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Traumatic brain injury and coextensive psychopathology: New evidence from the 2016 Nationwide Emergency Department Sample (NEDS)

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ABSTRACT

Traumatic brain injury (TBI) is a significant public health issue associated with increased medical comorbidity and economic burden. The majority of studies of TBI among clinical populations are geographically limited and rely on small samples. As such, the current study seeks to examine the prevalence and psychosocial correlates of TBI in a nationally representative emergency department (ED) sample. Using the 2016 Nationwide Emergency Department Sample, logistic regression was employed to examine the relationship between TBI history, sociodemographic factors and mental health disorders. An estimated 179,986 adults age 18 and older were admitted to United States EDs in 2016 with a personal history of TBI. The majority of patients were male (69.71%), ages 50 years or older (50.92%) with Medicare (44.30%) or Medicaid (28.65%) insurance. Diagnoses of posttraumatic stress disorder (AOR = 3.99), affective disorders (AOR = 2.97), anxiety disorders (AOR = 1.68), personality and behavior disorders (AOR = 2.77), and schizophrenia (AOR = 2.80) were significantly associated with history of TBI. These results provide insight into the developmental pathogenesis of TBI and its comorbid psychiatric consequences.

1. Introduction

Traumatic brain injury (TBI) is a significant global health problem that is associated with coextensive psychiatric and behavioral impairment. In the United States, more than 1 million TBIs occur each year that result in emergency medical services (Emery et al., 2016; Langlois et al., 2006; Maas et al., 2008) and it is estimated that millions more TBIs occur that do not result in medical care. The most common reasons for TBI admissions to emergency departments are falls, motor vehicle/traffic accidents, brunt force injuries (e.g., being struck by an object), and physical assaults (Langlois et al., 2006). TBI is importantly related to mortality and is a contributing factor to one in three injury-related deaths in the United States (Faul et al., 2010). In terms of aggregate monetary burden, TBI in the United States produces annual costs ranging from $50 to $100 billion (Cook et al., 1999; Finkelstein et al., 2006; Stevens et al., 2006), which quantifies its standing as a social problem.

Moreover, TBI is even more salient to psychiatrists and criminologists given that the prevalence of TBI is exponentially higher among clinical and correctional populations relative to the general population as are the prevalence of mental health disorders and global psychopathology (Farrer et al., 2012, 2013; Farrer and Hedges, 2011; Shiroma et al., 2010; Williams et al., 2018). Prior research makes clear that for clinical populations, the cause of TBI often relates more to a generalized involvement in externalizing behaviors and/or stems from psychiatric deficits and impairments. To illustrate, Vaughn et al. (2014) analyzed data from the Pathways to Desistance Study and found that male gender, global psychiatric symptoms, impulsivity, and criminal victimization were significantly associated with TBI status (also see, Daigle and Harris, 2018; Schwartz et al., 2017; Schwartz et al., 2018; Veeh et al., 2018). Overall, these studies reveal that TBI has important implications for core self-regulation deficits as invoked in self-control (Gottfredson and Hirschi, 1990) and temperament theories (DeLisi and Vaughn, 2014) of crime. Studies employing correctional samples have also found that TBI has enduring and significant associations with life-course conduct problems even when accounting for neurological medical conditions, ADHD, psychopathy, and low self-control (Behnken et al., 2015). This suggests that although TBI is interrelated with psychiatric symptoms it maintains independent associations with downstream behavioral consequences of those symptoms.

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2. Current aim

Unfortunately, most prior studies of TBI among clinical populations employ localized data and small samples (e.g., Behnken et al., 2015; Farrer et al., 2012; Schofield et al., 2018), epidemiological studies of TBI and its linkages with psychiatric problems using national-level data are lacking. As such, the developmental pathogenesis of TBI and its comorbid and downstream psychiatric and behavioral consequences is unclear. To rectify this, the current study examined 41,770 individuals with self-reported history of TBI and examined its correlates and mental health associations.

