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Relationship Between Traumatic Brain Injury History and Recent Suicidal Ideation in Iraq/Afghanistan-Era Veterans

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This study evaluated whether a history of traumatic brain injury (TBI) was associated with increased risk for recent suicidal ideation (SI) after accounting for demographics, depression, posttraumatic stress

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disorder (PTSD), and sleep quality. In terms of increased risk, we hypothesized that a history of lifetime TBI would be associated with increased recent SI when compared with no history of TBI; multiple injuries were also evaluated. The sample included Iraq and Afghanistan war-era veterans (n = 838) who served in the United States military since 9/2001 and completed a structured TBI interview. Approximately 50% reported a lifetime history of at least 1 TBI, and 17.9% met criteria for current major depressive disorder (MDD). SI over the past week per the Beck Scale for Suicide Ideation was the primary outcome. Demographics, current MDD and posttraumatic stress disorder (PTSD) per Structured Clinical Interview of *DSM–IV* Axis I Disorders, sleep quality per Pittsburgh Sleep Quality Index, and TBI history per structured interview were included in all statistical models. Current depression and poor sleep quality were consistently associated with recent SI. A history of any TBI history across the life span was not associated with increased recent SI (OR = 1.35, 95% CI [0.83, 2.19]). However, a history of multiple TBIs compared with no history of TBI was associated with increased recent SI (OR = 1.76, 95% CI [1.01, 3.06]). Results support the assertion than an accumulation of injuries amplifies risk. Severity of injury and deployment injuries were not significant factors. Among those with a history of 1 TBI, sleep, and depression, which may also be injury sequelae, may be salient treatment targets.

Keywords: veteran, suicidal ideation, traumatic brain injury, depression, sleep

Since 9/11/2001, over 3.9 million U.S. service members have completed a combat deployment (Reger et al., 2015), and nearly half have deployed more than once (Committee on the Assessment of the Readjustment Needs of Military Personnel, Veterans, & Their Families, 2013). In the decade prior to U.S. involvement in the wars in Iraq and Afghanistan (Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn [OEF/OIF/OND]), military service was a protective factor against suicide, and military suicide rates were consistently lower than in civilian populations (Eaton, Messer, Garvey Wilson, & Hoge, 2006). However, higher rates of suicide have been more recently noted in both service members and veterans. Compared with the general population, veterans who served in the U.S. military between 2001 and 2007 demonstrated an increased risk of suicide regardless of whether they did (SMR = 1.41, 95% CI [1.26, 1.56]) or did not deploy to a combat zone (SMR = 1.61, 95% CI [1.53, 1.69]; Kang et al., 2015). A population-based study using data from 16 U.S. states evaluating male veteran versus civilian suicide risk reported a higher rate of suicide in the veteran cohort across all age groups (RR = 1.58, 95% CI [1.53, 1.62]); the highest risk was seen with veterans in the age range of 17 to 24 years (RR = 3.84, 95% CI [3.26, 4.51]; Gibbons, Brown, & Hur, 2012). These statistics suggest the inherent need to better understand factors associated with recent increases in risk across the veteran population.

Combat exposure has been suggested as one factor potentially underlying the recent increase in veteran suicide risk (Vanderploeg et al., 2015). Relatedly, among military personnel and veterans, posttraumatic stress disorder (PTSD) has been shown to increase risk for suicidal ideation (DeBeer et al., 2016; Vanderploeg et al., 2015; Wisco et al., 2014a). However, despite the stress of a combat deployment and difficulties related to postdeployment readjustment, recent studies have not found a significantly higher rate of suicide in veterans who deployed compared with those who did not, or in veterans with multiple deployments (Kang et al., 2015; Reger et al., 2015). Instead, the suicide rate was highest during the initial years following separation from the military for both deployed and nondeployed veterans. Work by members of the Army STARRS team also highlighted increased risk for suicide attempts among those who had never deployed (Ursano et al., 2016).

