

Sequelae of Deployment TBI in Iraq and Afghanistan Veterans

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Disclaimer

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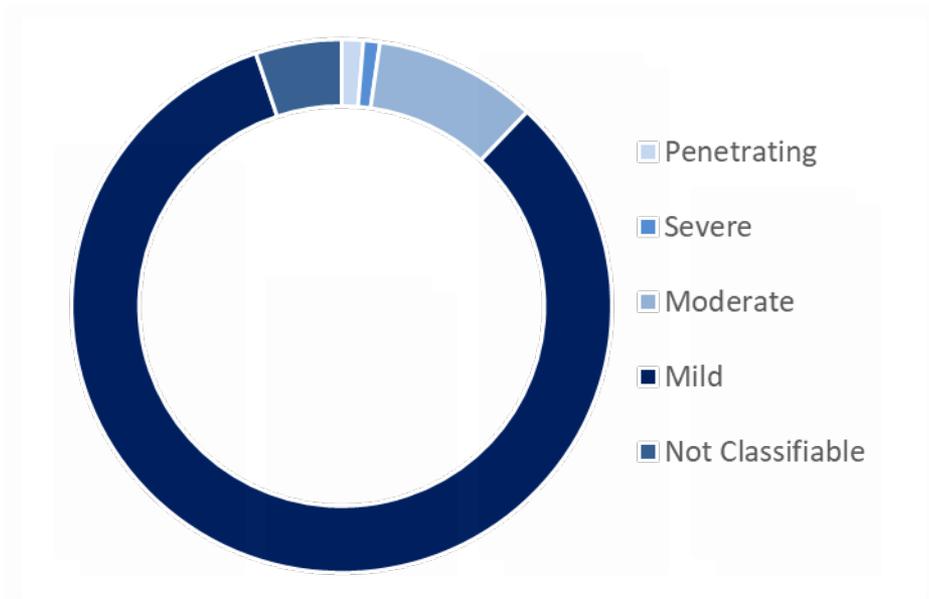
TBI in Veterans

Most are mild in severity (82.8%)

Alteration of consciousness (< 24 hours)

Loss of consciousness (< 30 minutes)

Posttraumatic amnesia (< 24 hours)



Symptoms expected to resolve within 3-6 months

Vestibular
 nausea
 dizziness
 balance problems

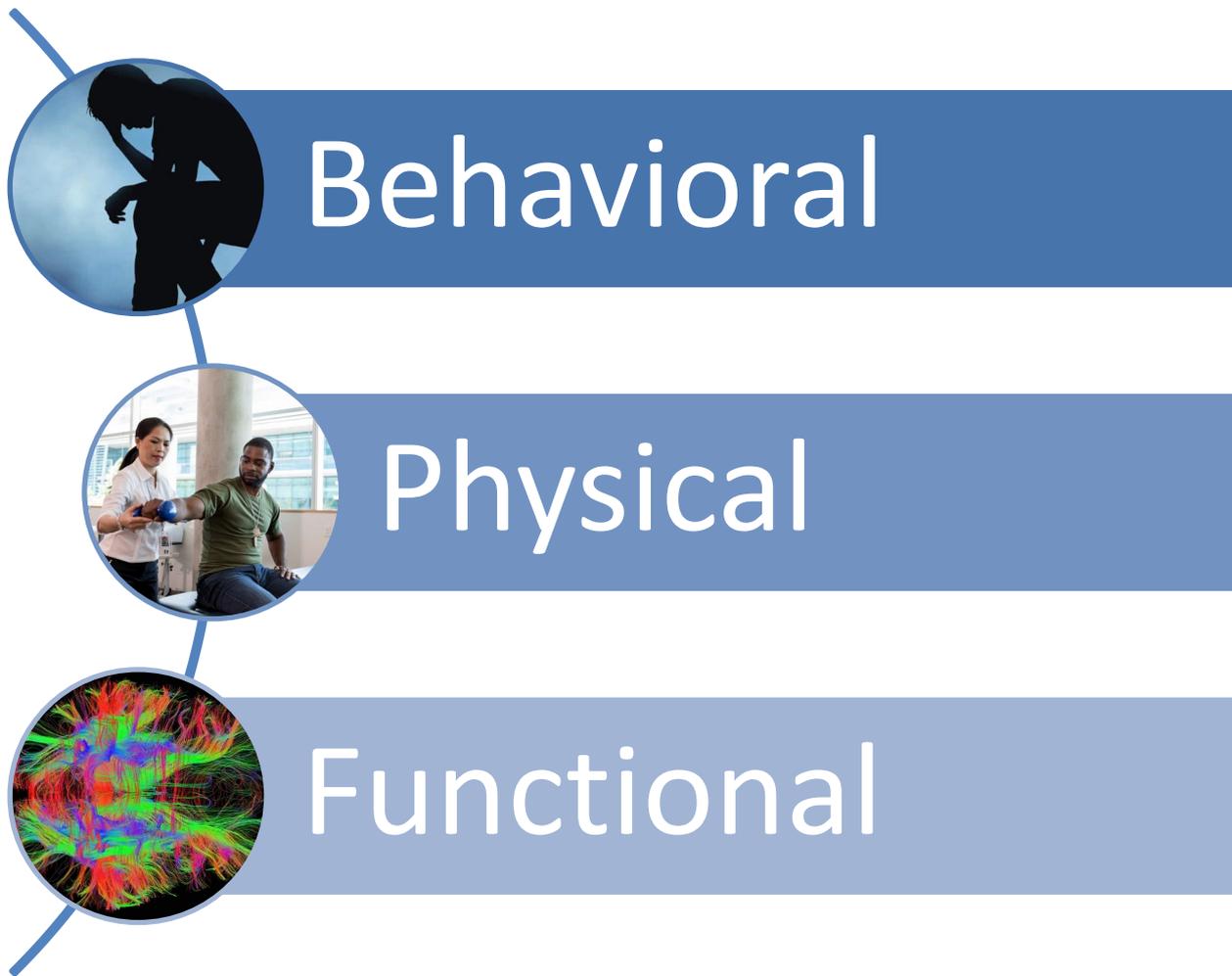
Sensory
 altered vision
 headaches
 tinnitus

