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The Impact of Previous Traumatic Brain Injury on Health and Functioning: A TRACK-TBI Study

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Abstract

The idea that multiple traumatic brain injury (TBI) can have a cumulative detrimental effect on functioning is widely accepted. Most research supporting this idea comes from athlete samples, and it is not known whether remote history of previous TBI affects functioning after subsequent TBI in community-based samples. This study investigates whether a previous history of TBI with loss of consciousness (LOC) is associated with worse health and functioning in a sample of individuals who require emergency department care for current TBI. Twenty-three percent of the 586 individuals with current TBI in the Transforming Research and Clinical Knowledge in Traumatic Brain Injury study reported having sustained a previous TBI with LOC. Individuals with previous TBI were more likely to be unemployed ($\chi^2 = 17.86$; $p = 0.000$), report a variety of chronic medical and psychiatric conditions ($4.75 \leq \chi^2 \geq 24.16$; $p < 0.05$), and report substance use ($16.35 \leq \chi^2 \geq 27.57$; $p < 0.01$) before the acute injury, compared to those with no previous TBI history. Those with a previous TBI had less-severe acute injuries, but experienced worse outcomes at 6-month follow-up. Results of a series of regression analyses controlling for demographics and acute injury severity indicated that individuals with previous TBI reported more mood symptoms, more postconcussive symptoms, lower life satisfaction, and had slower processing speed and poorer verbal learning, compared to those with no previous TBI history. These findings suggest that history of TBI with LOC may have important implications for health and psychological functioning after TBI in community-based samples.

Key words: adult brain injury; cognitive function; recovery; traumatic brain injury

Introduction

More than 1.7 million individuals in the United States experience a traumatic brain injury (TBI) each year.[1] At least 75% of these injuries are concussions or mild TBI (mTBI),[2] defined as a brief alteration of mental status, or a period of loss of consciousness (LOC) shorter than 30 minutes.[3] Commonly reported symptoms of mTBI include poor attention and concentration, slowed information-processing speed, impaired memory, headaches, dizziness, fatigue, sleep difficulty, and mood changes.[4] For most people, these symptoms resolve in a matter of days or weeks; however, an estimated 10–20% of individuals experience persistent symptoms 1 or more years after injury.[5] Annual costs associated with mTBI in the United States may exceed $60 billion.[2,6]

Almost four decades ago, a small case-control study found that individuals with a previous history of mTBI experience poorer outcomes upon reinjury,[7] and the idea that multiple TBIs can have a cumulative detrimental effect has since become widely accepted. However, most research on multiple mTBI has focused on athletes, who are more likely than community-based samples to sustain multiple mTBIs over a shorter period of time by virtue of risks associated with contact sports. Several studies in collegiate and

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professional athletes report slower recovery or poorer outcomes among concussed athletes with a previous history of mTBI.[8,9]

Few studies have examined the effect of previous TBI in non-athletes.[10] It is uncommon for researchers to thoroughly screen participants for previous injuries in community-based TBI samples, and when these data are available, they are often used to exclude individuals with previous TBI from analyses (e.g., Zhou and colleagues[11]). Presumably, this is done to control for a factor that may confound study outcomes. It is not known whether the literature in sports-related concussion is generalizable to community samples, and there is limited empirical evidence that a previous TBI (particularly those sustained years before the most recent injury) affects recovery from a subsequent injury. However, the few studies that have considered previous TBI have found associations with decreased life satisfaction,[12] and higher levels of depression[13] after the most recent injury, and increased risk for subsequent TBIs.[14–16]

Given the prevalence and care costs associated with TBI, it is important to understand the factors that may contribute to poorer outcomes. The current study investigated the prevalence of previous TBI (history of previous TBI sustained before the current or acute injury) among individuals who received emergency department (ED) care for a current TBI (the majority of which are mild in severity) and compared patients with and without a previous TBI. Throughout this article, the term ''current injury'' will be used to refer to the aTBI for which the person most recently sought ED care and resulted in eligibility for the Transforming Research and Clinical Knowledge in Traumatic Brain Injury (TRACK-TBI) study. Areas of comparison include psychosocial functioning, health, and substance use preceding the current injury, current injury characteristics, and health and functional outcomes 3 and 6 months after the current injury. We will test the hypothesis that among individuals presenting to an ED for TBI, those who have a previous history of TBI will have more difficulties in the areas of psychosocial functioning and health, greater substance abuse, and worse outcomes after the current, acute injury.