As traumatic brain injury (TBI) history has been noted as a "signature injury" among recent military cohorts, it has also been discussed as a potential factor associated with increases in suicide risk. In the OEF/OIF/OND veteran cohort, 357,048 TBIs have been reported in U.S. service members from 2000 through the third quarter of 2016, 82.3% of which were classified as mild in severity (Defense and Veterans Brain Injury Center [DVBIC], 2016). Most mild TBI (mTBI) individuals are unlikely to require medical attention. As such, those injuries are often not captured in medical records or surveillance data (Orman, Kraus, Zaloshnja, & Miller, 2011). Underreporting, more generally, may be increased due to military culture and deployment contexts (Armistead-Jehle, Soble, Cooper, & Belanger, 2017), suggesting that the DVBIC numbers likely represent an underestimate of the true prevalence of TBI in the OEF/OIF/OND population. It is also important to note that though commonly thought of as a combat-related injury, many TBIs in the military occur outside of deployment (Cameron, Marshall, Sturdivant, & Lincoln, 2012; Voss, Connolly, Schwab, & Scher, 2015).

The potential relationship between TBI and suicide among OEF/OIF/OND veterans is provided by multiple studies which suggest that a history of TBI is uniquely associated with increased risk for death by suicide (Bahraini, Simpson, Brenner, Hoffberg, & Schneider, 2013; Fazel, Wolf, Pillas, Lichtenstein, & Langstrom, 2014; Richard et al., 2015). For example, a large database study found that veterans with a history of TBI (any severity level, not specific to deployment) were 1.55 times more likely to die by suicide than veterans without a history of TBI, after adjusting for psychiatric medical chart diagnoses (Brenner, Ignacio, & Blow, 2011). A study among a national sample of OEF/OIF veterans reported that TBI (any severity level, specific to deployment) was associated with increased risk of suicidal ideation (SI) following return from deployment, a finding that remained significant in male veterans even after accounting for depression symptoms (Gradus et al., 2015). Despite evidence in support of an association between TBI and suicide risk, there remains a need to better understand how additional factors such as multiple TBIs, multiple comorbidities, and TBI severity levels potentially relate to risk.

To address some of these factors, Bryan and Clemans (2013) conducted a study of U.S. military personnel based in Iraq who were undergoing assessment at an outpatient TBI clinic, and found that a significant increase in lifetime SI was associated with increasing number of lifetime TBIs. Service members who had experienced more than one lifetime TBI (range 2 to 19) also reported higher levels of other symptoms (depression, PTSD, postconcussive symptoms); however, reporting more than one TBI across the lifetime was associated with an increased suicide risk (based on the Suicide Behaviors Questionnaire–Revised [SBQ-R]), even after adjusting for depression, PTSD, and postconcussive symptoms (self-report symptom-level assessments) soon after the time of injury (Bryan & Clemans, 2013). These results are difficult to interpret because all participants were seen in a military TBI clinic for a recent injury (median time since injury 2 days), but they reported TBI events and SI across the life span. Not only might the service member provide inaccurate history due to acute effects of the brain injury, but remote events were collapsed with very acute events making it difficult to discern if SI was an acute or cumulated chronic problem. Despite these limitations, findings suggest that a history of multiple brain injuries might add unique risk of SI beyond that attributed to other factors, warranting additional empirical examination.

The aim of this study was to investigate the relationship between lifetime TBI and recent SI after adjusting for demographics, sleep quality, PTSD, and depression. In contrast to prior studies, the current study used a sample of OEF/OIF/OND-era veterans to evaluate SI rather than attempts or deaths by suicide. Examining recent SI might provide conclusions different from research on deaths by suicide, and would allow for more clinically applicable information for how best to design screening, assessment, and intervention delivery models within psychological services. Furthermore, our study builds upon previous research by utilizing structured interviews to confirm TBI history and psychiatric diagnoses with a validated self-report assessment of suicide risk. Additionally, we included sleep problems in our analysis, a critical symptom that is frequently identified post-TBI and is also associated with suicide risk. Nonetheless, sleep related problems have rarely been independently examined in comprehensive models of TBI history and suicide risk. Hypotheses were as follows: (a) after accounting for the effects of demographic variables, PTSD, depression, and poor sleep quality, a positive history of TBI at any time during the life span would be associated with the presence of SI; and (b) a lifetime history of multiple TBIs would be associated with both a significantly higher level of recent SI compared with history of a single TBI and with no lifetime history of TBI.

