CLOSE BLAST EXPOSURE AND POSTTRAUMATIC STRESS DISORDER

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Table 1

Sociodemographic Characteristics of Participants

Characteristic	*n*	%	*M*	*SD*
Gender				
Male	71	87.7		
Female	6	7.4		
Gender Queer	1	1.2		
Open Option	3	3.7		
Nationality				
USA	64	79		
Other	17	20.9		
Age			41.3	14.2
21-30	22	27.2		
31-40	25	30.9		
41-50	9	11.1		
51-60	15	18.5		
61 +	10	12.3		
Education Level				
High School/GED	14	17.3		
Associates or Tech	15	18.5		
Bachelor’s	23	28.4		
Master’s	23	28.4		
Doctorate	6	7.4		
Marital Status				
Single	22	27.2		
Married	48	59.3		

Divorced	5	6.2
Cohabitating	4	4.9
Other	1	1.2
Ethnicity		
Black/African Am.	3	3.7
White/Caucasian	72	88.9
Asian/Asian-Am.	2	2.5
Hispanic/Latinx	6	7.4
Native Am.	1	1.2
Other	4	4.9
Current Military		
Yes	23	28.4
No	58	71.6
Military Branch		
Army	56	69.1
Air Force	8	9.9
Navy	14	7.3
Marine Corps	9	11.1
Coast Guard	3	3.7
Military Status		
Active	20	24.7
Reserve	3	3.7
Nat’l Guard	2	2.5
Retired	24	29.6
Veteran	32	39.5
Highest Rank		
Officer	28	34.6
Warrant Officer	8	9.9

Enlisted	45	55.6

Note. $N = 81$.

Table 2

Descriptive Statistics for Control Variables

Control Variables	Mean	Standard Deviation	Correlations			
			1	2	3	4
1. PTSD	2.33	1.1 5				
2. CBE	0.37	0.24	0.32**			
3. Combat Exposure	2.14	1.09	0.30**	0.31**		
4. Substance Use	0.13	0.23	0.25*	0.16	0.14	
5. TBI	0.25	0.38	0.50**	0.43**	0.56**	0.17

*Note: *= $p < .05$, **= $p < .001$*

Table 3

Descriptive Statistics for Target Variables

Target Variables	Mean	Standard Deviation	Correlations		
			1	2	3
1. PTSD	2.33	1.15			
2. CBE	0.28	0.22	0.30**		
3. Distance	0.99	1.20	0.18	0.30**	
4. Multiple Exposure	1.54	1.70	0.26*	0.69**	0.51**

*Note: *= $p < .05$, **= $p < .001$*

Table 4

Regression Analysis Predicting PTSD from CBE, Distance, and Multiple Blast Exposure

						95% CI for *B*		Effect Size
	B	*SE*	β	*t*	*p*	Lower	Upper	r_{sp}
Step 1								
Trauma History	0.56	0.52	0.12	1.08	0.28	-0.48	1.60	0.11
Combat Exposure	0.01	0.12	0.01	0.10	0.92	-0.23	0.26	0.01
Substance Use	0.71	0.46	0.15	1.55	0.13	-0.20	1.61	0.15
TBI	1.27	0.38	0.42	3.36	0.00	0.52	2.03	0.33
Step 2								
Trauma History	0.60	0.52	0.12	1.14	0.26	-0.44	1.64	0.11
Combat Exposure	0.09	0.15	0.09	0.63	0.53	-0.20	0.39	0.06
Substance Use	0.73	0.46	0.16	1.60	0.12	-0.18	1.64	0.16
TBI	1.46	0.42	0.48	3.50	0.00	0.62	2.30	0.34
CBE	-0.83	0.84	-0.16	-0.99	0.33	-2.51	0.85	-0.10
Step 3								
Trauma History	0.59	0.54	0.12	1.10	0.28	-0.49	1.67	0.11
Combat Exposure	0.11	0.18	0.10	0.61	0.54	-0.25	0.46	0.06
Substance Use	0.73	0.47	0.16	1.55	0.13	-0.21	1.67	0.15
TBI	1.46	0.43	0.48	3.41	0.00	0.61	2.31	0.34
CBE	-0.80	0.90	-0.15	-0.90	0.38	-2.57	0.98	-0.09
Distance	0.00	0.11	0.00	0.02	0.98	-0.22	0.23	0.00
Multiple	-0.02	0.12	-0.03	-0.16	0.87	-0.26	0.22	-0.16

Notes: CI = confidence interval. Effect size $_{sp}$ is the semi-partial Pearson correlation.

ABSTRACT

The conflicts in Iraq and Afghanistan have continued to provide unique challenges for military personnel and researchers alike. Of note is the increase in literature linking posttraumatic stress disorder with the exposure of service personnel to improvised explosive devices or road-side bombs. This study utilized a sample of 81 combat veterans ($N = 81$) to evaluate the connections between close blast exposure from roadside bombs, distance from said device, and multiple exposure on post-traumatic stress disorder, while controlling for various other variables. This analysis was undertaken using a hierarchical linear regression. The results indicated that traumatic brain injury was the single most significant predictor of post-traumatic stress disorder, above and beyond all other factors. Additionally, it was found that close blast exposure, multiple blast exposure, and distance from the blast were all significantly correlated with traumatic brain injury and post-traumatic stress disorder, but not significantly after controlling for traumatic brain injury.

INTRODUCTION

The current military conflicts in the Middle East, in which the US has been embroiled for over a decade, have brought forth unique challenges to the veterans, mental health providers, and researchers. The wars in Afghanistan and Iraq have engendered a new and terrifying method of combat with the introduction of the improvised explosive device (IED); which marks a departure from the antiquated set-piece engagements of the past and ushers in an asymmetrical, or guerrilla type, of combat punctuated by indiscriminate maiming and killing (United Nations Office for Disarmament Affairs[UNODA], n.d.). IED strikes are estimated to be responsible for approximately 60% of the total injuries incurred at all levels within the US order of battle (Ling et al., 2009).

By and large, IED is a blanket term that encompasses a bewildering array of devices that vary in both composition and destructive power. These devices can range from home-made explosives, such as ammonium nitrate and fuel oil, to the more conventional such as artillery shells or landmines (UNODA, n.d.). The common thread in all of these devices is that they produce injuries in a variety of ways, all stemming from the instantaneous, or near-instantaneous release and propagation of energy, heat, light, acoustic, and electromagnetic forces (Ling et al., 2009). The force and damage wreaked by these devices also can range from minor damage to a vehicle to total destruction of even the most robust of equipment and the killing of all occupants. Perhaps most poignant is the fact IEDs have affected all echelons of service members regardless of occupation or rank due to the highly mechanized structure of the military, the indiscriminate properties of the devices, and unscrupulous natures of the individuals planting the devices (UNODA, n.d.).

Traumatic Brain Injury

The actual mechanism of injury resulting from IEDs is not well understood but is thought to be the product of pressure waves as the air is compressed in front of the explosion in geometric progression (Bowen, Fletcher, & Richmond, 1968). Along these lines, the most well-documented and exhaustively researched phenomenon has been the mild traumatic brain injury (mTBI). The propagation of pressure-related forces can impact and damage soft brain tissue and cause rotational and acceleration-related damage as well, thereby resulting in both short-term and long-term changes in brain structure and functionality (Tschiffely, Ahlers, & Norris, 2015). The mTBI itself is often defined and diagnosed via the primary use of the Glasgow Coma Scale which documents any loss of consciousness, alteration of mental status or awareness, and additional abrupt onset of neurological symptoms (Nelson et al., 2019). Tschiffely and colleagues (2015) also noted that some of the more persistent mTBI symptoms can include insomnia, fatigue, irritability, memory deficits, concentration problems, and more. In current research, IED blast exposure has been linked to approximately 86% of mTBI in the veteran population (Kamnash et al., 2012). On the whole, however, most of the more acute mTBI effects remediate very quickly or are significantly attenuated within days (Verfaellie et al., 2014).