Methods

Study population

Subjects were recruited from three level 1 trauma centers and one rehabilitation center as part of the multi-center, prospective TRACK-TBI study.[17] Patients were eligible for the TRACK-TBI study if they (1) presented to the ED within 24 h after sustaining head trauma of sufficient severity to necessitate noncontrast head computed tomography (CT) using the American College of Emergency Physicians/Centers for Disease Control evidence-based joint practice guideline,[18] (2) were 6 years of age or older, and (3) were able to provide informed consent independently or through proxy. Individuals who were non-English speaking, pregnant, in custody, in the process of psychiatric evaluation, or who had potential contraindications to magnetic resonance imaging were excluded from the study. For the current study, only patients over 16 years of age who were recruited from one of the level 1 trauma centers were included in the analysis.

Procedures

All participants or their legal authorized representatives provided written informed consent. Information needed to characterize the TBI, including duration of LOC, duration of amnesia, and mechanism of trauma, were gathered based on patient self-report and medical records. Study participants underwent clinically indicated CT scans and provided a blood sample for toxicology screens as well as genetic and proteomic biomarker analysis. Participants completed brief outcome assessments by telephone 3 months after the injury and then completed a more extensive outcome assessment 6 months postinjury. Participants who initially provided consent by legal proxy, but later regained cognitive capacity, were asked to provide informed consent before follow-up outcome assessments. Study protocols were approved by the institutional review boards of participating centers (San Francisco General Hospital, University of Pittsburgh Medical Center, University Medical Center Brackenridge, and Mount Sinai School of Medicine).

Baseline measures

Demographic characteristics included age, gender, race, ethnicity, and education.

Lifetime history of TBI. The Ohio State University TBI Identification method (OSU TBI-ID) Short Form was administered at the time of baseline data collection. The OSU TBI-ID is a standardized, structured interview designed to elicit lifetime history of TBI. The interview consists of five questions designed to prompt recall of injuries to the head or neck, then queries the presence, severity, and nature of altered consciousness and the age(s) at which injury occurred. Inter-rater and test-retest reliability are acceptable, and construct validity has also been supported.[19, 20]

Health status before current injury. Participants were asked whether they had ever been diagnosed with a structured list of medical and psychiatric conditions. We supplemented participant self-report with data gathered through medical record abstraction.

Psychosocial functioning before current injury. Participants were asked about their alcohol use, tobacco use, illicit drug use, employment status, and marital status before the current injury.

Current/acute injury and acute care characteristics. A variety of indices were collected to characterize the etiology and severity of the current TBI. These included Glasgow Coma Scale (GCS) score[21] assessed by a neurosurgeon at hospital admission, duration of LOC, duration of post-traumatic amnesia (PTA), Injury Severity Score (ISS),[22] blood-alcohol content upon arrival to the ED, hospital length of stay, discharge disposition (dead or alive), and location of discharge from the ED. CT scans were categorized as being positive or negative for acute traumatic intracranial lesions.

Current injury outcome measures

The TRACK-TBI outcome assessment battery consisted primarily of TBI common data element (CDE) measures.[23] Self-report measures of family strain and current employment status were collected by telephone at 3-month follow-up and in person at 6-month follow-up. The standardized neurocognitive and psychosocial measures collected at 6-month follow-up included the following.

Glasgow Outcome Scale-Extended.[24] The Glasgow Outcome Scale-Extended (GOS-E) provides an overall measure of disability based on information about cognition, independence, employability, and social and community participation gathered from a structured interview. Individuals are described by one of eight outcome categories: dead; vegetative state; lower severe disability; upper severe disability; lower moderate disability; upper moderate disability; lower good recovery; and upper good recovery.

Brief Symptom Inventory-18.[25] The Brief Symptom Inventory-18 (BSI-18) is a brief self-report instrument designed to assess psychological distress along three domains: somatization; anxiety; and depression.