Cognitive
 forgetfulness
 lack of focus

Emotional
 irritability
 depression

TBI in Veterans



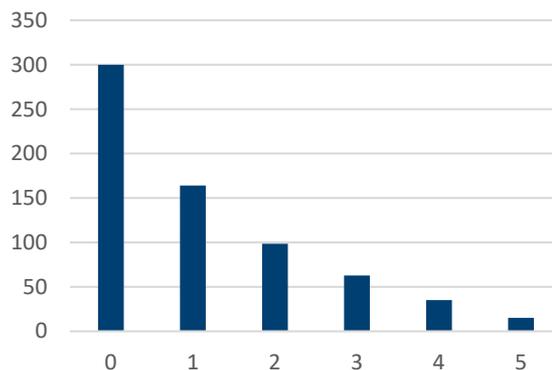


Samples and Methods

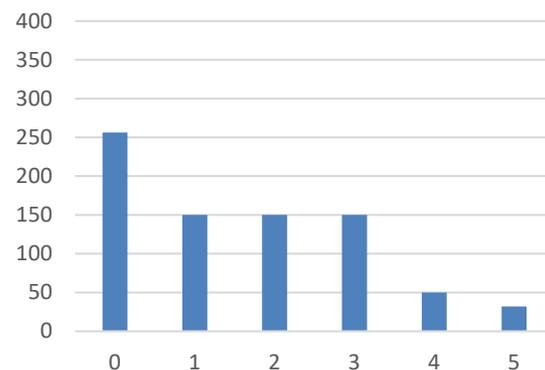
	CENC-34	PDMH	Pilot
Cross-sectional	✓	✓	✓
Iraq/Afghanistan Veterans	✓	✓	✓
Neuroimaging	✓		✓
Sample Size	341	1399	28
Age	41.16 (10.13)	37.55 (10.38)	39.0 (9.5)
Male	86.2%	81.7%	100%
Years since Deployment	9.71 (3.53)	6.64 (5.01)	6.2 (2.70)

Salisbury Blast Interview

Pressure Median Distance



Wind Median Distance



BIAM INQUIRY
https://doi.org/10.1080/0369652.2020.1729418



Check for updates

Sequelae of Blast Events in Iraq and Afghanistan War Veterans using the Salisbury Blast Interview: A CENC Study

Jared A. Rowland¹, Sarah L. Martindale², Kayla M. Spengler³, Robert D. Shura⁴, and Katherine H. Taber^{5,6}