The American Psychiatric Association (APA) (2013) has taken a slightly different direction in the definition of such neurological injuries. It is now defined as a Mild Neurocognitive Disorder due to a Traumatic Brain Injury. It is defined by the APA (2013) using two distinct criteria which break down the disorder into the cause or mechanism of injury, in this case “impact to the head or other mechanism of rapid movement or displacement of the brain within the skull” (p. 624), and the resulting cognitive deficits commonly associated with similar

types of disorders such as memory impairments (APA, 2013). This broader and more encompassing definition allows for greater flexibility in the diagnosis of the disorder and also provides for greater inclusion of the veteran population. For instance, the APA (2013) includes in the criteria such manifestations to consciousness as disorientation or confusion following the traumatic event, whereas older models relied more heavily on actual loss of consciousness, thus reflecting the evolution in conceptualization of the injury as a direct result of ever-increasing literature. Despite the transition in nomenclature, the disorder will still be referred to as m/TBI in this work for the purposes of brevity and consistency with other sources.

Much attention has recently been focused on the actual physics initiating the injuries resulting in mTBI and close blast exposure (CBE) caused by IEDs. Bowen and his colleagues (1968) found in their seminal work during the Vietnam era that explosions and their projected damage to the human body could be identified and predicted mathematically. Using animal test subjects, they were able to conceptualize the amount of internal and external trauma caused by blast waves at certain distances. As with most exposures, the duration of the exposure and the force generated by the wave, as measured with either pounds per square inch (psi) or kilopascals (kPa) can be charted along a curve that accounts for time, distance, and force as well as denoting where specific types of injuries and/or death will likely occur (Bowen et al., 1968). Creatively enough, this is known as Bowen's Curve and it remains in common usage to this day.

Bowen's research has been expanded upon in recent years primarily due to the experience of the military with IEDs and the high variability or individuation noted in symptoms and outcomes. One study in particular truly highlighted the differences and similarities in IED exposures. Lu and colleagues (2014) exposed groups of monkeys to blasts of either 80 kPa, which equates to approximately 24 meters from an IED, and 200 kPa which is roughly

corresponding to about 19 meters distance, and then monitored for behavioural changes and conducted necropsies for additional findings. It was discovered that distinct and possibly persistent neurological changes were evident within various brain structures signifying damage and some likely associated behavioural ramifications based on "distance" or pressure (Lu et al., 2014). It should be noted that this "distance" was estimated, and the numbers may change significantly based on composition of the IED and protective barriers or additional ancillary factors which can alter the kPa or psi to which the victim is exposed resulting in differential effects across the spectrum of exposures.

Other studies have suggested cognitive changes and damage that may occur from lower level, or sub-concussive events, that fail to produce the common mTBI symptoms. This evolution in the research also strongly suggests the possibility of a cumulative effect from the repeated exposure to low-level blasts. Carr and associates (2016) studied a group of Marines who were consistently exposed to low yield detonations in the < 1 psi to 13 psi range and found evidence for "blast induced impairments in selected domains of cognition," strongly indicative of a cumulative effect (pg. 38). Support for this theory among animal models has met with mixed results, although nearly all studies have identified marked changes in brain structures, principally those related to memory and processing such as the hippocampus (Kamnash et al., 2012).

Post-Traumatic Stress Disorder

Posttraumatic stress disorder (PTSD) has also been an ongoing problem in the veteran population as a result of the recent conflicts. According to a review of literature by Tschiffely and associates (2015), PTSD is evident in anywhere between 2.2-43.9% of combat veterans. This high degree of variability reflects not only the differences in combat exposure but also the

subjective experiences of veterans and the assessment guidelines utilized by individual practitioners. PTSD is primarily marked by symptoms of dissociation, avoidance, anxiety, and negative cognitive alterations following exposure to a traumatic event (Tschiffely et al., 2015).

The APA (2013) provides a similar definition of PTSD, requiring the exposure to a traumatic event, defined generally as an event whereby the individual is subjected to the real or threatened possibility of death, serious bodily harm, or sexual violence. From there, the presentation of PTSD is grouped into a number of distinct yet potentially overlapping categories encompassing dissociation, anxiety, avoidance, intrusive thoughts/memories, and several others (APA, 2013). Given the complex and seemingly limitless combination of presentations in persons exposed to trauma, the actual strain of PTSD exhibited is subject to high degree of individuation. Furthermore, the clusters of symptoms, when viewed narrowly and individually, can share a high degree of overlap with other mental disorders and can reach a problematic level on their own making the diagnostic process difficult. Prevalence estimates in the general population hover around 3.5% in a given year (APA, 2013).

Among the ever-growing abundance of literature on the subject, the prevalence of, or association of PTSD to various combat tactics has increasingly come into focus. Contemporary evidence is demonstrating that exposure to IEDs represents a new type of combat as it pertains to PTSD presentation. Thanks to the application of factor analysis, empirical evidence is developing which is unequivocally demonstrating that IED exposure is uniquely associated with potentially different underlying mechanisms than is traditional combat. For instance, Osorio and colleagues (2018) noted that IED exposure loads onto a different statistical factor than conventional combat suggesting both a divergent apparatus of action and psychological presentation based on the combination of PTSD symptoms and combat exposure. This

association was borne out statistically as Osorio and collaborators (2018) were able to identify a third factor as "encountering explosive devices," in opposition to factor one which was "violent combat" or traditional combat. Other studies have mirrored this finding, lending additional weight to the theory of IED ambushes representing an entirely unique battlefield experience.

The reasons for this factor loading differential may have their roots in the actual presentation of PTSD in the individuals. To support this assertion, Rosenblatt and associates (2018) found in their analysis that the EN model, which is a four-factor representation of PTSD symptom groupings for combat exposed veterans, and specifically CBE exposed veterans, demonstrated that CBE veterans tended to express more reexperiencing, avoidance/emotional numbing, and hyperarousal symptoms than did other types of PTSD sufferers. Other studies have noted an increase in anxiety and irritability symptoms among individuals repeatedly exposed to low level blasts (Carr et al., 2016). Despite some limited amount of disagreement between studies, it is abundantly clear that PTSD symptomology of a certain type is more common among IED or CBE exposed veterans than in the general PTSD population.

Unfortunately, the interaction between PTSD and IED strikes is not one that has been widely studied. However, some researchers have hypothesized that the nature of the IED strike/ambush is closely tied with subjective feelings of helplessness and/or the fear of being killed at any time; both of which have been linked to substantial PTSD presentation (Osorio et al., 2018). Other studies have shown more definitively that the fear of being killed at any moment was a stronger predictor of PTSD than any other facet of combat, even overshadowing the actual act of killing or witnessing killing of combatants or civilians (Porter et al., 2018). Thus, the field of IED induced PTSD offers a new and unique vein of research to the psychological community.