Rivermead Postconcussion Symptoms Questionnaire-13 item.[26] The Rivermead Postconcussion Symptoms Questionnaire-13 item (RPQ-13) queries the presence and severity of somatic, cognitive, and emotional symptoms that are commonly reported after TBI. Participants are asked to compare current (past 24 h) and preinjury symptom severity on a scale from 0 to 4: not experienced; no more of a problem; mild problem; moderate problem; and severe problem.

Satisfaction with Life Scale.[27] The Satisfaction with Life Scale (SWLS) is a global measure of life satisfaction consisting of five statements that the respondent is asked to endorse on a 7-point scale ranging from 1 (strongly disagree) to 7 (strongly agree).

Post-Traumatic Stress Disorder Checklist-Civilian Version.[28] The Post-Traumatic Stress Disorder (PTSD) Checklist-Civilian Version (PCL-C) is a standardized self-report rating scale of comprising 17 PTSD symptoms that correspond to the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* criteria for PTSD. Respondents are asked to rate how much they have been bothered by each symptom in the past month on a 5-point scale ranging from 1 (not at all) to 5 (extremely).

Wechsler Adult Intelligence Scale–Fourth Edition, Processing Speed Index.[29] The Wechsler Adult Intelligence Scale–Fourth Edition, Processing Speed Index (WAIS-IV-PSI) consists of two timed cognitive subtests (coding and symbol search) that require visual attention and motor speed.

Trail Making Test.[30] The Trail Making Test (TMT) is a cognitive assessment consisting of two timed parts (TMT-A and TMT-B) that measure visual attention and mental sequencing, respectively.

California Verbal Learning Test–2nd Edition.[31] The California Verbal Learning Test–2nd Edition (CVLT-II) is a test of verbal learning and memory that consists of five word-list learning trials and an interference trial, followed by immediate- and delayed-recall trials. The CVLT-II was used in the TRACK-TBI study instead of the TBI CDE–recommended Rey Auditory Verbal Learning Test because of the recent revision and improved psychometric properties of the CVLT-II.[32]

Statistical analysis

Statistical analyses focused on examining differences between individuals with and without a previous history of TBI with LOC in the areas of health and functioning (before the current injury), current injury and acute care characteristics, and current injury outcomes. First, descriptive statistics were used to summarize the demographic features (age, gender, race, ethnicity, and educational history) of the total sample. Group differences between individuals with and without a previous TBI with LOC were evaluated using *t*-tests (for continuous measures) and chi-square tests (for categorical measures). Effect sizes were calculated for comparisons of preinjury health and functioning, current injury and acute care characteristics, and current injury outcomes.

Multiple regression analyses were conducted to compare those with and without previous TBI on the GOS-E, RPQ-13, SWLS, PCL-C, BSI-18 (Somatic, Depression, and Anxiety subscales), WAIS-IV-PSI, TMT, and CVLT-II, controlling for key individual characteristics (age, education, and race) and current injury variables (admission GCS, length of stay, LOC, and CT results). Logistic regression analyses were conducted to compare those with and without previous TBI on the presence or absence of Return to Work and Family Strain at 3 and 6 months, controlling for key individual characteristics (age, education, and race) and current injury variables (admission GCS, length of stay, LOC, and CT results). Level of significance was set as $p < 0.05$, and significance level was adjusted for false discovery rates by domain (previous medical health, previous psychiatric health, previous psychosocial functioning, current injury and acute care characteristics, and current injury outcomes).[33] Statistical analyses were conducted using SPSS 19.0 (SPSS, IBM; Chicago, IL).

Results

Sample demographics

Demographic information for individuals with and without a previous history of TBI is presented in Table 1. There were no significant differences between groups in sex, race, or ethnicity. A slightly higher proportion of Hispanics had a previous TBI (33%), compared to non-Hispanics (22%; $p = 0.06$, not significant). Of 586 TRACK-TBI participants above the age of 16, 136 (23%) reported having sustained at least one previous TBI with LOC. One hundred individuals reported one previous TBI with LOC, 23 reported two previous TBIs with LOC, and 13 reported three or more previous TBIs with LOC. Among the 136 people who reported one or more previous TBIs, 97 (71.3%) reported that they were hospitalized for their previous TBI. Etiology of previous TBIs included motor vehicle accidents (44.9%), falls (51.5%), sports (33.1%), fights (36.8%), and blast (10.3%). Approximately 54% of individuals with previous TBIs reported a LOC of 1–20 min, 22% reported LOC lasting between 20 min and 24 h, 5% reported LOC lasting longer than 24 h, and 19% were unsure of the duration of LOC after their previous TBI.