Method

Procedures

Data for the current study were obtained from the VA Mid-Atlantic Mental Illness Research, Education and Clinical Center (MIRECC) as part of the Post-Deployment Mental Health (PDMH) study, an ongoing, multisite cohort study of postdeployment mental health (Brancu et al., 2017). The PDMH study was approved by respective institutional review boards for each site (two in North Carolina and two in Virginia). Additionally, approval by the collaborating authors' IRB (COMIRB) was obtained prior to initiating analytics. Voluntary verbal and written informed consent from each participant was obtained prior to initiation of any study activities. Data were collected between June 2010 and February 2013. Participants were recruited by mailings, brochures, flyers, and OEF/OIF clinics. Participants were reimbursed for time and travel. SAS versions 9.2 and higher and SPSS version 21 were used to analyze data.

Participants

To be included in the PDMH study, participants must have served in the U.S. Armed Forces since September 11, 2001 (including both those who deployed and those who did not); there were no exclusion criteria. The total sample for this study included 838 veterans who completed a structured TBI interview as part of the PDMH. Participants in the final sample were 80.5% male (n = 675), 50.5% Caucasian (n = 423), 48.6% married (n = 407), and 93.9% had at least a high school education (n = 787). The average age of the participants was 37.05 years old (SD = 9.98, range 21–65). Detailed demographics are presented in Table 1.

Measures

TBI history was assessed with a structured TBI interview developed as part of the PDMH study (Brancu et al., 2017). Participants were queried regarding TBI across four life eras: prior to military service, during military service but not during a combat deployment, during a combat deployment, and after discharge from military duty. For each era, a maximum of three injury events were evaluated according to the American Congress of Rehabilitation Medicine criteria (Menon, Schwab, Wright, & Maas, 2010). A mild TBI was classified as loss of consciousness (LOC) $<$30 min, posttraumatic amnesia (PTA) $<$24 hr, and at a minimum, the presence of some alteration of consciousness (AOC) in response to a head injury (The Management of Concussion/mTBI Working Group, 2009). Using the same criteria, a moderate TBI involves LOC $>$30 min and/or PTA $>$1 day, and a severe TBI involves LOC $>$24 hr and/or PTA $>$7 days. For this study, due to the small numbers of moderate and severe injuries and different prognosis compared to mild TBIs, injuries of greater severity were collapsed into the moderate-to-severe category. From the interview data, a dichotomous variable was calculated indicating the presence or absence of a history of TBI of any severity across the life span. Categorical variables indicating a history of any TBI (yes-no) and the number of TBIs (zero, one, or more than one) were calculated, both for the deployment period and summative across the entire life span.

Presence of depression and PTSD were assessed using the Structured Clinical Interview of *DSM–IV* Axis I Disorders (SCID-I; First, Spitzer, Gibbon, & Williams, 1997). Interrater reliability for examiners administering the SCID in PDMH was κ = .94. For the current study, dichotomous variables representing presence or absence of current major depressive disorder (MDD) and presence or absence of PTSD were used.

Demographic information was provided by participants via self-report questionnaires administered on a computer workstation. Recent SI was assessed using the Beck Scale for Suicide Ideation (BSI; Beck & Steer, 1991), a 21-item self-report measure. Severity of ideation over the past week was calculated by summing responses to the first 19 items (range 0 to 38). Of note, the first five items act as a screen, and a score of 0 on these items results in discontinuation of the measure (i.e., a total score of 0). Although there are no cut scores or interpretive ranges, the manual states that "Any positive response to any BSI item may reflect the presence of suicidal intention," (Beck