¹Research & Academic Affairs Service Line, Salisbury VA Medical Center, Salisbury, North Carolina, USA; ²Mid-Atlantic Mental Illness Research Education and Clinical Center, Durham, North Carolina, USA; ³Department of Neurobiology and Anatomy, Wake Forest School of Medicine, Winston-Salem, North Carolina, USA; ⁴Department of Physiology and Pharmacology, Wake Forest School of Medicine, Winston-Salem, North Carolina, USA; ⁵Department of Neurology, Wake Forest School of Medicine, Winston-Salem, North Carolina, USA; ⁶Division of Biomedical Sciences, Via College of Osteopathic Medicine, Blacksburg, Virginia, USA; ⁷Department of Physical Medicine and Rehabilitation, Baylor College of Medicine, Houston, Texas, USA

ABSTRACT

Objective: To determine the prevalence of sequelae of blast events occurring during a blast event.

Design: Prospective cohort study.

Setting: Salisbury VA Medical Center, Salisbury, North Carolina, USA.

Participants: 100 Iraq and Afghanistan War Veterans.

Measures and Main Results: 94.4% of participants reported exposure to a blast event during a blast event.

Conclusions: The prevalence of sequelae of blast events is high.

Keywords: Blast, Iraq, Afghanistan, Veterans, Sequelae.

Introduction

Military service during combat (1,2), exposure to blast events in support of Iraq and Afghanistan, and exposure to blast events during the instance of 78% of wounded members and exposure to blast events during the instance of 78% of wounded members and exposure to blast events during the instance of 78% of wounded members.

Currently, no standardized criteria exist to identify and characterize explosive events.

Explosive events are characterized by a rapid increase in pressure and temperature.

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	Behind Cover	No Cover
Wind*	1.19 (1.4)	1.42 (1.6)
Debris	1.56 (1.6)	1.71 (1.7)
Ground*	2.44 (1.4)	2.66 (1.5)
Pressure*	1.24 (1.4)	1.55 (1.5)
Temp	0.63 (1.1)	0.70 (1.2)
Sound*	3.18 (1.2)	3.44 (1.3)

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Behavioral Outcomes



Archives of Physical Medicine and Rehabilitation

Journal homepage: www.archives-pmr.org

Archives of Physical Medicine and Rehabilitation 2018;99:2485-95



ORIGINAL RESEARCH

Behavioral and Health Outcomes Associated With Deployment and Nondeployment Acquisition of Traumatic Brain Injury in Iraq and Afghanistan Veterans



Sarah J. Martindale, PhD^{a,b,c}, Erica L. Epstein, PsyD^{a,b}, Katherine H. Tabor, PhD^{a,b,d,e}, VA

Table 3 Outcome and covariate descriptive measures for aims 1 and 2

Measure	Total Sample (N=1399) Mean ± SD	Nondeployment TBI		Deployment TBI		PTSD Diagnosis	
		– (n=835) Mean ± SD	+ (n=564) Mean ± SD	– (n=1071) Mean ± SD	+ (n=328) Mean ± SD	– (n=786) Mean ± SD	+ (n=613) Mean ± SD
BDI-II	14.79±12.67	14.08±12.98	15.84±12.12	12.74±12.08*	21.50±12.24*	9.23±10.13*	21.92±12.02*
DTS	41.30±39.67	39.20±40.32	44.42±38.52	33.82±36.98*	65.73±38.37*	19.67±26.60*	69.02±36.30*
PSQI	9.57±4.90	9.29±4.96	9.98±4.77	8.78±4.75*	12.16±4.46*	7.49±4.38*	12.24±4.19*
AUDIT	5.11±6.00	4.65±5.63	5.79±6.44	4.76±5.75	6.24±6.45	4.20±4.86*	6.27±7.03*
DAST	1.08±2.82	0.94±2.62	1.28±3.07	1.03±2.82*	1.24±2.80* [†]	0.75±2.14*	1.51±3.45*
BPI [‡]	3.34±2.51	3.22±2.61	3.50±2.38	3.05±2.51*	4.28±2.30*	2.67±2.36*	4.23±2.43*
CES	11.97±10.36	11.08±10.22	13.30±10.44	9.51±9.11*	20.02±10.12*	8.02±8.69*	17.03±10.13*

NOTE. Results from aims 1 and 2. Independent samples *t* tests were conducted on the CES to report differences between groups; however, they are not reported in the body of the article because the CES was included in analyses as a covariate. – = absence of condition, + = presence of condition.

