F(4, 103) = 40.62$, $p < .001$, at 12 months; and for the IOF-G, $F(4, 93) = 2.67$, $p < .05$ at baseline; $F(4, 102) = 10.84$, $p < .001$, at 6 months; and $F(4, 101) = 17.00$, $p < .001$, at 12 months. As Table III shows, the number of C/S symptoms accounted for unique variance in both the FBII and IOF-G at 6 and 12 months postinjury but not at baseline, even after accounting for

Table III. Prediction of Perceived Family Burden at Three Occasions

Out. measure	*n*	Group membership *F*[a]	*p*	ΔR^2	C/S symptoms *F*	*p*	E/B symptoms *F*	*p*	C/S & E/B sym. ΔR^{2b}
FBII									
Baseline	97	6.12	.001	.13	3.06	ns	3.98	.05	.12
6 months	107	15.80	.001	.23	8.86	.001	23.30	.001	.38
12 months	108	11.89	.001	.18	27.49	.001	6.81	.01	.43
IOF-G									
Baseline	98	6.19	.001	.08	1.82	ns	0.02	ns	.02
6 months	107	2.64	ns	.05	10.65	.001	1.89	ns	.25
12 months	106	0.65	ns	.01	12.57	.001	5.07	.05	.39

Each regression equation had four predictors: two dummy variables representing group membership, the total number of C/S symptoms, and the total number of E/B symptoms. The two dummy variables representing group membership were entered first, and the two symptom variables were entered second. FBII = Family Burden of Injury Interview. IOF-G = Impact on Family Scale, Version G.
[a] *F* and ΔR^2 computed prior to entry of symptom measures as predictors.
[b] ΔR^2 computed after entry of both C/S and E/B symptoms as predictors.

group membership. The number of E/B symptoms accounted for unique variance in the FBII at all three occasions and did so for the IOF-G at 12 months postinjury but not at baseline or 6 months. The amount of variance in family burden accounted for collectively by C/S and E/B symptoms increased substantially over time. At both 6 and 12 months, neurobehavioral symptoms collectively accounted for more variance in family burden than did group membership.

Discussion

During the first year postinjury, parents report the onset or exacerbation of neurobehavioral symptoms more often among children with CHIs than among those with OIs. These results are consistent with previous studies (Barry et al., 1996; Rivara et al., 1994). These findings extend prior results by showing that prevalence rates vary over time depending on symptom type. Specifically, C/S symptoms become somewhat less common over time among children with severe CHIs, while E/B symptoms become relatively more common because of modest increases among children with severe CHIs and decreases among those with OIs. Postinjury decreases in cognitive symptoms and increases in behavioral symptoms were described in another large study of childhood CHIs (Rivara et al., 1994), but this is the first time that such trends have been examined across more than two occasions using appropriate statistical analyses.

Decreases in C/S symptoms likely reflect the recovery in neuropsychological functioning frequently documented following childhood CHIs (Yeates, 2000). Persistent or even increased E/B symptoms, on the other hand, are less easily explained. Previous studies have not consistently found sustained postinjury behavioral disturbance following childhood CHIs (Fletcher et al., 1990, 1996; Rivara et al., 1994; but see Kinsella, Ong, Murtagh, Prior, & Sawyer, 1999; Taylor et al., 1999). However, many previous studies used measures of behavioral adjustment designed for mental health populations, such as the CBC, that may not be sensitive to the effects of brain impairment. Studies like ours, which assess E/B symptoms of the sort associated with specific neuropsychiatric disorders (Max, Castillo, Lindgren, & Arndt, 1998), may be more likely to document persistent behavioral problems following severe CHIs.

Persistent E/B symptoms could reflect the reaction of family members and their impact on children following CHIs. We have shown that severe childhood CHI is associated with increases in parental maladjustment (Wade et al., 1998), which could in turn maintain a heightened rate of children's E/B symptoms following CHI. Consistent with this notion, the OI group showed a decline in E/B symptoms that could reflect less sustained distress among children and parents (Wade et al., 1998). Persistent E/B symptoms among children with CHIs also could reflect the direct effect of brain injuries. The latter alternative is supported by the presence of group differences on E/B symptoms across the first year postinjury even after controlling for other child and family risk factors.