While the connection between IED exposure and subjective feelings of danger seems evident, it is entirely theoretical at this point. Osorio and associates (2018) discovered that IED ambushes and the subjective experience of soldiers as it pertains to feelings of being threatened actually loaded strongly onto different and distinct factors. Correspondingly, at least one study has theorized that going out on patrols, where IEDs are likely to exist, is possibly a better predictor, and therefore more strongly associated with the development of PTSD than the occasional rocket/mortar strike on a larger installation (Porter et al., 2018). This divergence is likely due to the different personal experiences of the soldiers involved, among other factors. Factor analysis by Porter and colleagues (2018), however noted that noted that IED exposure loaded substantially stronger onto the "direct combat factor" than did the subjective feeling of being in danger, again showing the intricate link between the two. Similarly, Booth-Kewley and colleagues (2010) found that the subjective feelings of being in danger and experiencing IED strikes were stronger predictors of PTSD than almost any other aspect of combat. What is starkly evident from this literature is that the threat of, and the act of attack via IEDs has a substantial psychological effect on servicemen often out of all proportion to the actual damage inflicted.

The cognitive effects of PTSD on the functionality of veterans are, likewise, poorly understood, albeit well researched. This is especially true when CBE or mTBI is added to the equation. Kalkstein and colleagues (2017) discovered no difference between CBE exposed veterans and those diagnosed with mTBI as expressed by scores on PTSD assessment but did note a significant difference in neurological functioning on a battery of tests. While this study limited its comparison to the mTBI versus no-mTBI groups for the purposes of neurological outputs, the lack of observed differences in PTSD presentation is telling because it indicates that the diagnosis of mTBI is possibly inconsequential to that end (Kalkstein et al., 2017). Meaning,

the very act of being exposed to CBE or IED attacks may be as significant to the genesis of PTSD in veterans as the supposed physical injury to the brain.

The aforementioned results provide an interesting basis for the relationship between PTSD and CBE. To further that assumption and add a different dynamic, Nelson and comrades (2019) demonstrated in their revolutionary study that mTBI and CBE did not affect cognitive performance significantly without the addition of PTSD. They found that it was truly the PTSD that was impacting the neurological functioning. Thus, they noted that the addition of PTSD strongly mediated the link between mTBI and impaired cognitive functioning (Nelson et al., 2019). One possible confound in this, which actually furthers the connection between CBE and PTSD, was the manner in which mTBI was operationalized in this study. Based on new data such as what has been presented in the above paragraphs, the likelihood of suffering mTBI was supposed in many cases where the veteran reported "feeling a blast wave," thus emphasizing the probable effect of CBE (Nelson et al., 2019). It is unclear whether feeling a blast wave would put the veteran in close enough proximity to an IED to justify such an action, but the data is beginning to mount to support such a conclusion.

An additional factor that substantially impacts PTSD symptomology and subsequent presentation involves the interaction with substance use. The comorbidity of the two disorders is often understanded in many investigations, but decades of research including epidemiological studies and meta-analyses continually note the seemingly intrinsic connection (Hein et al., 2010). This is often attributed to a self-medication model, but this explanation remains somewhat controversial. What is less controversial is the solid empirical findings of such researchers as Hein and colleagues (2010) who have consistently noted the intercorrelation between substance

use and PTSD. Certainly, the connection of these two conditions is notable and each can have an exacerbating, or additive effect on the other (Hein et al., 2010).

The importance of this research cannot be understated. While advancements in vehicles, tactics, trauma care, and body armour have increased survivability on the battlefield for soldiers, the overall effect is that more CBE will be experienced. Therefore, it is vital to understand the connection between CBE, PTSD, and ensuing neurological and psychological dysfunction as a consequence of IED exposure. The ability to predict, determine, and intervene at critical points will influence the outcome for countless veterans and may have broader applications in the civilian world. This can, however, only be accomplished by the direct research and application of previous findings specifically related to the connection between CBE and PTSD, hence the dire need for this precise study.

THE CURRENT STUDY

Based on the aforementioned findings, the current investigation had several aims. Given the dearth of evidence explicitly investigating the interaction between PTSD and CBE, a novel approach was undertaken to examine the relationship. Specifically, the bulk of literature has outlined that: 1) damage does often occur to the brain following CBE; 2) the amount of damage and subsequent functional impairment is likely directly related to distance from the blast; 3) PTSD formation is likely, but not certainly, significantly intertwined with CBE; 4) PTSD affects functional performance; 5) PTSD severity is likely significantly dependent upon both distance from blast and number of exposures; these conventions formed the basis of the study and the study attempted to further evidence thereof. Therefore, this study undertook measures to investigate different hypotheses related to these factors.

While there is a growing abundance of literature suggesting that mTBI and CBE have neurocognitive effects, this study will be evaluating CBE's unique impact on PTSD. The connection between CBE and PTSD is often presumed due to the stressful nature of the event itself (Nelson et al, 2019). However, evaluating the connection utilizing hierarchical linear regression allows for statistical control of various factors which may impact the presentation of PTSD, such as witnessing a death or dismemberment and the subjective feeling of being killed at any moment. This investigation utilized divergent methods in order to establish the unique predictive power of CBE on PTSD. This included taking into account factors such as distance from the blast, which the literature has shown affects mTBI and should, by extension, affect PTSD severity and symptom presentation, and also other varieties of combat exposure.

This study also utilized conventional methods to measure ubiquitous combat exposures but analysed them in a unique way in order to expose and describe the effect of CBE on PTSD. The identification and description of this theorized connection assists to fill an important gap in the literature and may add to the growing abundance of evidence in favour of such a connection. The effect of this research is, however, person oriented at its core. As ever-growing numbers of service members are exposed to CBE the investigation between this event and possible delayed repercussions is paramount. From benefits for exposed soldiers, to accommodations in life and education, to merely understanding the underlying cause of pathology, this vein of research is absolutely crucial to health and well-being of service members, and thus, the nation at large. The following hypotheses were investigated in this work:

Hypothesis 1. CBE will predict PTSD, controlling for other types of combat exposure, non-military trauma, the fear of being killed at any time, and mTBI.

Hypothesis 2. Distance from the IED/device will predict PTSD severity, as determined through a well-validated assessment instrument while controlling for such variables as dismemberment, TBI, historical non-military trauma, and conventional combat exposure among others. This will be evident above and beyond standard CBE exposure.

Hypothesis 3. Multiple CBE will have a cumulative effect, as displayed through PTSD symptom severity whereby more numerous exposures will equate to higher PTSD scores above and beyond standard CBE.

METHODS

Participants. Respondents in this study were gathered through online recruiting measures. Participants were recruited from various online forums and asked to participate in the study, with the software Qualtrics being used administer and aggregate data. These procedures were reviewed by the Western Carolina University Institutional Review Board (IRB) to ensure compliance with ethical and procedural standards. This project was determined to be IRB exempt by the board.

Participant demographics can be found on Table 1. According to the data gathered, and when compared to contemporary military demographics, males and the White or Caucasian ethnicity individuals were overrepresented in this study (Department of Defense [DOD], 2016). Self-identified males accounted for 87.7% of the sample, with self-identified females at 7.4%, gender queer at 1.2% and other options accounting for 3.7%. The male to female ratio in the military is roughly 80/20 according to US government data (DOD, 2016). The mean age of participants was 41.3 years old, with a standard deviation of 14.2 years. It should be noted that a significant minority of study participants were of extra-US origin. Approximately 20.9% of those surveyed were outside of the US, primarily located in the UK and the low countries of Western Europe. Given the multinational nature of the coalitions that have served in the most recent conflicts, this variability adds to the generalizability of results.