3. Material and methods

3.1. Data and sample

This study employed data from the 2016 Nationwide Emergency Department Sample (NEDS) from the Healthcare Cost and Utilization Project (HCUP) distributed by the Agency for Healthcare Research and Quality (AHRQ). The NEDS is the largest, publicly available all-payer database of ED visits. The 33 million observations from 953 hospitals represents a 20 percent stratified sample of all hospital-owned EDs in the United States. The weighted analysis allows for the calculation of national estimates, which represent 144 million ED visits (Agency for Healthcare Research and Quality, 2018). The analytic sample consists of adults ages 18 and older (n = 26,168,895) who were discharged from US EDs in 2016.

3.2. Measures

3.2.1. Personal history of traumatic brain injury

A single dichotomous International Classification of Diseases (ICD-10-CM) (World Health Organization, 1993) diagnostic code was used to identify personal history of traumatic brain injury (Code = Z87.820).

3.2.2. Mental health disorders

Four mental health disorder categories were measured on the basis of ICD-10-CM codes. Codes F20–F29 were labeled psychotic disorders and include schizophrenia disorder, schizotypal disorder, delusional disorder, brief psychotic disorder, shared psychotic disorder, schizoaffective disorder, other psychotic disorder not due to a substance or known physiological condition, and unspecified psychosis not due to a substance or known physiological condition affective. Codes F30–F39 were labeled affective disorders and include manic episode, bipolar disorder, major depressive disorder, single episode, major depressive disorder, recurrent, persistent mood disorders, and unspecified mood disorders. Codes F40–F48 were labeled anxiety disorders, consisting of phobic anxiety disorders, other anxiety disorders, obsessive-compulsive disorder, reaction to severe stress, adjustment disorders, dissociative and conversion disorders, somatoform disorders, and other non-psychotic mental disorders. Disorders of adult personality and behavior included codes F60–F69 for specific personality disorders, impulse disorders, gender identity disorders, paraphilias, other sexual disorders, other disorders of adult personality and behavior, and unspecified disorder of adult personality and behavior. Post-traumatic stress disorder (PTSD) (F43.1) was also included in the analysis.

3.2.3. Demographic variables

Sociodemographic variables available in the NEDS were used to describe patients with a history of TBI including age, sex, urbanicity, insurance status (expected primary payer: Medicare, Medicaid, private insurance, or other, including self-pay, no charge, or other), and national quartile for median household income of patients' ZIP codes. Urbanicity is indicated by the urban-rural classification system for US counties developed by the National Center for Health Statistics. The central counties of metro areas of ≥1 million population were labeled central city, fringe counties of metro areas of ≥1 million population labeled suburban, medium metro (250,000–999,999 population) and small metro (50,000–249,999 population) were combined into a medium/small city category, and micropolitan and not metropolitan or micropolitan counties were combined into rural. The classification of the estimated median household income of residents in the patient's ZIP code are derived from ZIP code-demographic data obtained from Claritas and are estimated annually (Agency for Healthcare Research and Quality, 2016). For 2016, the dollar ranges for estimated median household income by ZIP code represented by each category are $1-$42,999 for quartile 1, $43,000-$53,999 for quartile 2, $54,000-$70,999 for quartile 3, and over $71,000 for quartile 4. Sex, age, and income were used as controls for all logistic regression models.

3.3. Analyses

Bivariate analyses were conducted to identify the prevalence of a diagnosis of history of TBI among ED patients as well as provide descriptive statistics for these individuals. Multivariate logistic regression was conducted with history of TBI as the dependent variable and mental health disorders as independent variables to determine which mental health diagnoses were associated with history of TBI. The reference categories for each mental health diagnosis included in the regression model were individuals without that specific diagnosis. As a sensitivity analysis, the model was also tested using the 2010–2015 NEDS. The analyses were weighted to account for the NEDS complex sampling design using the *svyset* command and *svy* prefix in Stata 14.2. Primary sampling units for the NEDS are individual hospitals for which discharge weights are constructed and applied as sampling weights. A more detailed description of the NEDS sampling design is available from Agency for Healthcare Research and Quality (2018).

4. Results

Table 1 provides descriptive statistics for the 40,737 adults age 18 and older admitted to US EDs with a diagnosis of personal history of

Table 1
Descriptive statistics for emergency department patients with a personal history of TBI.