Abbreviations: AUDIT, Alcohol Use Disorders Identification Test; BDI-II, Beck Depression Inventory II; BPI, Brief Pain Inventory; CES, Combat Exposure Scale; DAST, Drug Abuse Screening Test; DTS, Davidson Trauma Scale; PSQI, Pittsburgh Sleep Quality Index.

* Significant differences after applying FDR ($p < .05$).

[†] Difference was only significant for aim 1 analyses, not adjusting for the current diagnosis of PTSD.

[‡] The BPI was administered to fewer participants (n=807) in this sample.

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Disclosures: none.

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Behavioral Outcomes

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* Significant differences after applying FDR ($p < .05$).

[†] Difference was only significant for aim 1 analyses, not adjusting for the current diagnosis of PTSD.

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Behavioral Outcomes

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DAST					1.24±2.80* [†]
BPT [‡]					4.28±2.30*
CES					20.02±10.12*

Measures	Non-Deployment TBI (n = 160)			Deployment TBI (n = 140)		
	M	SD	range	M	SD	range
AUDIT	4.89	4.69	0-29	5.58	4.87	0-23
PCL-5	32.14	18.75	1-74	36.83	19.27	0-75
PHQ-9	11.75	6.66	0-27	13.15	6.78	0-27
PROMIS-PI	19.41	9.43	8-40	21.24	9.82	8-40
PSQI	11.12	4.21	1-21	11.76	4.24	1-21
NSI	25.59	15.51	1-72	30.26	17.01	2-74

Abstract
Objective: To characterize belt deployment settings.
Design: Cross-sectional assessment diagnoses.
Setting: Veterans Affairs Medical Centers.
Participants: Iraq and Afghanistan Veterans.
Interventions: Not applicable.
Main Outcome Measures: Comorbidity and behavioral and health measures.
Results: There was a main effect of deployment on all measures. Veterans with deployment stress disorders had higher scores on all measures than those who did not.
Conclusions: TBIs acquired during deployment are associated with higher rates of comorbidity and behavioral and health problems. Lifetime prevalence of behavioral and health problems persist chronically after a deployment. Treatment interventions to improve behavioral and health outcomes are needed.
 Archives of Physical Medicine and Rehabilitation. 2018;99(10):1016f. Published by Elsevier Inc. on behalf of the American Congress of Rehabilitation Medicine.

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 Disclosure: none.

an estimated 16% higher.^{2,3,7} TBI is a major concern for health professionals because patients often present with cooccurring mental health and/or medical problems,^{2,3,7} including

Clinical Outcomes



Archives of Physical Medicine and Rehabilitation

Journal homepage: www.archives-pmr.org

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ORIGINAL RESEARCH

Behavioral and Health Outcomes Associated With



Deployment Traumatic Injuries in Veterans

Sarah L. Martindale, PhD
Mid-Atlantic

From the "Research, Education, and Rehabilitation" Program, Winston-Salem, NC, and the Department of Veterans Affairs Medical Center, Winston-Salem, NC.

Abstract

Objective: To examine behavioral and health outcomes in veterans with deployment setting traumatic injuries and comorbid diagnoses.

Design: Cross-sectional.

Setting: Veterans Affairs Medical Center.

Participants: Iraq and Afghanistan veterans.

Interventions: None.

Main Outcome Measures: Behavioral and health outcomes.

Results: There were significant associations between deployment setting traumatic injuries and posttraumatic stress disorder, major depressive disorder, dysthymic disorder, alcohol use disorder, polysubstance use disorder, and anxiety disorder NOS.