Health and psychosocial functioning before current injury

There were differences in previous medical health status among the groups. Those with a previous TBI were more likely to have a significant medical history (82% reported one or more medical conditions), compared to 68% of those with no previous TBI ($p = 0.001$). In particular, those with previous TBI were more likely to report otolaryngologic or ear/nose/throat (ENT), hepatic, musculoskeletal, spinal, neurological, pulmonary, and developmental conditions, but the groups did not differ in their history of cardiac, endocrine, gastrointestinal (GI), hematologic, oncologic, or renal problems (see Table 2). Post-hoc analyses were conducted to further explore whether the presence of a developmental disability was associated with age at previous TBI. Individuals who sustained a previous TBI before the age of 18 were more likely to have been diagnosed with a developmental disability (20%), compared to 8%

Table 1. Demographic Information for TRACK-TBI Participants without and with a Previous TBI with LOC

Demographics	*Cases with no previous TBI* (n = *450*)	*Cases with previous TBI* (n = *136*)	p *value*
Gender (% male)	70.7	74.3	0.241
Age, years, mean (SD)	43.97 (19.3)	41.23 (15.5)	0.130
Education, years, mean (SD)	13.8 (2.9)	13.6 (3.2)	0.444
Race (% Caucasian)	85.2	83.0	0.704
Ethnicity (% Hispanic)	12.6	20.6	0.060

TRACK-TBI, the Transforming Research and Clinical Knowledge in Traumatic Brain Injury study; TBI, traumatic brain injury; LOC, loss of consciousness; SD, standard deviation.

Table 2. Preindex Injury Medical and Psychiatric Health History among TRACK-TBI Participants without ($N=450$) and with ($N=136$) a Previous TBI with LOC

Medical condition category	*Cases with no previous TBI, no. (%)*	*Cases with previous TBI, no. (%)*	*Pearson's chi square*	p *value*	*Effect size (φ)*[a]
Hepatic	22 (4.9)	20 (14.7)	15.127	0.000*	0.16
Spinal	22 (4.9)	20 (14.7)	15.127	0.000*	0.16
Neurological	79 (17.6)	44 (32.4)	13.789	0.000*	0.15
Developmental	30 (6.7)	25 (18.4)	16.855	0.000*	0.17
Musculoskeletal	72 (16.0)	35 (25.7)	6.632	0.010*	0.11
Pulmonary	78 (17.3)	37 (27.2)	6.453	0.011*	0.11
ENT	65 (14.4)	32 (23.5)	6.240	0.012*	0.10
GI	61 (13.6)	27 (19.9)	3.245	0.072	—
Endocrine	71 (15.8)	15 (11.0)	1.880	0.170	—
Cardiac	150 (33.3)	37 (27.2)	1.805	0.179	—
Oncologic	34 (7.6)	15 (11.0)	1.645	0.200	—
Renal	25 (5.6)	4 (2.9)	1.518	0.218	—
Hematologic	35 (7.8)	13 (9.6)	0.441	0.507	—
Psychiatric condition	*Cases with no previous TBI, no. (%)*	*Cases with previous TBI, no. (%)*	*Pearson's chi square*	p *value*	*Effect size (φ)*
Anxiety	47 (10.4)	31 (22.8)	13.804	0.000†	0.15
Depression	74 (16.4)	49 (36.0)	24.155	0.000†	0.20
Sleep disturbance	22 (4.9)	18 (13.2)	11.439	0.001†	0.14
Bipolar disorder	8 (1.8)	7 (5.1)	4.753	0.029†	0.09
Schizophrenia	3 (0.7)	4 (2.9)	4.578	0.054	—
PTSD	2 (0.4)	2 (1.5)	1.622	0.203	—