	Personal History of TBI *n* = 40,737
	% (95% CI)
Sex	
Male	69.71 (68.82–70.59)
Female	30.29 (29.41–31.18)
Age	
18–34 years	22.10 (21.24–22.99)
35–49 years	26.98 (26.23–27.73)
50 years and older	50.92 (49.76–52.08)
Median Household Income Quartile	
0–25th percentile	31.64 (29.07–34.33)
25-50th percentile	26.66 (24.73–28.68)
50–75th percentile	22.77 (21.10–24.53)
75–100th percentile	18.93 (16.78–21.29)
Insurance Status	
Medicare	44.30 (43.18–45.43)
Medicaid	28.65 (27.24–30.10)
Private	16.10 (15.10–17.15)
Other	10.95 (10.07–11.91)
Urbanicity	
Central City	26.67 (23.18–30.48)
Suburban	21.64 (18.75–24.84)
Medium/Small City	34.47 (31.33–37.75)
Rural	17.22 (15.34–19.28)

Table 2
Diagnosis of personal history of TBI in the emergency department.

	Odds Ratio	
	AOR	(95% CI)
Mental Health Diagnoses		
Post-traumatic Stress Disorder	**3.99**	**(3.65–4.36)**
Affective Disorders	**2.97**	**(2.79–3.16)**
Anxiety Disorders	**1.68**	**(1.59–1.77)**
Personality and Behavior Disorders	**2.77**	**(2.34–3.29)**
Schizophrenia	**2.80**	**(2.58–3.04)**
Age		
18–34 years	Reference	
35–49 years	**1.52**	**(1.45–1.59)**
50 years and older	**1.48**	**(1.40–1.57)**
Median Household Income Quartile		
0–25th percentile	Reference	
25-50th percentile	1.07	(0.99–1.16)
50–75th percentile	**1.19**	**(1.09–1.30)**
75–100th percentile	**1.23**	**(1.10–1.38)**
Sex		
Male	Reference	
Female	**0.31**	**(0.30–0.33)**

Note: Odds ratios and 95% confidence intervals in bold are statistically significant at $p < .001$.

TBI. The estimated number of adults (i.e., weighted prevalence) with a personal history of TBI was 179,986 in 2016. The majority of patients were male (69.71%, 95% CI = 68.82%–70.59%) and aged 50 years or older (50.92%, 95% CI = 49.76%–52.08%). Approximately 60% of patients resided in ZIP codes in the lowest median household income quartiles (0–25th percentile: 31.64%, 95% CI = 29.07%–34.33%; 25-50th percentile: 26.66%, 95% CI = 24.73%–28.68%) with Medicare insurance (44.30%, 95% CI = 43.18%–45.43%) or Medicaid insurance (28.65%, 95% CI = 27.24%–30.10%). The majority of patients resided in either a medium/small city (34.47%, 95% CI = 31.33%–37.75%) or in a central city (larger metropolitan area) (26.67%, 95% CI = 23.18%–30.48%).

Table 2 displays the adjusted odds ratios (AOR) for the likelihood of a diagnosis of personal history of TBI. Individuals admitted to the ED and diagnosed with a mental health disorder were significantly more likely—compared to those without a mental health disorder—to have a history of a TBI. Specifically, diagnoses of PTSD (AOR = 3.99, 95% CI = 3.65–4.36), affective disorders (AOR = 2.97, 95% CI = 2.79–3.16), anxiety disorders (1.68 95% CI = 1.59–1.77), disorders of adult personality and behavior (AOR = 2.77, 95% CI = 2.34–3.29), and schizophrenia (AOR = 2.80, 95% CI = 2.58–3.04) were significantly associated with history of TBI. With regard to demographic characteristics, males and adults aged 35 years and older are significantly more likely than younger adults to present to the ED with a history of TBI. Additionally, adults residing in ZIP codes with higher median household incomes were 19%–23% more likely to have history of TBI.