This study may help to account for changes in the prevalence of C/S and E/B symptoms by revealing differences in the predictors of the two types of symptoms. C/S symptoms were predicted primarily by injury severity (i.e., group membership), concurrent neuropsychological functioning, and premorbid child adjustment, with the latter accounting for unique variance only at the baseline assessment. In contrast, although E/B symptoms also were predicted by injury severity and neuropsychological functioning, the latter influence declined over time, while concurrent parent adjustment and family characteristics increased in importance as predictors.

C/S symptoms thus appear to depend primarily on the brain trauma associated with CHIs, as indexed by injury severity and residual neuropsychological deficits, and are not predicted by concurrent parent adjustment and family functioning. In contrast, E/B symptoms are related less strongly to injury severity than C/S symptoms but are predicted by concurrent parent and family functioning. These findings are consistent with previous research showing that neurocognitive outcomes depend more on injury severity, whereas behavioral outcomes depend more on child and family adjustment, as well as sociodemographic factors (Rivara et al., 1994; Taylor et al., 1999; Yeates et al., 1997).

Although C/S and E/B symptoms were predicted by different factors, both types of symptoms independently contributed to predicting injury-related family burden. Indeed, C/S symptoms predicted injury-related family burden despite not being related to concurrent parent adjustment or family functioning. This finding provides support for our conceptualization of family burden as a potential outcome of neurobehavioral symptoms and of the other parent and family measures as predictors. More important, it suggests that C/S and E/B symptoms may differ in their relationships to parent and family functioning following childhood CHIs. C/S symptoms do not appear to be related to parent and family risk factors but do predict postinjury family burden. On the other hand, E/B symptoms are predicted by concurrent parent and family risk factors and also predict family burden. C/S symptoms therefore may have a unidirectional relationship with parent and family functioning, whereas E/B symptoms and parent and family factors may be related bidirectionally.

Neurobehavioral symptoms became stronger predictors of family burden over time, accounting for more of the variance in family burden than group membership at both 6 and 12 months postinjury. There are a variety of reasons why neurobehavioral symptoms may become increasingly important determinants of family burden (Brooks, 1991; Demellweek & O'Leary, 1998; Rivara, 1994). Parents may be more tolerant of neurobehavioral symptoms immediately after a CHI but become increasingly distressed by both C/S and E/B symptoms as time passes, especially if they expect complete recovery. Parents might find neurobehavioral symptoms increasingly burdensome because of the cumulative difficulties of coping with the symptoms and the associated disruption in family life. The increasing burden associated with C/S and E/B symptoms also might reflect a decrease in the amount of external support that the families have available to help manage the symptoms, as well as an increase in the demands made on children as they return to school and are expected to resume normal activities. Whatever the reason, the findings suggest that clinicians working with families following childhood CHIs must be alert to the stresses imposed by neurobehavioral symptoms and implement interventions intended both to reduce the child's symptoms and to assist parents in coping with them.

This study is characterized by several potential shortcomings, including limitations in the procedure used to assess neurobehavioral symptoms. The format of the ratings, which involved a simple present/absent distinction, was likely less sensitive than Likert ratings of symptom severity. In addition, parents were required to decide whether symptoms represented changes from pre-injury functioning. Such retrospective judgments are subject to a variety of biases (Mittenberg, DiGiulio, Perrin, & Bass, 1992). To avoid reliance on parents' perceptions of behavioral change, future studies should collect pre-injury ratings of neurobehavioral symptoms soon after injury and then obtain ratings of current symptoms at various times postinjury with which the pre-injury ratings can be compared. Future studies also should obtain ratings from children as well as parents and might use structured interviews as well as formal rating scales (Mittenberg, Wittner, & Miller, 1997). The use of multiple raters and of both interview and rating scale formats will likely result in more reliable and valid estimates of the prevalence and severity of neurobehavioral symptoms. Similar considerations apply to most of the other interviews and questionnaires used in the study, because they also depend almost exclusively on parent report. The inclusion of information from other sources, such as siblings, and using other methods, such as direct observations, would lend additional validity to the results reported here.