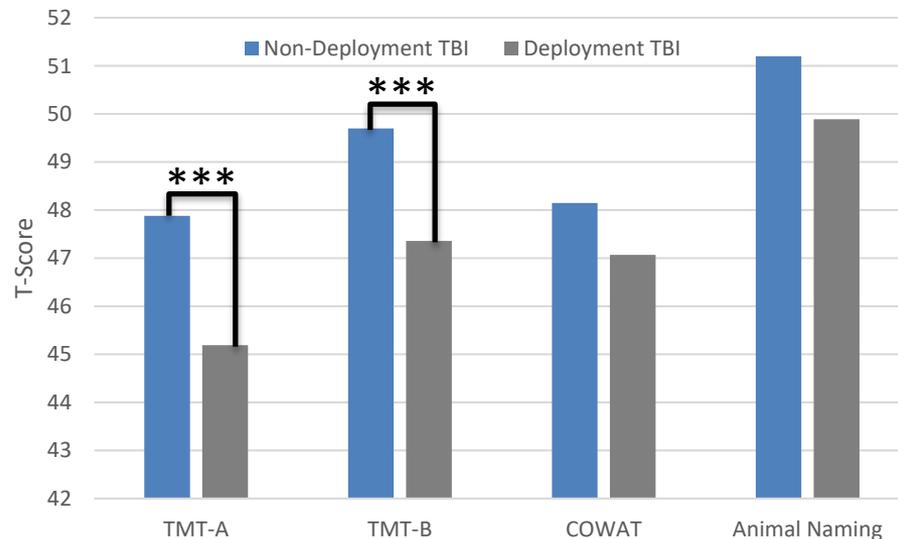
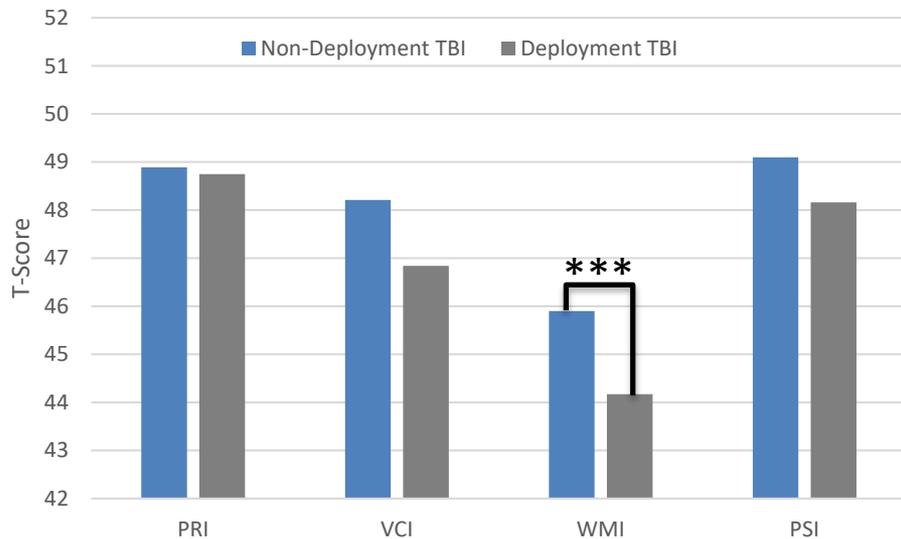
Conclusions: Traumatic brain injury (TBI) is a major concern for health professionals because patients often present with comorbid mental health and/or medical problems, including posttraumatic stress disorder, major depressive disorder, dysthymic disorder, alcohol use disorder, polysubstance use disorder, and anxiety disorder NOS.

Keywords: Traumatic brain injury, posttraumatic stress disorder, major depressive disorder, dysthymic disorder, alcohol use disorder, polysubstance use disorder, anxiety disorder NOS.

Abbreviations: TBI, traumatic brain injury; PTSD, posttraumatic stress disorder; MDD, major depressive disorder; DD, dysthymic disorder; AUD, alcohol use disorder; PUD, polysubstance use disorder; ANOS, anxiety disorder NOS.

Supplemental Digital Content: S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, S15, S16, S17, S18, S19, S20, S21, S22, S23, S24, S25, S26, S27, S28, S29, S30, S31, S32, S33, S34, S35, S36, S37, S38, S39, S40, S41, S42, S43, S44, S45, S46, S47, S48, S49, S50, S51, S52, S53, S54, S55, S56, S57, S58, S59, S60, S61, S62, S63, S64, S65, S66, S67, S68, S69, S70, S71, S72, S73, S74, S75, S76, S77, S78, S79, S80, S81, S82, S83, S84, S85, S86, S87, S88, S89, S90, S91, S92, S93, S94, S95, S96, S97, S98, S99, S100, S101, S102, S103, S104, S105, S106, S107, S108, S109, S110, S111, S112, S113, S114, S115, S116, S117, S118, S119, S120, S121, S122, S123, S124, S125, S126, S127, S128, S129, S130, S131, S132, S133, S134, S135, S136, S137, S138, S139, S140, S141, S142, S143, S144, S145, S146, S147, S148, S149, S150, S151, S152, S153, S154, S155, S156, S157, S158, S159, S160, S161, S162, S163, S164, S165, S166, S167, S168, S169, S170, S171, S172, S173, S174, S175, S176, S177, S178, S179, 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Cognitive Outcomes