5. Discussion

Drawing on NEDS data on 40,737 persons with a personal history of TBI, the current study offered findings that provide clues to the developmental pathogenesis of TBI and its comorbid and downstream psychiatric and likely behavioral consequences. Four points can guide future research. First, about one in five cases were young adults, one quarter were ages 35 to 49, and nearly half were ages 50 or older. Whereas TBI can be a marker of abuse as part of adverse childhood experiences, the increasing prevalence of TBI with age suggests it is likely a result of the clinical features of the included disorders (Maas et al., 2008). For instance, individuals with PTSD were four times more likely to have history of TBI and agitation, hostility, and irritability are core behavioral symptoms of PTSD. Given the linkages between self-regulation especially regarding negative emotionality and antisocial behavior (DeLisi and Vaughn, 2014; Garofalo and Velotti, 2017; Jang and Johnson, 2003; Velotti et al., 2017), we suspect the symptoms of PTSD contribute to aversive social interactions that can produce an assault and subsequent injury. The link between PTSD and TBI may also be related to military service with research suggesting that military veterans with TBI are also more likely to be diagnosed with PTSD (Tanev et al., 2014). It is revealing that affective disorders, personality and behavior disorders, and schizophrenia all share aversive symptoms that increase the likelihood of conflict with others which would explain why individuals with these disorders 2–3 times the odds of TBI history as shown in the multivariate model. Indeed, the psychiatric conditions with the lowest association with TBI—anxiety disorders—is the one most characterized by social inhibition and withdrawal.

Second, the significant linkages between mental health diagnoses and TBI reflects both active and passive features of the disorders. We advance that active features describe how symptoms of the disorder directly translate into dangerous and risky settings whereby a TBI can result. This would most clearly occur among the personality and behavior disorders that implicate impulse control problems and high-risk behaviors (e.g., sexual promiscuity, aggressive driving, stunt-like behavior) (see, Behnken et al., 2015; Behnken et al., 2016; Prehn et al., 2013). Passive features refer to ways that symptoms of disorders compromise cognitive functioning and decision-making that in turn lead to increased likelihood of dangerous settings and TBI risk. A common example is going outside during inclement weather, slipping on ice, and incurring a TBI.

Third, despite the use of what is to our knowledge the largest study group of individuals with TBI, there is an important limitation to consider. Foremost is the cross-sectional nature of the data that precludes articulation of whether the TBI predated or postdated the psychopathology. The diagnostic coding unfortunately does not provide information about timing or origin of the TBI. It is possible that individuals with newly diagnosed TBIs differ significantly in their comorbidity compared to those with a longer history of TBI. Additionally, individuals whose TBIs were caused for diverse reasons (e.g., as the result of abuse, as the result of sensation-seeking, as a consequence of intoxication, or as incurred during a violent victimization) may significantly differ from each other especially with regard to mental health. Future research should elucidate the possible role of the origin of the TBI in its relationship with mental health. Although we cannot statistically specify the timing of the TBI relative to the mental health diagnosis, we hypothesize that the mental health disorders most likely predated and thus contributed to the TBI based on clues in the literature. For instance, 80%–90% of TBI that occur in the United States are mild in severity, such as a concussion or brief loss of consciousness (Faul et al., 2010). In addition, Emery and colleagues' (2016) systematic review of mild TBI among children and adolescents reported little evidence that psychiatric, behavioral, or psychological problems persisted much beyond the acute and subacute period after the injury. Further still, prior research has shown that less than one in five patients develop a psychiatric illness up to one year after incurring a TBI (Deb et al., 1999). We encourage the collection of longitudinal data to specifically address the timing issue regarding TBI and mental health diagnoses.

Fourth, although we found significant associations between PTSD, affective disorders, schizophrenia, personality and behavior disorders, and anxiety disorders and TBI, we are missing a likely mechanism that connections mental health with TBI: substance use disorders. The current forms of psychopathology are significantly comorbid with drug use, abuse, and dependence (Lai et al., 2015) and intoxication is often an immediately proximal condition to TBI. Future research should clarify how mental illness contributes to intoxicated states that increase the liability for a traumatic brain injury.

Declarations of interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jpsychires.2019.05.002.

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