Racial and ethnic representation was broken down as such: White/Caucasian 88.9%, Hispanic/Latinx at 7.4%, Black/African American 3.7%, Asian/Asian-American 2.5%, Native American 1.2%, and other accounting for 4.9% of participants. Again, according to government statistics, this shows that Black/African American, Asian/Asian-American, and Hispanic/Latinx

are variably underrepresented in this pool (DOD, 2016). Roughly 28.4% of the sample indicated that they were currently in the military, with the lion's share of 71.6% indicating that they had been separated from service. Of these, most, or about 55.6% indicated they were enlisted, 34.6% identified themselves as officers, and the remaining 9.9% were members of the warrant officer corps. Additionally, some 69.1% of participants were in the Army, 11.1% Marine Corps, 9.9% in the Air Force, 7.3% in the Navy, and 3.7% in the Coast Guard.

Education level varied somewhat, with an equal number, 28.4% indicating they had a Bachelor's degree or a Master's degree. Some 18.5% indicated they had an Associate's degree or a trade school degree, 17.3% with a High School diploma or GED, and 7.4% with a Doctorate or other professional degree of a similar stature. Most of the pool identified as married, 59.3%, with 27.2% being single, 6.2% divorced, 4.9% in a cohabitating relationship, and 1.2% identified as other.

Materials

Demographics. Basic information from participants was collected for later analysis. Such demographic information that was collected involved age, gender, race, military branch, and rank. The demographic questions were contained in a separate battery of questions that appeared before the collection of target variables, see Appendix E. Open options, or free text blocks, were avoided to the extent possible in order to prevent the contamination of data or the input of obviously false answers. Where possible, participants were limited to several options from which to choose and overlapping answers were avoided as well.

Non-Military Trauma. Traumatic experiences suffered outside of military service will be assessed using a 14-item trauma pre-screen tool developed by Carlson and colleagues (2011) and modified for this study, which is located in Appendix A. This measure asks the participant to select whether or not a traumatic or extremely stressful event has happened to them in their lifetime. The responses to the questions are dichotomous in nature with 0 (*No*) and 1 (*Yes*). A sample item reads, "[have you ever had this happen] Forced or made to have sexual contact-as a child." This measure also includes a question related to combat and other questions that could conceivably be experienced in combat environments. These questions were removed or re-worded to specifically indicate trauma occurring outside of military service due to the redundant nature of these questions in regard to the nature of this study. Reliability of this measure on the veteran population has been found to have a mean kappa of .68, and test-retest reliability correlations in the range of .73 to .95 (Carlson et al., 2011). Convergent validity of this measure to other similar assessments is also quite high in the range of .73 to .81 depending upon the constructs measured and alternate measures studied (Carlson et al., 2011). This measure was converted into an aggregate for use in the regression.

Post-Traumatic Stress Disorder. This study requires the use of reliable and evidence-based inventories or assessments to identify, confirm, and characterize both PTSD and CBE. To this end, the posttraumatic stress disorder checklist (PCL-5) will be utilized to gauge PTSD presence and symptom severity, this measure can be found in Appendix D. The PCL has been the gold standard in the diagnosis of PTSD for a number of years. The inventory utilizes a 17-item Likert-type scale asking respondents to rate their symptoms from 1 (*Not at all*) to 5 (*Extremely*). A sample items reads, "In the past month how much were you bothered by:

Repeated, disturbing, and unwanted memories of the past experience." The PCL has an alpha of .95 has similarly good validity results (Booth-Kewley et al., 2010). The scores can easily be aggregated in statistical software providing accurate and efficient information processing. For this investigation, this measure will be converted into an aggregate for use in the analysis. In this investigation, the PCL rendered a Cronbach's alpha of .97, verging on .98.

Combat Exposure. Combat exposure will be measured using a hybrid measure designed for this study. The base model for the inventory is the Combat Exposure Scale (CES) adapted from the Army Mental Health Assessment, see Appendix B. This measure also uses a Likert-type scale from 1 (*Never*) to 5 (*26+ times*), although given the variation within the questions the actual representation of 1-5 can differ somewhat. The CES boasts an overall alpha of .92 (Booth-Kewley et al., 2010). Most of the question simply ask the respondent to rate whether or not they have experienced various combat stressors or experiences and how often, higher scores equal higher amounts of combat exposure. An example item reads, "Were you ever under enemy fire?" An additional item was taken from Porter and associates (2018) combat experience measure for addressing the subjective feeling of being killed at any time. This item reads, "Feeling that you were in great danger of being killed." This item, similarly, asks the respondent to rate number of times this was experienced. This item performed well and the overall Cronbach's alpha for the CES with this addition was .93. On this measure, an aggregate will be calculated and utilized in the regression analysis. In this analysis, the CES had a Cronbach's alpha of .94, roughly consistent with other prior findings.

Close Blast Exposure. The CES will be supplemented by several questions taken from the Army Post-Deployment Health Assessment (DD form 2796) which specifically addresses questions related to CBE, distance from IEDs in meters and also any adverse effects to consciousness (Executive Services Directorate, 2015). This form can be found in Appendix C. This bank of questions consists of 6 items that as the respondent to select whether an CBE related event has happened to them during their deployments. An example CBE question reads "During your deployment, did the following event happen to you: IED." Answer choices for these items are 0 *(No)* and 1 *(Yes)*. These questions cover nearly all eventualities associated with CBE exposure and allows for various experiences to be included in the greater CBE fold. Other examples of items covered include exposure to landmines, grenades, and other pyrotechnic devices likely to result in CBE. These 6 items demonstrated a Cronbach's alpha of .96.

Additional items measured multiple CBE exposure and also the distance from the exposure. The distance question was presented in Likert-type scale with options ranging from 1 *(< 25 meters)* to 4 *(> 100 meters)*. The resulting distances accumulated from this will be put into the model as another facet of the investigative process. The multiple exposure item was similarly constructed, asking for number of exposures ranging from 1 *(1)* to 4 *(6+)*.

TBI. Questions to establish the likelihood of TBI (all types) have similarly been pulled from the DD form 2796 in Appendix C. This group of 3 questions will be used to determine likelihood of mTBI (and more ominous types of TBI) presence in accordance with established practices from Nelson and colleagues (2019). An example question for mTBI presence reads "As a result of events…Did you receive a blow or jolt to your head that resulted in you…Losing memory for the event" (Executive Services Directorate, 2015). Answer choices to this item are 0

(No) and 1 *(Yes)*. These questions performed moderately well delivering a Cronbach's alpha of .71 overall.

Combat Wounds. Additional questions that are missing from the CES will be added as well in an effort to control for various types of stressful events often associated with combat exposure. Such events as being wounded in combat, having limbs amputated, or being rendered unconscious are likely correlates of PTSD and could potentially confound the results. As a result, these items will be added to the CES in the form of "yes/no" answers to specific questions and will be subsequently coded 0 (*No*) and 1 (*Yes*). Unlike many of the CES questions, it highly improbable that a soldier would have been the victim of these events and been placed back on the line due to the catastrophic nature of the injuries (Booth-Kewley et al., 2010). As such, the need to follow the standard CES protocol of assessing the number of times a veteran was exposed to such events is rendered moot. Thus, for this study the total score of the CES is less important than the actual exposure to various types of combat related stressors. Again, these questions meshed well with the CES as evidenced by the excellent overall performance.