Table 1
Demographics Based on TBI Status

Demographic	No TBI (n = 417)	One TBI (n = 215)	>One TBI (n = 206)	ES statistic	ES	p
Age at visit: Mean (SD)[++]	37.8 (10.0)	37.1 (10.2)	35.5 (9.5)	Omega^2	.006	.03
Gender: Male	307 (73.6%)	183 (85.1%)	185 (89.8%)	Cramer's V	.18	<.001
Race[*]						
White	170 (40.8%)	117 (54.4%)	136 (32.2%)	Cramer's V	.21	<.01
Black	243 (58.3%)	97 (45.1%)	69 (33.5%)	Cramer's V	.21	<.001
Native American	11 (2.6%)	5 (2.3%)	5 (2.4%)	Cramer's V	.01	.97
Asian	6 (1.4%)	4 (1.9%)	2 (1.0%)	r_equivalent	.01	.80[**]
Islander	2 (.5%)	1 (.5%)	0 (0%)	r_equivalent	<.01	>.99[**]
Hispanic (n = 833)	23 (5.5%)	12 (5.6%)	16 (7.9%)	Cramer's V	.04	.49
Marital status				Cramer's V	.09	.14
Separated	39 (9.4%)	18 (8.4%)	19 (9.2%)			
Never married	105 (25.2%)	38 (17.7%)	43 (20.9%)			
Divorced	70 (16.8%)	41 (19.1%)	29 (14.1%)			
Married	192 (46.0%)	111 (51.6%)	104 (50.5%)			
Remarried	8 (1.9%)	7 (3.3%)	11 (5.3%)			
Widowed	3 (.7%)	0 (0%)	0 (0%)			
Education				r_equivalent	.08	.02[***]
Elementary	1 (.2%)	0 (0%)	0 (0%)			
G.E.D	19 (4.6%)	9 (4.2%)	22 (10.7%)			
High school	128 (30.7%)	81 (37.7%)	79 (38.4%)			
Technical/trade school	43 (10.3%)	18 (8.4%)	18 (22.8%)			
Associates degree	77 (18.5%)	41 (19.1%)	35 (17.0%)			
Bachelor degree	94 (22.5%)	41 (19.1%)	33 (16.0%)			
Master degree	39 (9.4%)	10 (4.7%)	10 (4.9%)			
Doctorate degree	2 (.5%)	3 (1.4%)	3 (1.5%)			
Other	14 (3.4%)	12 (5.6%)	6 (2.9%)			
PSQI score: Mean (SD; n = 836)[+]	8.3 (4.6)	9.7 (5.1)	10.9 (4.5)	Omega^2	.05	<.001
Current depression diagnosis	55 (13.2%)	41 (19.1%)	54 (26.2%)	Cramer's V	.14	<.001
Current PTSD diagnosis	84 (20.1%)	68 (31.6%)	96 (46.6%)	Cramer's V	.24	<.001

Note. ES = effect size; PSQI = Pittsburgh Sleep Quality Index; PTSD = posttraumatic stress disorder; TBI = traumatic brain injury; G.E.D = General Equivalency Diploma. n = 838.
[*] Categories are not mutually exclusive. [**] *Fisher's Exact test*. [***] Monte Carlo Estimate for the Exact Test. [+] All comparisons < .05. [++] No TBI vs > 1 TBI < .05.

& Steer, 1991, p. 8). The test manual (Beck & Steer, 1991) reported internal reliability α = .87 for the BSI in an outpatient sample, and the total score correlated with the Beck Hopelessness Scale (r = .62) and the Beck Depression Inventory (r = .75). For the current study the BSI total score was converted to a dichotomous variable indicating the presence (BSI total >0) or absence (BSI total = 0) of suicidal ideation (SI), a method that has been used in other studies (Lewis et al., 2017). This approach identified a broad group who reported presence of at least minimum SI in the week prior to participating in the study.

The Pittsburgh Sleep Quality Index (PSQI; Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) is a 10-item self-report questionnaire that assesses sleep quality and disturbances over the prior 1-month period. PSQI scoring followed standards available from the measure's web page (http://www.sleep.pitt.edu/). The total score (range 0 to 21) is an indicator of overall sleep quality, with higher scores equating to poorer overall sleep quality, and a score greater than 5 suggesting "poor sleep quality" more generally. Subscales measure sleep duration, sleep disturbances, sleep latency, dysfunction caused by sleepiness, efficiency of sleep, a categorical rating of overall sleep quality, and sleep medication use. Test reliability for the total score was α = .83, and the score showed significant differences across groups of sleep-disorder patients compared with controls and patients with depression (Buysse et al., 1989).