In summary, these findings indicate that the prevalence and correlates of neurobehavioral symptoms in childhood CHI vary as a function of symptom type and time since injury. The results highlight the need to distinguish between different types of neurobehavioral symptoms, to study their onset and persistence over time, and to consider both neurological and environmental correlates when attempting to explain the origin and functional consequences of these symptoms. The study also underscores the need for appropriate comparison groups, which help to control for factors that might contribute to the occurrence of neurobehavioral symptoms for reasons other than residual brain injury.

Future research that takes these considerations into account is needed in children with mild CHIs, because we are uncertain whether these findings can be generalized to them. Mild CHIs account for the majority of pediatric head trauma, but their outcomes remain in dispute. Children with mild CHIs rarely show persistent deficits on standardized cognitive testing but are reported to display postconcussive symptoms more often than uninjured children or those with injuries not involving the head (Satz, Zaucha, McCleary, Light, & Asarnow, 1997; Yeates et al., 1999). Research using methods similar to those in this study but focusing on mild CHIs may help to resolve the ongoing controversy regarding the clinical significance of postconcussive symptoms.

Acknowledgments

The research presented here was supported by grant MCJ 390611 from the Maternal and Child Health Research Bureau (Title V, Social Security Act), Health Resources and Services Administration, Department of Health and Human Services, and by grant 5 RO1 NS36335 from the National Institute of Neurological Disorders and Stroke. We acknowledge the contributions of Matt Diamond, Nori Mercuri Minich, Madeline Polonia, Barbara Shapero, and Elizabeth Shaver. We also thank the Rainbow Pediatric Trauma Center at Rainbow Babies and Children's Hospital, the Trauma Program at Children's Hospital of Columbus, and the Trauma Center at MetroHealth Medical Center. We also acknowledge the participation of the Children's Hospital Medical Center of Akron and the collaboration of Duane Bishop, Timothy Mapstone, Scott Maxwell, George Thompson, G. Dean Timmons, and Dennis Weiner. A preliminary version of this article was presented at the annual meeting of the International Neuropsychological Society in Boston, February 1999.

Received August 19, 1999; revisions received January 22, 2000; accepted April 11, 2000

References

Achenbach, T. M. (1991). *Manual for the Child Behavior Checklist/4–18 and 1991 profile*. Burlington: Department of Psychiatry, University of Vermont.

Axelrod, B., Fox, D. D., Less-Haley, P. R., Earnest, K., Dolezal-Wood, S., & Goldman, R. S. (1996). Latent structure of the Postconcussion Syndrome Questionnaire. *Psychological Assessment, 8,* 422–427.

Barry, C. T., Taylor, H. G., Klein, S., & Yeates, K. O. (1996). Validity of neurobehavioral symptoms reported in children with traumatic brain injury. *Child Neuropsychology, 2,* 213–226.

Brooks, D. N. (1991). The head-injured family. *Journal of Clinical and Experimental Neuropsychology, 13,* 155–188.

Burgess, E. S., Drotar, D., Taylor, H. G., Wade, S., Stancin, T., & Yeates, K. O. (1999). The Family Burden of Injury Interview (FBII): Reliability and validity studies. *Journal of Head Trauma Rehabilitation, 14,* 394–405.

Byles, J., Byrne, C., Boyle, M. H., & Oxford, O. R. (1988). Ontario Child Health Study: Reliability and validity of the General Functioning Scale of the McMaster Family Assessment Device. *Family Process, 27,* 97–104.