Substance Use. Substance use is a common confound in the world of PTSD research. In the civilian population, some 43% of individuals diagnosed with PTSD have a comorbid substance use disorder (Back, 2010). This significant comorbidity rate, and the symptom entanglement it can engender must be controlled for. For this study, the Drug Abuse Screening Test-10 (DAST-10), a short 10-item self-report measure will be used to screen for substance use symptomology. This measure has an overall Cronbach's alpha of .80 or better in some circumstances, and its brief nature lends itself well to a multifaceted investigation of this type

(Villalobos-Gallegos et al., 2015). This measure will also be aggregated for use in the regression analysis.

Procedures

Analyses. Based on the research to date, CBE has been shown to be a unique factor in PTSD acquisition and an exceptional combat stressor (Osario et al., 2018). However, this fact may fail to account for mTBI symptomology, which could prove to be a confounding element in the equation (Nelson et al., 2019). The possible confound of mTBI and other potential combat stressors necessitated the use of a hierarchical multiple linear regression with three steps being utilized to construct the model. This ideally provided the necessary statistical control for the confound variables and rendered an appropriate model for analysis. As a result, the unique predictive ability of CBE as it pertains to PTSD was able to be properly evaluated.

Prior to the initiation of the hierarchical linear regression, a series of Pearson correlations were undertaken. This methodology allows for the a priori determination of potential connections and covariation amongst the predictors and control variables. Also, as alluded to in the above measures section, Cronbach's alpha values were determined for each of the new additions to measures. This ensured that not only were the newer items and scales performing up to par but also that no problems existed that were negatively affecting scale or measure implementation.

Missing data was dealt with using mean imputation, after an initial processing of culling non-completers. After sorting cases of non-combat veterans, who would have not completed the requisite measures for inclusion, a total of 120 participants remained out of the original 198. Of

these 120, another 39 were removed from the study for failing to complete the minimum number of instruments, such as the PCL-5, the CBE questionnaire, and other primary measures, leaving a total number of participants at $N = 81$. From here, each item was run in SPSS to determine percentage of missing data in each category. Based on findings by Shrive and colleagues (2006), it was determined that no more than 10% of data could be missing from any one item for mean imputation to be undertaken safely. No item had more than 2.5% of data missing, and this falls well within even the most stringent of mean imputation estimates (Shrive et al., 2006). Mean imputation was undertaken at the item level for all 81 participants via SPSS. Where mean imputation was not feasible, missing data was replaced with zero, indicating a null response.

An a priori power analysis for a multiple linear regression with three predictors was conducted in G*Power to determine a sufficient sample size using an alpha of 0.05, a power of 0.80, and a small effect size ($f^2 = 0.02$; Faul et al., 2013). Based on the listed assumptions, the desired sample size is 550 (Statistics Solutions, 2013). Due to the results of this a priori analysis, a target sample size of 550 participants was set.

As events transpired, a sample of 81 combat veterans was garnered via the listed methods. Using similar criteria to those set forth above, save for actual sample size, this information was calculated in the G*Power software as a post hoc analysis, in order to determine the actual statistical power rendered by the sample (Faul et al., 2013). This sample size was found to generate a statistical power of 0.35, or a little less than half of the intended target power (Faul et al., 2013). Based on these results, it can be concluded that this study is somewhat underpowered, and the results should be interpreted with caution.

RESULTS

Preliminary Analyses. Prior to engaging in the more complex regression analyses, correlations between all target and control variables were engaged in. This pre-emptive analysis resulted in a number of significant correlations. See Tables 2 and 3. Measures of PTSD were positively and significantly associated with a number of other variables. Due to the large number of correlations noted, only more salient and investigation related connections will be listed and discussed here.

PTSD was significantly associated with TBI, $r = .50$, $p < .001$; close blast exposure, $r = .30$, $p = .006$; combat exposure, $r = .30$, $p = .006$; and multiple blast exposures, $r = .26$, $p = .019$. This means that individuals with greater PTSD symptomology were more likely to have experienced TBI, tended to have been in more combat situations, and been exposed to multiple close blasts. Individuals with higher PTSD scores also showed strong positive correlations with non-combat related trauma, $r = .32$, $p = .003$, and substance abuse symptomology, $r = .25$, $p = .028$.

The TBI measures also showed a number of positive and significant correlations with other measured variables. TBI was strongly and positively associated with CBE, $r = .68$, $p < .001$, as well as with multiple blast exposures, $r = .54$, $p < .001$. This means that people who higher TBI symptoms were more likely to have been exposed to close blasts as well as multiple ones. Unsurprisingly, TBI was also significantly associated with a history of trauma, $r = .43$, $p < .001$, and combat exposure, $r = .56$, $p < .001$.

The combat exposure variable was also significantly and positively associated with some other variables. Greater combat exposure was strongly associated with multiple blast exposures,

$r = .77$, $p < .001$, and close blast exposure itself at, $r = .72$, $p < .001$. This demonstrates that individuals with greater combat exposure tended to be exposed to more close blasts and a greater number of those. Additionally, combat exposure was associated with distance from blast, $r = .40$, $p < .001$, which tends to show that individuals who were closer to blasts tended to rate higher combat exposure experiences.

Hypothesis Testing. In the three-step regression model, PTSD symptomology was regressed onto CBE as well as distance from the blast and multiple blast exposures, while controlling for TBI, substance use, trauma history, and other combat exposures. See Table 4. Below, semi-partial Pearson's r (r_{sp}) are reported as a measure of effect size for regression coefficients (Dudgeon, 2016).

In the first step of the model, the control variables of TBI, combat exposure including being wounded in action, substance use, and trauma history were entered concurrently. This first step accounted for 28.7% of the variance, $R^2 = .29$, $F(4, 76) = 7.65$, $p < .001$. In this first step, TBI was positively and significantly associated with PTSD, $B = 1.27$, $\beta = 0.42$, $t(81) = 3.36$, $p = .001$, 95% CI [0.52, 2.03], $r_{sp} = .325$. Other control variables did not have significant associations with PTSD symptomology. This means that of the control variables, TBI had the strongest predictive power regarding PTSD presentation.

Adding CBE to the second step of the model accounted for another 0.9% of the variance, $\Delta R^2 = .009$, $F(1, 75) = 0.97$, $p = .327$. Once again, the only variable that associated with PTSD symptomology in this step of the model was TBI, which was positively and significantly associated, $B = 1.46$, $\beta = .48$, $t(81) = 3.45$, $p < .001$, 95% CI [0.62, 2.30], $r_{sp} = .335$. In other

words, CBE did not possess predictive power for PTSD above and beyond control variables. However, TBI did possess such predictive capabilities.

In the third step of the model, distance from blast and multiple CBE exposures were entered. This final step only accounted for less than .01% of the variance, $\Delta R^2 < .001$, $F(2, 73) = 0.01$, $p = .986$. Like the previously established patter, TBI was positively and significantly associated with PTSD, and with a slightly stronger association, $B = 1.46$, $\beta = .48$, $t(81) = 3.41$, $p = .001$, 95% CI [0.61, 2.31], $r_{sp} = .335$. In sum, only TBI possessed significant and consistent predictive power for PTSD with roughly a medium effect size. Indeed, the higher the score on the TBI measures, the higher the probability of and greater the severity of PTSD symptomology.