[a]φ = phi coefficient.
*p < critical value of 0.027; †p < critical value of 0.033.
TRACK-TBI, the Transforming Research and Clinical Knowledge in Traumatic Brain Injury study; TBI, traumatic brain injury; LOC, loss of consciousness; ENT, ear/nose/throat; GI, gastrointestinal; PTSD, post-traumatic stress disorder.

of people who did not sustain a TBI previous to the age of 18 ($p=0.000$). The groups also differed in self-reported psychiatric history before the current injury. Those reporting a previous TBI with LOC were more likely to have a significant psychiatric history, compared to those with no previous TBI (46 vs. 22%; $p=0.001$). More specifically, those with a previous TBI were more likely to report a history of anxiety disorder, depression, sleep disorder, and bipolar disorder ($p<0.05$) and were slightly more likely to have a history of schizophrenia ($p=0.054$). The groups did not differ in rates of PTSD (see Table 2).

Individuals who reported a previous TBI were more likely to have been unemployed at the time of the current injury. At the time of the current injury, individuals with a previous TBI were more likely to be separated or divorced (14%) than those with no previous TBI (8%). At the time of baseline data collection, individuals who reported a previous TBI with LOC were more likely to report more frequent current tobacco use (45 vs. 24%), alcohol use (57 vs. 37%), and illicit drug use (35 vs. 15%), compared to those with no previous TBI ($p=0.000$; see Table 3).

Current injury and acute care characteristics

Eighty-two percent of the sample had an acute injury that was mild in severity (GCS 13–15), 5% had a moderate TBI (GCS 9–12), and 12% had a severe (GCS ≤ 8). Individuals with a previous TBI were almost half as likely (36%) as individuals with no previous TBI (61%) to have positive CT scans ($p=0.000$). Generally, people with a previous TBI reported a shorter duration of LOC ($p=0.001$) and shorter duration of PTA ($p=0.000$), compared to people with no previous TBI. GCS scores were higher for individuals with a

Table 3. Preindex Injury Psychosocial Functioning among TRACK-TBI Participants without and with a Previous TBI with LOC

Measure	*Cases with no previous TBI, no. (%)*	*Cases with previous TBI, no. (%)*	*Pearson's chi square*	p *value*	*Effect size (φ)*[a]
Unemployed	76 (18.0)	46 (34.1)	17.860	0.000*	0.23
Separated/divorced	36 (8.4)	19 (14.1)	9.090	0.011*	0.20
Tobacco use	108 (24.0)	61 (44.9)	22.129	0.000*	0.19
Alcohol use	167 (37.1)	77 (56.6)	16.353	0.000*	0.17
Illicit drug use	67 (14.9)	48 (35.3)	27.569	0.000*	0.22

[a]φ = phi coefficient.
*p < critical value of 0.040.
TRACK-TBI, the Transforming Research and Clinical Knowledge in Traumatic Brain Injury study; TBI, traumatic brain injury; LOC, loss of consciousness.

previous TBI, and ISSs were lower (reflecting less-severe injuries among individuals with a previous TBI). Those with a previous TBI had a shorter length of hospital stay (average, 2.8 days), compared to those with no previous TBI (average, 5.2 days; $p = 0.000$). They were also less likely to be admitted to inpatient rehabilitation upon discharge ($p = 0.000$). The groups did not differ in hospital discharge status (dead or alive). In terms of etiology of current mild TBI (mTBI), those with a previous TBI were more likely to sustain their current injury in an assault (25%), compared to 12% of those with no previous TBI ($p = 0.002$). There were no differences between groups in blood-alcohol content at ED admission.

Current injury outcomes

Regression analyses were used to evaluate the relationships between 3- and 6-month outcomes and previous TBI history, controlling for demographics and severity of the current injury. First, we conducted logistical regression analyses to evaluate whether differences existed between those with and without a previous TBI with LOC in self-reported family strain and employment status, controlling for sociodemographic variables (age, race, and education) and injury severity variables (hospital length of stay, presence of LOC for the current injury, presence of positive CT scan, and GCS). Though there were no differences in return to work at 3-month follow-up (odds ratio [OR], 0.66; 95% confidence interval [CI], 0.31, 1.39; $p = 0.271$), previous TBI with LOC was associated with lower likelihood of return to work by the time of 6-month follow-up (OR, 0.30; 95% CI, 0.14, 0.63; $p = 0.002$). Previous TBI was associated with greater likelihood of reporting family strain at both 3- (OR, 1.88; 95% CI, 1.06, 3.34; $p = 0.031$) and 6-month follow-up (OR, 4.17; 95% CI, 2.31, 7.52; $p = 0.000$).