Cicerone, K. D., & Kalmar, K. (1995). Persistent postconcussion syndrome: The structure of subjective complaints after mild traumatic brain injury. *Journal of Head Trauma Rehabilitation, 10,* 1–17.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. 2nd ed. Hillsdale, NJ: Lawrence Erlbaum.

Delis, D. C., Kramer, J. H., Kaplan, E., & Ober, B. A. (1994). *Manual for the California Verbal Learning Test for Children*. New York: Psychological Corporation.

Demellweek, C., & O'Leary, A. (1998). The impact of brain injury on the family. In R. Appleton & T. Baldwin (Eds.), *Management of brain-injured children* (pp. 207–230). New York: Oxford University Press.

Derogatis, L., & Melisaratos, N. (1983). The Brief Symptom Inventory: An introductory report. *Psychological Medicine, 13,* 595–605.

Drotar, D., Stein, R. E. K., & Perrin, E. C. (1995). Methodological issues in using the Child Behavior Checklist and its related instruments in clinical child psychology research. *Journal of Clinical Child Psychology, 24,* 184–192

Ewing-Cobbs, L., Levin, H. S., Fletcher, J. M., Miner, M. E., & Eisenberg, H. M. (1990). The Children's Orientation and Amnesia Test: Relationship to severity of acute head injury and to recovery of memory. *Neurosurgery, 27,* 683–691.

Fletcher, J. M., Ewing-Cobbs, L., Miner, M. E., Levin, H. S., & Eisenberg, H. M. (1990). Behavioral changes after closed head injury in children. *Journal of Consulting and Clinical Psychology, 58,* 93–98.

Fletcher, J. M., Levin, H. S., Lachar, D., Kusnerik, L., Harward, H., Mendelsohn, D., & Lilly, M. A. (1996). Behavioral outcomes after pediatric closed head injury: Relationships with age, severity, and lesion size. *Journal of Child Neurology, 11,* 283–290.

Jennett, B., & Bond, M. (1975). Assessment of outcome after severe brain damage. *Lancet, 1,* 480–487.

Kinsella, G., Ong, B., Murtagh, D., Prior, M., & Sawyer, M. (1999). The role of the family for behavioral outcome in children and adolescents following traumatic brain injury. *Journal of Consulting and Clinical Psychology, 67,* 116–123.

Max, J. E., Castillo, C. S., Lindgren, S. D., & Arndt, S. (1998). The Neuropsychiatric Rating Schedule: Reliability and validity. *Journal of the American Academy of Child and Adolescent Psychiatry, 37,* 297–304.

Max, J. E., Castillo, C. S., Robin, D. A., Lindgren, S. D., Smith, W. L., Sato, Y., Mattheis, P. J., & Stierwalt, J. A. G. (1998). Predictors of family functioning after traumatic brain injury in children and adolescents. *Journal of the American Academy of Child and Adolescent Psychiatry, 37,* 83–90.

Mayer, T., Matlack, M., Johnson, D., & Walker, M. (1980). The Modified Injury Severity Scale in pediatric multiple trauma patients. *Journal of Pediatric Surgery, 15,* 719–726.

Miller, I. W., Bishop, D. S., Epstein, N. B., & Keitner, G. I. (1985). The McMaster Family Assessment Device: Reliability and validity. *Journal of Marital and Family Therapy, 11,* 345–356.

Mittenberg, W., DiGiulio, D. V., Perrin, S., & Bass, A. E. (1992). Symptoms following minor head injury: Expectation as etiology. *Journal of Neurology, Neurosurgery, and Psychiatry, 41,* 611–616.

Mittenberg, W., Wittner, M. S., & Miller, L. J. (1997). Postconcussion syndrome occurs in children. *Neuropsychology, 11,* 447–452.

Moos, R., & Moos, B. (1988). *Life Stressors and Social Resources Inventory: Preliminary manual*. Palo Alto, CA: Stanford University Medical Center.

Moos, R. H., Fenn, C. B., Billings, A. G., & Moos, B. I. (1989). Assessing life stressors and social resources: Applications to alcoholic patients. *Journal of Substance Abuse, 1,* 135–152.