Statistical Analysis

Demographic and clinical variables were compared between groups (no TBI, 1 TBI, and greater than 1 TBI) using t tests, chi-square, and Fisher's exact tests, as appropriate. Hierarchical logistic regression was used to examine if TBI status contributed to the SI model above and beyond known demographic and clinical variables (see Table 2). A three-block analysis was run where the first block included demographic variables (age, education level, gender, race/ethnicity, and marital status; see Huang, Ribeiro, Musacchio, & Franklin, 2017), the second block included clinical variables (diagnosis of current depression, diagnosis of current PTSD, and PSQI total score), and the third block included TBI status. The third block was repeated to account for the different hypotheses that were being explored (i.e., lifetime history of TBI and number of TBIs). Odds ratios, 95% confidence intervals, and p values were also reported for all TBI status variables.

Results

Lifetime History of Any TBI and Recent SI

A total of 421 participants (50.2%) were determined to have lifetime history of at least one TBI. The group endorsing a history

Table 2
Hierarchical Logistic Regression Results

Variables in the model	R_L^2	R_L^2 Incremental	Block likelihood Ratio test	*p*-value
Block 1: Demographics variables*	.03	.03	$x_{10}^2 = 18.9$	.04
Block 2: Clinical variables**	.10	.07	$x_3^2 = 44.2$	<.0001
Block 3: Lifetime history of TBI	.10	.03	$x_1^2 = 1.4$	.23
Block 3: Number of TBIs	.11	.04	$x_2^2 = 5.1$	.08
Block 3: History of deployment TBIs	.10	.03	$x_1^2 = 1.2$	.27
Block 3: Number of deployment TBIs	.11	.03	$x_2^2 = 1.7$	.43
Block 3: Severity of TBIs	.11	.04	$x_3^2 = 4.6$	.21

Note. TBI = traumatic brain injury.
* Age, gender, race, marital status, education level. ** Sleep, depression, and posttraumatic stress disorder.

of TBI was significantly younger, and more likely to be male and Caucasian, than the group without a history of TBI. Additionally, the TBI group reported significantly poorer sleep quality and significantly higher rates of current depression and PTSD. In Table 1, characteristics by group, *p* values for significance testing differences, and effect sizes are presented. Recent SI was reported in 38 (9.1%) of those without a history of TBI and in 63 (15.0%) of those with a history of TBI. In the hierarchal logistic regressions, MDD was significant for all models (all $p < .002$); sleep quality was significant in all models (all $p < .008$); but PTSD was not significant in any model (all $p > .80$). TBI status did not significantly add to the model that accounted for demographic and clinical variables, ($p = .23$). Therefore, the first hypothesis was not supported, as lifetime TBI history was not a significant predictor of recent suicidal ideation after adjusting for demographics, sleep quality, depression, and PTSD.

Relationship of Multiple TBIs and Recent SI

Across the lifetime, 417 (49.8%) participants denied a history of TBI exposure, 215 (25.7%) reported a single TBI, and 206 (24.6%) reported multiple TBIs. Recent SI was endorsed in 38 (9.1%) of those without a history of TBI, 23 (10.7%) of those with a history of one TBI, and 40 (19.4%) of those with a history of multiple TBIs. The hierarchical logistic regression did not show that the number of TBIs contributed to the overall model. A priori comparisons between no TBI, 1 TBI and >1 TBI were performed revealing one significant association (see Table 3). Those with a history of multiple TBIs were 1.77 times more likely to report recent SI than those without a history of TBI (95% CI [1.02, 3.06], $p = .04$). The second hypothesis was partially supported, as a history of multiple TBIs was associated with recent SI compared with no lifetime history of TBI, but there was no association with recent SI when comparing multiple and single TBI history.