Hierarchical multiple regression analyses were used to test the relationships among previous TBI history and both objective neuropsychological tests and self-report symptom measures. For each multiple regression model, the outcome measure (GOS-E, BSI Somatic, Depression, and Anxiety subscales, RPQ-13, SWLS, PCL-C, WAIS-IV PSI, TMT-A, TMB-B, CLVT-II Trials 1–5, and CVLT-II Delayed Recall) was the dependent variable, demographic variables (age, race, and education) were entered in the first step, current injury severity variables (hospital length of stay, presence of LOC for the current injury, presence of positive CT scan, and GCS) were entered in the second step, and history of previous TBI with LOC was entered in the third step. Results from the third step of each of these analyses, which represent the effect of previous TBI history on each outcome after controlling for demographics and current injury severity, are presented in Table 4. Results indicate that previous TBI with LOC was associated with greater somatic complaints (BSI Somatic), depression (BSI Depression) and anxiety (BSI Anxiety), lower life satisfaction (SWLS), more postconcussive (RPQ-13) and -traumatic stress (PCL-C) symptoms at 6-month follow-up, and worse processing speed (WAIS-IV PSI) and verbal learning (CVLT-II Trails 1–5). After controlling for demographics and current injury characteristics, there were no differences between groups on overall global outcome (GOS-E) or other indices of cognitive functioning (CVLT Delayed Recall, TMT-A, and TMT-B) 6 months after the current injury.

Table 4. Effect of Previous TBI with LOC on 6-Month Outcomes after Controlling for Demographic Variables and Current Injury Severity

Dependent variable	*β*	*Adjusted R square*	*R-square change*	*F (df)*
GOS-E	−0.08	0.21	0.01	7.25 (1, 247)
BSI-Somatization	0.22	0.14	0.05	4.90 (1, 247)*
BSI-Depression	0.19	0.09	0.03	3.33 (1, 247)*
BSI-Anxiety	0.25	0.15	0.06	5.02 (1, 247)*
RPQ-13	0.24	0.20	0.05	6.81 (1, 247)*
SWLS	−0.18	0.04	0.03	1.96 (1, 247)*
PCL-C				
WAIS-IV PSI	−0.17	0.29	0.03	9.97 (1,226)*
TMT–Part A	0.04	0.19	0.00	5.88 (1, 236)
TMT–Part B	0.08	0.26	0.01	8.41 (1, 226)
CVLT-II Trials 1–5	−0.12	0.31	0.01	10.51 (1, 226)†
CVLT-II Delayed Recall	−0.04	0.23	0.00	7.33 (1, 226)

*$p < 0.01$; †$p < 0.05$.

TBI, traumatic brain injury; LOC, loss of consciousness; GOS-E, Glasgow Outcome Scale-Extended; BSI, Brief Symptom Inventory; RPQ-13, Rivermead Postconcussion Symptoms Questionnaire-13 item; SWLS, Satisfaction with Life Scale; PCL-C, Post-Traumatic Stress Disorder Checklist-Civilian Version; WAIS-IV PSI, Wechsler Adult Intelligence Scale–Fourth Edition, Processing Speed Index; TMT, Trail Making Test; CVLT-II, California Verbal Learning Test–2nd Edition.

Discussion

The current study examined the hypothesis that individuals with a previous history of TBI with LOC would demonstrate worse functioning before sustaining the current TBI and have poorer outcomes than individuals who did not report a previous TBI with LOC. We found that 23% of individuals seeking ED care for TBI reported a previous history of TBI, and the majority of these repeat injuries would be considered mild in severity. The rate of repeat injury among those with a history of TBI is consistent with earlier studies.[15,16]