As far as the confirmation or disconfirmation of hypotheses, these results tend to disconfirm all three hypotheses. In step two of the model, where CBE is measured against PTSD symptomology, CBE was found to be negatively correlated to PTSD symptomology, although not significantly, thus negating the entire premise on which the hypothesis was founded. Therefore, hypothesis 1 was not supported. In the third step, likewise, the distance from the blast and multiple exposure items were both positively associated with PTSD, although this too was not significant. As a result, hypotheses 2 and 3 can similarly be discarded in favour of the null.

DISCUSSION

This investigation sought to undertake a unique approach to the evaluation of PTSD as it pertains to the exposure of the individual soldier to CBE from a wide variety of devices. While the primary hypotheses were all unsupported by the data, the sheer amount of information garnered and many of the underlying correlations and associations add significantly to the ever-growing knowledge base. There were, however, some important limitations and potential obstacles within this study that must be covered and should urge caution in the reader.

Perhaps the first of these caveats revolves around the statistical power garnered by the sample size in this study. The initial power estimates denoted a needed sample size of some 550 participants in order to detect small-medium effect sizes and achieve .80 power (Faul et al., 2013). As it transpired, this number was hopelessly ambitious and only a fraction of that number, approximately 15% to be more specific, were actually recruited using the listed methods. The underpowered nature of the study should promote caution as this means that primary effects may have gone unnoticed due to a minute effect size rendering them undetectable.

The small sample size likely resulted from problematic recruiting methods employed during collection. The online recruiting necessitated investigators casting a broad net in both open and private groups among various social media platforms. This type of recruitment and advertising engenders several problems. Although a great deal of Post 9/11 veterans utilize such social media platforms as Facebook daily, estimated as high as 60% or more, the actual interaction with the material they see is unclear (Teo et al., 2019). It is also noteworthy that a number of individual factors could affect this interaction, such as perceived legitimacy of the survey, and even lack of desire to participate in such an endeavour without tangible and

immediate benefits. These factors may have also influenced completion rate, as some 32.5%, or nearly 1/3rd, of the original 120 combat veteran sample failed to complete even the most basic of requisite measures.

Next is the unequal distribution of the sampling methods. It is utterly impossible to find or post in every single veteran's group that exists on these platforms just due to the incredibly high number of observed, and especially niche groups. Veteran's groups were often broken down by subtype and/or interest, leading to a bewildering array of potential groups with a wildly vast and diverse potential population. Such groups as Socialist Veterans would likely have a massively different subset of veterans, including potentially divergent scores on measures of interest, than say a more conservative group such as Veteran's for Trump. Entrance criteria to these groups was often contradictory, alternately rigorous or lax but still highly involved, and time consuming to undertake. Thus, gaining entrance to these groups was an arduous process that was far from guaranteed, albeit a necessary effort in order to reach as many as possible. This process often detracted from the ability to actually post the survey and interact with said veteran groups since so much time was spent in limbo, awaiting approval or denial.

Finally, perhaps the most debilitating of all social media recruitment obstacles was the individual group/page rules and bylaws, as well as the overarching community standards of the platforms themselves. Many of these platforms attempt to reduce spam by removing suspicious posts, banning certain people, groups, or profiles, and finally by restricting ability to post and even revoking access to the platform altogether. Unfortunately, during this investigation, every single eventuality listed above was visited upon the investigators or confederates attempting to help. Much time was wasted in the ethereal social media purgatory of the 30-day ban and,

ultimately, total suspension from the network. It appears that many factors, perhaps all of the listed factors, conspired together in order to limit the sample size and, ergo, statistical power.

Among the potential results of this limited sample size was a demographically unbalanced sample population. Although the split of the military branches was realistically equitable, according to the general separation of branches in vivo, that was perhaps the only element that was truly well distributed (Teo et al., 2019). As stated above, White males were overrepresented in this sample and other minorities were underrepresented accordingly (DOD, 2016). Efforts to weight the responses of such populations to negate the imbalance were not undertaken in this investigation leaving the results potentially slightly skewed. It should be noted that in a sample as small as this, just a couple of responses can alter the balance. Indeed, part of this imbalance may be attributable to the difficulties in online recruiting and the various niche groups that were rendered all but inaccessible by the barriers already mentioned. It should be noted that the distribution of gender, race, and other factors may or may not adequately represent the distributions present in multinational coalition forces, and this was not investigated.

Another limitation of this study that deserves mention is the manner in which certain constructs were measured. Such conditions as TBI are inherently complex and multifaceted yet this study identified possible TBI through a short series of questions (Flanagan et al., 2008). The use of TBI in the following pages incorporates all types, including mTBI, as the assessment instruments were not sensitive enough to distinguish subtypes. These questions, though valid on their face, do not entirely encompass the breadth of TBI, nor were they designed to. These questions were meant to identify potential TBI and subsequently control for it in a rather rudimentary manner. More in-depth investigations into TBI often utilize more exact and task-specific measures to identify clusters of symptoms that occur in such things as memory,

executive function, behavioural aspects, motor control, and advanced neuroimaging techniques (Flanagan et al., 2008). Instead, this investigation utilized subjective experiences, which can be problematic, in order to make a presumptive determination for TBI presence based on the literature review cited in the introduction.

Along this same vein, the important yet often understated concept of subjective feeling of imminent death was also measured with a single question in this investigation. It should be noted that this question performed quite well and even slightly enhanced the overall performance of the CES. However, it is highly debatable whether this single item effectively captured the feelings. Other researchers, such as Nozaki (2006) opted to use such things as perspiration, others have used stress hormones or other tailor-made measures to objectively assess this construct. None of these methods were feasible for this study which was conducted online while retroactively assessing combat experiences. Strangely, literature reviews at the time of this writing had failed to identify comprehensive measures that directly assess this construct, rather it seemed to be subsumed by broader measures such as the CES and PCL-5 as an element of the larger structures.

Despite the number of pitfalls mentioned in the above paragraphs, this study was, in fact, quite unique in its composition, ambitious in its goals, and worthwhile to the psychological community as a whole. Certainly, this study has not only identified areas for further investigation, has also noted additions to relatively common measures, as well as lending credence to hitherto variably supported constructs (i.e., CBE) in regard to veteran health and combat experiences. These positives provide direction for research and bolster the growing literature body for these important veteran issues.

Of note were the improvements made to the CES during the course of this investigation. Based on the necessity to control for such things as injury in combat, a particularly onerous stressor, as well as the aforementioned specific feeling of imminent death or dismemberment, other questions had to be written. These fit well with the overarching framework of the CES and were designed specifically to be an adjunct, given their same Likert-type scale and formatting and other similarities. So, these were added to the CES and these actually improved the overall performance from the cited alpha of .92 to a slightly higher .93, verging on .94 (Booth-Kewely et al., 2010).

The additional questions regarding combat injuries worked well with the CES framework, boasting corrected item total correlations (CITC) of .74 and .65, which roughly falls in line with the other classical items on the CES. It was shown that the deletion of these two items would have had negligible impacts on the overall alpha of the CES and their performance was admirable overall, given they were written specifically for this investigation and not rigorously evaluated as the more conventional CES items. Importantly, the current data seems to indicate that these items are roughly measuring the same underlying constructs as other items on the CES. Although broad in scope, all of these items tend to correlate highly with each other.