Post Hoc Exploratory Analyses

Given these findings and prior literature, we explored two additional factors that may be relevant to the association between TBI and recent SI. First, a lifetime history of TBI includes injuries from early in life that might be less likely to affect SI in adulthood. To evaluate the possibility that context and timing of injury might

Table 3
Odds Ratios, Confidence Intervals, and p-Values for TBI Status From Hierarchical Logistic Regression Models

Model	OR	95% CI	*p*
Lifetime history of TBI			
TBI positive ($n = 420$) vs. TBI negative ($n = 416$)	1.35	[.83, 2.19]	.22
Number of TBIs			
1 TBI ($n = 215$) vs. No TBI ($n = 416$)	1.00	[.56, 1.81]	>.99
>1 TBI ($n = 205$) vs. No TBI ($n = 416$)	1.76	[1.01, 3.06]	.04
>1 TBI ($n = 205$) vs. 1 TBI ($n = 215$)	1.76	[.98, 3.17]	.06
Lifetime History of Deployment TBIs			
Deployment TBI positive ($n = 185$) vs. Deployment TBI negative ($n = 651$)	1.34	[.80, 2.26]	.27
Number of deployment TBIs			
1 deployment TBI ($n = 121$) vs. No deployment TBI ($n = 651$)	1.21	[.66, 2.21]	.54
>1 deployment TBI ($n = 64$) vs. No deployment TBI ($n = 651$)	1.61	[.79, 3.03]	.19
>1 deployment TBI ($n = 64$) vs. 1 deployment TBI ($n = 121$)	1.33	[.60, 2.95]	.48
Severity of TBIs			
1 mild TBI only ($n = 178$) vs. No TBI ($n = 417$)	.95	[.50, 1.81]	.88
>1 mild TBI, no moderates ($n = 163$) vs. No TBI ($n = 417$)	1.67	[.93, 3.02]	.09
At least 1 moderate TBI ($n = 80$) vs. No TBI ($n = 417$)	1.62	[.80, 3.25]	.18
>1 mild TBI, no moderates ($n = 163$) vs. 1 mild TBI only ($n = 178$)	1.76	[.89, 3.46]	.10
At least 1 moderate TBI ($n = 80$) vs. 1 mild TBI only ($n = 178$)	1.70	[.78, 3.72]	.18
At least 1 moderate TBI ($n = 80$) vs. > 1 mild TBI, no moderates ($n = 163$)	.97	[.47, 1.99]	.93

Note. Adjusting for age, gender, race, marital status, education level, sleep, depression, and posttraumatic stress disorder. TBI = traumatic brain injury; Moderate TBI/moderates = moderate and severe TBI.

affect how an injury relates to recent SI, both models were run a second time using only TBIs that occurred during deployment (regardless of injuries at other times during the life). Of the 652 who denied deployment TBI, 65 (10.0%) reported recent SI; of the 121 who reported one deployment TBI, 20 (16.5%) reported recent SI; and of the 65 who reported multiple deployment TBIs, 16 (24.6%) reported recent SI. The hierarchal logistic regression showed that history of deployment TBI did not contribute (see Table 2) above and beyond the demographic and clinical variables ($p = .27$). Similarly, the number of deployment TBIs did not contribute to the model ($p = .43$) and individual comparisons were nonsignificant ($p > .05$).

Second, due to different prognosis expectations following mild compared with moderate-to-severe TBI, severity of TBI injury may also be a salient factor to explore when evaluating relationships between TBI and SI. TBI severity was classified based on the number/severity of TBIs (no TBI, one mild TBI only, more than one mild TBI with no moderate/severe TBIs, and at least one moderate TBI). This TBI severity variable was then added to the hierarchical logistic regression to determine if that was additive to the model. The TBI severity variable was determined not to be additive to the model ($p = .21$; see Table 2).

Discussion

The current study examined the relationship between recent SI and TBI history in OEF/OIF/OND veterans. Although prior research has found a significant relationship between lifetime TBI and SI across a variety of TBI populations (Bahraini et al., 2013; Fazel et al., 2014; Gradus et al., 2015; Richard et al., 2015), current results did not support an association between one TBI and recent SI after accounting for additional relevant factors demographic and clinical variables. Veterans endorsing multiple lifetime TBIs, however, had significantly higher odds of reporting recent SI compared with those who denied a history of any TBI (OR = 1.77). Consistent with Bryan and Clemans (2013), cumulative injuries seemed to amplify risk. Increasing biological disruption of neural networks with more stressors may be one explanation as to why multiple TBIs may increase risk for SI. Alternatively, those most likely to sustain multiple injuries may also be more likely to experience significant emotional distress (e.g., via preexisting psychiatric concerns or longer exposure to stressful environments and situations). Thus, the co-occurrence of multiple TBIs and associated sequelae in conjunction with other psychosocial stressors may contribute to an ongoing accumulation of adversity that overtime can lead to worse psychosocial outcomes, including SI. In short, cumulative disadvantage theory suggests that both short- and long-term challenges are “inextricably tied to . . . the unfolding of biological, psychological, and social processes through time” (Sampson & Laub, 1997, p. 134); thereby suggesting, that events over one’s lifetime may alter their life course in an enduring manner and increase risk for negative health-related outcomes including suicide. For further discussion, regarding cumulative disadvantage theory and TBI see Brenner, Vanderploeg, and Terrio (2009).