Our hypotheses that those with previous TBI would have worse functioning before and after the current injury were mostly supported. Individuals with previous TBI had worse medical and psychological health before the current injury and were more likely to engage in substance abuse before the current injury. It cannot be determined, in the current study, whether these indicators of poor health and functioning reflect lasting sequelae of the previous TBI or whether they preceded the previous injury, possibly playing a causal role in reinjury or even in the earlier injury or injuries. Our finding that individuals with a previous TBI reported higher rates of developmental disabilities raised the question of whether TBI sustained early in life may lead to potentially inaccurate diagnosis of developmental disorders and, consequently, misdiagnosis of TBI. We found that those who sustained their previous TBI before the age of 18 were more than twice as likely to have been diagnosed with a developmental disability as those who were injured later in life, which provides indirect support for this notion. It is similarly unclear whether the higher rates of mood disturbance, divorce or separation, and unemployment noted among those with previous TBI are consequences of the earlier injury, but this would certainly be consistent with earlier research documenting lasting mood changes, relationship difficulties, and reduced employment after TBI.[34,35]

Compared to individuals with no previous TBI history, those with a previous TBI had less-severe current injuries, as measured by GCS, ISS, duration of LOC and PTA, and length of hospital stay. They were also less likely to have positive findings on CT scan. Those with a previous TBI, perhaps as a result of their greater rates of medical comorbidity and psychosocial problems, may have presented with a clinical phenotype that motivated ED staff to order

CT scans for injuries that may otherwise not have met criteria to necessitate a CT scan. These findings are consistent with a recent article that evaluated rates of previous TBI among individuals with moderate to severe TBI in the National Institutes of Disability and Rehabilitation Research–funded TBI Model Systems: Those with previous injuries had less-severe ''index'' TBIs (the injury that led to their inclusion in the Model Systems research database) and had higher levels of functioning at admission and discharge from in-patient rehabilitation, compared to those without a previous injury.[36] The investigators speculated that high rates of preindex injury emotional and behavioral problems (also consistent with the findings of the current study) may result in those with previous TBI appearing more clinically complicated, and with a greater need for intensive rehabilitation care, despite the TBI itself being less severe. It is also possible that having sustained a previous TBI resulted in greater awareness and care seeking on the part of the injured individual, making those with a previous TBI more likely to recognize the injury present to the ED and possibly even request a CT scan. Finally, the finding in the current study that those with previous TBI were less likely to be discharged to in-patient rehabilitation could reflect unavailability of resources, given that they were less likely to have been employed at the time of the injury than those without previous TBI.

The current study found consistently worse injury outcomes among those with a previous TBI with LOC. Given that the majority of the TRACK-TBI participants sustained TBIs that were mild in severity (GCS 13–15), it was striking to find that previous TBI exerted a marked effect on 6-month outcomes across several areas of functioning, including cognition, mood, family strain, and life satisfaction. Because these same metrics were not collected before the current injuries that resulted in TRACK-TBI study participation, it cannot be determined whether these outcomes represent continuation or worsening of problems that existed before the current injury. However, support for a causative relationship comes from a recent study that found a direct relationship between severity of previous TBIs and levels of both anxiety and depression after the index (most recent) injury.[36]

Individuals with and without previous TBI reported similar rates of unemployment at the 3-month follow-up; but, at 6 months postinjury, most of the participants with no previous TBI had returned to work, whereas many of those with a previous TBI remained unemployed. These analyses excluded individuals who had been unemployed at the time of the current injury, so this finding suggests that recurrent TBI had a cumulative detrimental effect on these individuals.

Limitations

A limitation of this study is that assessment of previous TBI history is based on self-report in the current study. The OSU TBI-ID is reliable and valid as a self-report measure, but more-objective indicators, such as radiographic or blood-based biomarkers of previous TBI, would increase confidence in the findings presented here. It was not possible to evaluate the effect of multiple previous TBIs in the current study because of the relatively small number of people with multiple injuries, but this warrants further investigation in a larger study.

Conclusions

Results of this study indicate that a history of previous TBI is quite common (23%) among individuals seeking ED care for a TBI. Previous TBI may be an important contributor to poor TBI outcomes, even after mTBI. The findings presented here demonstrate the importance of systematically collecting information about previous TBI history in future TBI outcome studies, given the apparent importance of this covariate. This study adds to the existing literature that documents strong associations between previous TBI and substance abuse, medical and psychiatric comorbidity, strained relationships, and low life satisfaction.

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Author Disclosure Statement

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