Likewise, the item measuring the subjective feeling imminent death or dismemberment performed commendably. It rendered a CITC of .70 and also showed that it would actually slightly decrease the overall alpha of the CES if it was deleted. Again, this tends to indicate that this item too sticks together well with other items on the CES, from a correlational point of view. This also assumes that it too is likely measuring a similar construct to the other items. Similarly, to its above-mentioned cousins, this item was also purpose devised for this study and without the typical induction process typically utilized in psychometric measures, so the overall performance

is remarkable. As a result of the performance of these items and the overall improvement in the CES, and the dearth of these questions on the current CES version, it is recommended that research be undertaken in earnest to add these items or derivatives.

The CBE measures showed that they too did adequately well in this investigation. The CBE measures which are utilized by the US military for data gathering, showed an overall alpha of .71, which also includes the purpose-designed distance and multiple exposure questions (Executive Services Directorate, 2015). Some of the items on this measure may need further investigation and perhaps rewriting if they should be used in other investigations. However, among the best performing items was the question regarding multiple CBE exposures that was written for this study. That item demonstrated a CITC of .69, which was among the highest in the measure and also was noted to significantly reduce the overall alpha if it were to be removed. Again, this is an item that should be considered as a permanent addition to the measure should it remain in use.

Other items in the CBE and TBI measures did not perform so well and are likely in need of overhaul. These will be mentioned only briefly as this is beyond the scope of this investigation. One of the poorest performing items asked about losing memory of the event after exposure. This item showed a borderline unacceptable CITC of .29, and its deletion would improve the overall alpha of the measure. The same is true of the question asking if the respondent was knocked out by the explosion, which was not much improved with a CITC of .45. These items are among the TBI detection items. It should be noted that small sample size and limited number of TBI sufferers could also be to blame for such poor performance. Even though these items have good face validity, revamping this measure is recommended before it is to be implemented again.

Improvement in these measures would aid the research community and, by extension, the veteran community. All of these listed instruments are succinct, direct, valid, and superbly reliable. It is in these elements that the real utility of these measures lies. The ability for a clinician, the military, the DoD, or even a screener at military unit level could employ these devices to great effect for a variety of purposes. Not only do they provide a rich source of data, as evidenced in this investigation, but they also have clinical value as screening and diagnostic tools. Unfortunately, these measures have not kept up with the metamorphosis of knowledge regarding the interaction of PTSD, TBI, CBE, and combat exposure which unfortunately hamper their overall effectiveness. With some effort and modification, these instruments can be brought out of the dark ages of obsolescence and into a more enlightened period of purpose.

Despite the lack of support for the 3 main hypotheses, a great deal of information was garnered from the a priori correlations that were performed, along with the significant result of the TBI predicting PTSD. The connection between TBI and PTSD cannot be overstated and has been proved decisively in this investigation with TBI having such a robust statistic as $\beta = .48$, $p = .001$. Not only has this combination been previously identified as the "signature wound" of the current conflicts, but this interconnection also stresses the VA system as it is often polytraumatic (Tschiffley et al., 2015). On its own, TBI has been shown to have predictive value for PTSD and in this case, it had value over and above all other predictors and control variables, even in those participants with known combat history and traumatic history.

These results are highly suggestive of the fact that TBI should be viewed as a distinct yet important member of the greater veteran PTSD conceptualization. What this means, in other words, is that military forces need to be doing regular screenings for TBI at the same rate as they do for combat stressors and PTSD symptomology. TBI clearly has a place in the algorithm for

calculating potential PTSD in certain veterans, but its exact location and interaction remains cryptic and as yet out of reach. Similarly, it is suggested that veterans with a known history of TBI should be examined for PTSD symptomology. Again, the conceptualization of PTSD in this veteran population, potentially in others as well, could be restructured with TBI taking an important role, along with other proven and empirically derived factors.

How best to conceptualize TBI in light of this investigation is another matter altogether. This study utilized questions to detect this wily condition more as a function as CBE, not as an independent or stand-alone factor, necessarily. This is reflected in the structuring and specific wording of the questions. This is of paramount importance because the presence of TBI almost assumes the presence of CBE, although this is not exclusively the case. However, CBE and TBI had a strong and robust correlation with each other, likely because the underlying mechanism of injury or exposure is all but identical in many cases. This provides strong evidence for the nearly inextricable relationship between these two variables despite one being a pathologized medical condition and the other a more ambiguous or subjective abstract.

To add to this apparent connection, different elements of CBE were significantly and positively correlated with TBI as well. For instance, the multiple blast exposure also had a strong and robust association with TBI, indicating the probability of TBI increases along side the increasing number of exposures to CBE. Of less strength, but also of pivotal importance, was the significant and positive association between distance from blast and TBI probability. This connection indicates that the closer a person is to CBE the greater the likelihood of TBI. At first glance this seems to be a commonsense relationship, but as Ling and colleagues (2009) pointed out, the connection between an explosion and brain damage is anything but straightforward and is often fraught with co-occurring or confounding variables.

Given these strong links that have been established between TBI and CBE and sub-elements thereof, coupled with the overarching association between TBI and PTSD, the question still remains how best to conceptualize TBI/CBE in relation to PTSD. Unfortunately, there is no rudimentary answer to this burning question. However, some already stated suggestions can likely ameliorate this quandary, which would require minimal effort. These suggestions are not all-inclusive nor are they without drawbacks or potential hinderances within the context of research.

Perhaps one of the most straightforward practical adjustments to make in order to detect potential TBI and PTSD is to suitably alter the screening tools to better catch these concepts. An example being the venerable, but slightly flawed CES. This measure is no more than a screening tool to assess combat exposure on a broad scale, including statistically supported questions and supposed underlying factors (Booth-Kewley et al., 2010). As was performed in this study, a few questions capturing CBE and, it should be argued, the subjective experience of being in imminent danger, must be added to ensnare these important factors. What this study makes abundantly clear is that the CES is in dire need of updating and adding these questions could rejuvenate that questionnaire and usher it into the asymmetrical warfare of the 21st century properly.

The remaining question of how to deal with TBI in the greater scheme of PTSD is more complicated. While adding some TBI questions to the CES could potentially alleviate this hovering question, this would lengthen the form substantially, as it is meant to be a brief screener, and may unduly impact the overall performance of the measure, as evidenced by the poor performance of certain CBE/TBI questions. Certainly, given the gravity of the injury, TBI, if suspected, warrants a separate investigation with separate screeners. Historically, TBI has been

fully assessed with more intricate tools associated with neuropsychiatric measures, each encompassing its own construct (Flanagan et al., 2008). However, this is likely not entirely feasible for many clinicians, especially those in the field, necessitating the creation of specially designed CBE/TBI screener based on the well-performing questions utilized in this study, already in wide use in US government circles.

What this evidence suggests is a diagnostic flow chart that can be followed by practitioners who are rendering aid to combat veterans. A new and much improved CES would alert the clinician to the fact the veteran has been exposed to, or was likely exposed to CBE (and other combat stressors), thus triggering a suspicion of TBI. From here, a short TBI screener could be administered and the score of that, combined with CES data, which itself is positively correlated with PTSD, should indicate that greater deference be paid to PTSD symptomology. This multimodal assessment process will invariably alter the patient conceptualization by the clinician and allow for greater understanding of psychopathology and ultimate root causes. In turn, this understanding better informs treatment protocols, service provisions, and ultimately, outcomes.