In this sample, sleep quality and a *DSM* diagnosis of current MDD predicted recent SI in veterans with lifetime history of any TBI, as well as veterans with a history of multiple TBI. One possible explanation for our findings is that TBI resulted in MDD and/or poorer sleep, which in turn was significantly related to increased recent SI (i.e., a mediational effect). A sizable portion of our sample (17.9%) met criteria for current MDD, which is line with a larger study of depression prevalence in a sample of 289,000 veterans (Seal et al., 2009). These results are consistent with mounting evidence confirming sleep problems and MDD as independent risk factors for suicidal ideation and behaviors (Pigeon, Pinquart, & Conner, 2012). The relation among TBI, psychiatric diagnoses, and sleep disturbances is especially critical in veterans given that a recent large database study found that veterans with psychiatric diagnoses and/or a history of TBI reported significantly more nights of inadequate sleep compared with nonveterans or veterans without psychiatric diagnoses/TBI, after adjusting for demographics and health variables (London, Burgard, & Wilmoth, 2014). Although depression did not moderate the relationship between sleep problems and SI in one meta-analysis (Pigeon et al., 2012), sleep problems have been found to mediate the relation between rumination and depression/PTSD symptoms (Borders, Rothman, & McAndrew, 2015), an important finding as rumination has been found to be related to SI (Miranda & Nolen-Hoeksema, 2007; Miranda, Tsypes, Gallagher, & Rajappa, 2013). Thus, in veterans reporting recent SI and a positive TBI history, our findings support previous literature that, regardless of the mechanisms underlying the symptoms (i.e., organic or comorbid to TBI), sleep disturbance and depression might be the most salient consideration for treatment planning and suicide prevention.

Post hoc analyses were used to explore whether TBI sustained during the stressful context of combat deployment might better predict recent SI, as the lifetime TBI history variable included mild and remote injuries that might be of little relevance to current functioning. Evaluating TBI sustained over the course of a life span might inherently add noise to the analyses. For example, mild injuries sustained as a child are collapsed with injuries sustained in the context of combat and potentially traumatic events. However, when only TBIs sustained in the deployment context were examined, neither single nor multiple TBI history were related to recent SI. A similar outcome was found in another study of Iraq and Afghanistan veterans (Wisco et al., 2014b). This suggests that the deployment/nondeployment distinction may not be important when considering the effect of TBI history on recent SI and that when providing services, understanding the occurrence of TBI across the life span may be most helpful. This assertion is also consistent with cumulative disadvantage theory (discussed above). Results from these analyses must be replicated, especially due to the small sample size for some subgroups (e.g., the multiple-deployment-TBI group with SI). In addition, current diagnosis of PTSD was also not significant in any of the models, contrasting with prior research (Vanderploeg et al., 2015; Wisco et al., 2014a).

Another factor to consider when evaluating TBI and SI is the influence of TBI severity. Several studies have found that increasing severity of brain injury, such as those involving a fracture or hemorrhage, is associated with an increase in suicide risk as well as psychiatric comorbidities (Brenner et al., 2011; Mainio et al., 2007). As with civilian populations, most military TBIs are mild in severity, and 82.3% of the reported veteran TBIs since 2000 were classified as mild (DVBIC, 2016). Post hoc analyses from the present study found no relationship between SI and injury severity. Null findings may be related to the smaller numbers who sustained more severe injuries in this sample, though additional research is needed on the relations among SI and TBI severity.