Myers, J. L., DiCecco, J. V., White, J. B., & Borden, V. M. (1982). Repeated measurements on dichotomous variables: *Q* and *F* tests. *Psychological Bulletin, 92,* 517–525.

Rivara, J. B. (1994). Family functioning following pediatric traumatic brain injury. *Pediatric Annals, 23,* 38–43.

Rivara, J. B., Fay, G. C., Jaffe, J. M., Polissar, N. L., Shurtleff, H. A., & Martin, K. M. (1992). Predictors of family functioning one year following traumatic brain injury in children. *Archives of Physical Medicine and Rehabilitation, 73,* 899–910.

Rivara, J. B., Jaffe, J. M., Polissar, N. L., Fay, G. C., Liao, S., & Martin, K. M. (1996). Predictors of family functioning and change 3 years after traumatic brain injury in children. *Archives of Physical Medicine and Rehabilitation, 77,* 754–764.

Rivara, J. B., Jaffe, J. M., Polissar, N. L., Fay, G. C., Martin, K. M., Shurtleff, H. A., & Liao, S. (1994). Family functioning and children's academic performance and behavior problems in the year following traumatic brain injury. *Archives of Physical Medicine and Rehabilitation, 75,* 369–379.

Sattler, J. M. (1992). *Assessment of children*. 3rd ed. San Diego: Jerome M. Sattler.

Satz, P., Zaucha, K., McCleary, C., Light, R., & Asarnow, R. (1997). Mild head injury in children and adolescents: A review of studies (1970–1995). *Psychological Bulletin, 122,* 107–131.

Stein, R. E. K., & Jessop, D. T. (1985). *PACTS papers/AECOM: Tables documenting the psychometric properties of a measure of the impact of chronic illness on a family.* Bronx, NY: Department of Pediatrics, Albert Einstein College of Medicine.

Stevens, G., & Featherman, D. L. (1981). A revised socioeconomic index of occupational status. *Social Science Research, 10,* 364–395.

Taylor, H. G., Drotar, D., Wade, S., Yeates, K. O., Stancin, T., & Klein, S. (1995). Recovery from traumatic brain injury in children: The importance of the family. In S. Broman & M. E. Michel (Eds.), *Traumatic head injury in children* (pp. 188–216). New York: Oxford University Press.

Taylor, H. G., Yeates, K. O., Wade, S. L., Drotar, D., Klein, S., & Stancin, T. (1999). Influences on first-year recovery from traumatic brain injury in children. *Neuropsychology, 13,* 76–89.

Wade, S. L., Taylor, H. G., Drotar, D., Stancin, T., & Yeates, K. O. (1996). Childhood traumatic brain injury: Initial impact on the family. *Journal of Learning Disabilities, 29,* 652–661.

Wade, S. L., Taylor, H. G., Drotar, D., Stancin, T., & Yeates, K. O. (1998). Family burden and adaptation during the initial year after traumatic brain injury in children. *Pediatrics, 102,* 110–116.

Wechsler, D. (1991). *Manual for the Wechsler Intelligence Scale for Children*. 3rd ed. New York: Psychological Corporation.

Yeates, K. O. (2000). Closed-head injury. In K. O. Yeates, M. D. Ris, & H. G. Taylor (Eds.), *Pediatric neuropsychology: Research, theory, and practice* (pp. 92–116). New York: Guilford.

Yeates, K. O., Luria, J., Bartkowski, H., Rusin, J., Martin, L., & Bigler, E. D. (1999). Post-concussive symptoms in children with mild closed-head injuries. *Journal of Head Trauma Rehabilitation, 14,* 337–350.

Yeates, K. O., Taylor, H. G., Drotar, D., Wade, S. L., Klein, S., Stancin, T., & Schatschneider, C. (1997). Preinjury family environment as a determinant of recovery from traumatic brain injuries in school-age children. *Journal of the International Neuropsychological Society, 3,* 617–630.