This study has potentially altered the way in which PTSD, TBI, and CBE should be viewed in the combat veteran population. The connections established in this manuscript have opened the door for not only new avenues of investigation, but also aided in the global understanding of these factors. Thousands of combat veterans have been exposed to these devices and undergone their lingering aftereffects. This is the time for the psychological community to begin palliating the suffering of those who have sacrificed so much in defense of our freedom.

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APPENDIX A

Trauma History Screen

The events below may or may not have happened to you. Click "YES" if that kind of thing has happened to you or click "NO" if that kind of thing has not happened to you.

1. A really bad car, boat, train, or airplane accident:

   0 1

   Yes No

2. A really bad accident at work or home:

   0 1

   Yes No

3. A hurricane, flood, earthquake, tornado, or fire:

   0 1

   Yes No

4. Hit or kicked hard enough to injure-as a child:

   0 1

   Yes No

5. Hit or kicked hard enough to injure-as an adult:

   0 1

   Yes No

6. Forced or made to have sexual contact-as a child:

   0 1

Yes No

7. Forced or made to have sexual contact-as an adult:

   0 1

   Yes No

8. Attack with a gun, knife, or weapon (outside of military):

   0 1

   Yes No

9. Sudden death of close family or friend (outside of military):

   0 1

   Yes No

10. Seeing someone die suddenly or get badly hurt or killed (outside of military):

    0 1

    Yes No

11. Some other sudden event that made you feel very scared, helpless, or horrified (outside of military):

    0 1

    Yes No

12. Sudden move or loss of home and possessions:

    0 1

    Yes No

13. Suddenly abandoned by spouse, partner, parent, or family:

    0 1

    Yes No

APPENDIX B

Combat Exposure Scale

Please click the number above the answer that best describes your experience.

1) Did you ever go on combat patrols or have other dangerous duty?

1	2	3	4	5
No	1-3 Times	4-12 Times	13-50 Times	51+Times

2) Were you ever under enemy fire?

1	2	3	4	5
Never	< 1 Month	1-3 Months	4-6 Months	7+Months

3) Were you ever surrounded by the enemy?

1	2	3	4	5
No	1-2 Times	3-12 Times	13-25 Times	26+Times

4) What percentage of the soldiers in your unit were killed (KIA), wounded or missing in action (MIA)?

1	2	3	4	5
None	1-25%	26-50%	51-75%	76% or more

5) How often did you fire rounds at the enemy?

1	2	3	4	5
Never	1-2 Times	3-12 Times	13-50 Times	51+ Times

6) How often did you see someone hit by incoming or outgoing rounds?

1	2	3	4	5
Never	1-2 Times	3-12 Times	13-50 Times	51+ Times

7) How often were you in danger of being injured or killed (i.e. being pinned down, overrun, ambushed, near miss, etc.)?

1	2	3	4	5
Never	1-2 Times	3-12 Times	13-50 Times	51+ Times

8) Were you injured in combat (direct fire, indirect fire, IED, etc.)?

0	1
No	Yes

9) If you were injured, what was the nature of the injury?

1	2	3	4	5
Burns	Shrapnel	Gunshot	Amputation	All/Multiple

10) Feeling that you were in great danger of being killed?

1	2	3	4	5
Never	1-2 Times	3-12 Times	13-50 Times	51+ Times

APPENDIX C

DD 2796

During your deployment(s), did any of the following events happen to you? (Mark all that apply)

1) Blast or explosion (e.g. RPG, IED, EFP, landmine, grenade, etc.)?

   0 1

   No Yes

2) How many total exposures to blasts/explosions did you receive?

   1 2 3 4

   1 2-3 4-5 6 +

3) If yes, please estimate your closest distance from the blast/explosion (in meters).

   1 2 3 4

   < 25 M 25-50 M 50-100 M > 100 M

As a result of the event in question 1, did you receive a blow or jolt to your head that IMMEDIATELY resulted in:

4) Losing consciousness (“knocked out”)?

   0 1

   No Yes

5) Losing memory of the events before or after the injury?

   0 1

   No Yes

6) Seeing stars, becoming disoriented, functioning differently, or nearly blacking out?

0	1
No	Yes

APPENDIX D

PCL-5

Instructions: Below is a list of problems that people sometimes have in response to a very stressful experience. Please read each problem carefully and then click one of the numbers below to indicate how much you have been bothered by that problem in the past month.

In the past month, how much were you bothered by:

1) Repeated, disturbing, and unwanted memories of the stressful experience?

   0 1 2 3 4

   Not at all A Little bit Moderately Quite a bit Extremely

2) Repeated, disturbing dreams of the stressful experience?

   0 1 2 3 4

   Not at all A Little bit Moderately Quite a bit Extremely

3) Suddenly feeling as if the stressful experience were actually happening again (as if you were actually back there reliving it)?

   0 1 2 3 4

   Not at all A Little bit Moderately Quite a bit Extremely

4) Feeling very upset when something reminded you of the stressful experience?

   0 1 2 3 4

   Not at all A Little bit Moderately Quite a bit Extremely

5) Having strong physical reactions when something reminded you of the stressful experience (for example, heart pounding, trouble breathing, sweating)?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

6) Avoiding memories, thoughts, or feelings related to the stressful experience?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

7) Avoiding external reminders of the stressful experience (for example, people, places, conversations, activities, objects, or situations)?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

8) Trouble remembering important parts of the stressful experience?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

9) Having strong negative beliefs about yourself, other people, or the world (for example, having thoughts such as: I am bad, there is something seriously wrong with me, no one can be trusted, the world is completely dangerous)?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

10) Blaming yourself or someone else for the stressful experience or what happened after it?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

11) Having strong negative feelings such as fear, horror, anger, guilt, or shame?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

12) Loss of interest in activities that you used to enjoy?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

13) Feeling distant or cut off from other people?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

14) Trouble experiencing positive feelings (for example, being unable to feel happiness, or have loving feelings for people close to you)?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

15) Irritable behaviour, angry outbursts, or acting aggressively?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

16) Taking too many risks or doing things that could cause you harm?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

17) Being “superalert” or being watchful or on guard?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

18) Feeling jumpy or easily startled?

0 1 2 3 4

Not at all A Little bit Moderately Quite a bit Extremely

19) Having difficulty concentrating?

0	1	2	3	4
Not at all	A Little bit	Moderately	Quite a bit	Extremely

20) Trouble falling or staying asleep?

0	1	2	3	4
Not at all	A Little bit	Moderately	Quite a bit	Extremely

APPENDIX E

Demographic Information

Please answer the following questions.

Are you located:

In the United States

Outside of the United States

Please indicate your age:

Ethnicity (select all that apply):

Black or African-American

White/Caucasian

Asian or Asian-American

Hispanic or Latinx

Native American

Other:

What is your gender?

Man

Woman

Transgender

Gender Queer

Open option:

Please indicate your highest level of education obtained:

Less than a High School Diploma

High School Diploma or GED equivalent

Associates Degree or Certification (Technical College)

Bachelor's Degree

Master's or Other Professional Degree

Doctorate Degree

What is your marital status:

Single

Married

Separated

Divorced

Cohabitating

Other:

Have you ever served in Military?

Yes

No

Are you currently still in the Military?

Yes

No

Which branch(es) did you serve in? (select all that apply)

Army

Air Force

Navy

Marines

Coast Guard

Age during last deployment:

Highest military rank attained:

Select current status:

Active Duty

Reserves

National Guard

Retired

Veteran