Results of the current study must be considered in the context of the larger TBI and suicide literature. In the current volunteer veteran sample, recent SI was assessed using a liberal cut score on a self-report measure of SI over the prior week and structured interviews were utilized to assess for remote history of TBI, PTSD, and current depression. In contrast, the Bryan and Clemans (2013) study was comprised of an active duty in-theater sample and used self-report measures (e.g., a mean score across 5 items from the Behavioral Health Questionnaire-20) to identify symptoms and clinician diagnoses to identify TBI. Another study using a VA registry sample of Iraq and Afghanistan veterans (oversampled for females), assessed suicide risk using any positive response to four items on the MINI 5.0 with structured interviews for symptom and TBI identification. In this study, Wisco and colleagues, who utilized similar assessment approaches to the current study, also found a significant relationship between SI and multiple but not single TBI (Wisco et al., 2014b) and did not find deployment TBI specifically related to SI. A separate study evaluated veterans and reservists/guardsmen via mailed surveys and found that those identified as having multiple TBIs were significantly more likely to report SI compared with those reporting a history of a single TBI during military service; however, SI was assessed using a single item (#9) on the Patient Health Questionnaire (Lindquist, Love, & Elbogen, 2017). Collectively, the research seems to support multiple TBI more generally as a significant risk factor for SI; however, deployment-specific and history of single TBI results are more equivocal, with the variability in SI, TBI, time factors, and difficulty associated with attributing sequelae to injuries adding considerable challenges to the interpretation of findings across studies.

There are several limitations to this study. First, TBI history was based on self-report via structured interview and injuries were not corroborated by other sources. Thus, TBI history was susceptible to reporting and recall biases. However, in the absence of medical data at the time of injury, the structured interview approach used in this study is arguably more reliable than other methods of injury identification, such as self-report screeners or questionnaires. Similarly, there were no symptom validity measures included in the PDMH; thus, inaccurate self-report could not be modeled into these analyses. A number of other factors that have been related to SI were not included in the models, for example substance misuse, and consequently, more complex relationships might be overlooked. Time factors may also be confounding the results, as MDD, PTSD, and sleep quality were rated regarding current symptoms, SI rated across the prior week, and TBI events occurred across the life span. Operationalizing recent SI as a score of 1 or more on the BSI led to a broad and liberal definition of recent SI, and other methods of identifying SI may lead to different results. Additionally, there has been a consistent relationship between SI and various demographic characteristics; although demographics were accounted for in the models, they were not specifically explored as part of this study's hypotheses. Strengths of the current study include modeling sleep, use of structured interviews, and focus on SI instead of suicide deaths or behaviors. Future studies might further this line of research using more complex models with additional variables, and by incorporating longitudinal designs that evaluate SI at numerous time points.

Within the context of the broader literature, results suggest that a history of multiple TBIs may pose increased risk for presence of recent SI in veterans who have served in the OEF/OIF/OND eras. However, this relationship was only significant when considering TBI history across the life span, and was not significant when considering TBI sustained during deployment or more severe TBI injuries. Although further replication is necessary, results suggest an increased need for SI screening for veterans who report a history of multiple TBIs; for veterans with a history of any TBI, screening for depression and sleep difficulties is warranted. Our results suggest that assessment of TBI should not focus solely on deployment-specific events and that an over emphasis of deployment inquiry may not provide adequate data to inform suicide risk assessments. Furthermore, findings support the importance of understanding how the accumulation of injury and sequelae, as well as stress affect the individual over time. Efficient and effective management of suicide risk will also necessitate going beyond the endorsement of multiple TBIs to an understanding of how multiple TBIs affect specific drivers of suicide risk. Given the strong and consistent relation of depression and sleep problems to the presence of SI, results also suggest that depression and sleep maybe especially powerful intervention targets for OEF/OIF/OND veterans who have experienced with a history of TBIs. Future studies might further investigate temporal relationships of TBI and depression, possible moderator effects of sleep and depression between TBI history and SI, and how treatment of depression and sleep affect SI in those with a history of TBI. In addition, data only allowed for evaluation of recent SI; strategies to measure ideation over longer periods (e.g., month, multiple time points) are also indicated.

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