Measures	Non-Deployment TBI		Deployment TBI	
	<i>F</i>	η_{sp}^2	<i>F</i>	η_{sp}^2
WAIS-IV PRI	1.47	.005	1.80	.006
WAIS-IV VCI	0.00	< .001	4.88	.017
WAIS-IV WMI	0.01	< .001	5.62	.019
WAIS-IV PSI	1.07	.004	4.09	.014
TMT-A	0.19	.001	15.32	.049
TMT-B	0.18	< .001	9.36	.031
COWAT	0.15	< .001	4.14	.014
Animal Naming	0.89	.003	1.60	.006

Cognitive Outcomes



Neuropsychology

Influence of Blast Exposure

Table 4
Hierarchical Regression Outcomes (N = 254)

Model	Omnibus Model			Parameter Estimates						
	R ²	p	ΔR ² sig	B	SEB	t	p	LLCI	ULCI	
Trail Making Test A (TMT-A)										
Model 1	PTSD Severity	.024	.047	—	-0.11	0.04	-2.49	.014	-0.20	-0.02
Model 2	PTSD Severity	.073	<.001	<.001	-0.09	0.04	-1.93	.055	-0.17	0.00
	Deployment TBI				-4.84	1.34	-3.61	.000	-7.48	-2.20
Model 3	PTSD Severity	.075	.001	.582	-0.09	0.05	-2.05	.042	-0.18	0.00
	Deployment TBI				-5.31	1.48	-3.58	.000	-8.23	-2.39
	Blast Pressure				0.36	0.50	0.73	.463	-0.61	1.34
Trail Making Test B (TMT-B)										
Model 1	PTSD Severity	.009	.334	—	-0.06	0.04	-1.44	.152	-0.14	0.02
Model 2	PTSD Severity	.036	.028	.001	-0.04	0.04	-1.01	.315	-0.12	0.04
	Deployment TBI				-3.24	1.22	-2.65	.009	-5.65	-0.83
Model 3	PTSD Severity	.037	.050	.771	-0.03	0.04	-0.82	.410	-0.12	0.05
	Deployment TBI				-2.87	1.36	-2.12	.035	-5.54	-0.20
	Blast Pressure				-0.29	0.45	-0.64	.526	-1.18	0.61

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Model	PTSD severity	Deployment TBI	Blast pressure	R ²	p	ΔR ² sig	B	SEB	t	p	LLCI	ULCI
Model 1	.024	.047	—	.024	.047	—	-0.11	0.04	-2.49	.014	-0.20	-0.02
Model 2	.073	<.001	<.001	.073	<.001	<.001	-0.09	0.04	-1.93	.055	-0.17	0.00
							-4.84	1.34	-3.61	.000	-7.48	-2.20
Model 3	.075	.001	.582	.075	.001	.582	-0.09	0.05	-2.05	.042	-0.18	0.00
							-5.31	1.48	-3.58	.000	-8.23	-2.39
							0.36	0.50	0.73	.463	-0.61	1.34
Model 1	.009	.334	—	.009	.334	—	-0.06	0.04	-1.44	.152	-0.14	0.02
Model 2	.036	.028	.001	.036	.028	.001	-0.04	0.04	-1.01	.315	-0.12	0.04
							-3.24	1.22	-2.65	.009	-5.65	-0.83
Model 3	.037	.050	.771	.037	.050	.771	-0.03	0.04	-0.82	.410	-0.12	0.05
							-2.87	1.36	-2.12	.035	-5.54	-0.20
							-0.29	0.45	-0.64	.526	-1.18	0.61

Note. R² = coefficient of determination; ΔR² sig = p value for change in R²; B = unstandardized beta; SEB = standard error of beta; LLCI = lower-limit confidence interval; ULCI = upper-limit confidence interval; PTSD = posttraumatic stress disorder; TBI = traumatic brain injury. To be considered significant, omnibus models needed to be significant overall, have a significant ΔR², and survive correction for multiple comparisons. Results are corrected for multiple comparisons using the false-discovery rate for six hierarchical regression analyses. Bolded models are significant after correction. PTSD severity = Clinician-Administered PTSD Scale (CAPS-5) current severity score (0-78). For deployment TBI, 0 = absent, 1 = present. Blast pressure = maximum pressure experienced (0-5).

Cognitive Outcomes



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Influence of Blast Exposure on Cognitive Functioning in Combat

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Objective: We evaluated the contribution of blast-pressure severity to cognitive functioning beyond posttraumatic stress disorder (PTSD) severity and traumatic brain injury (TBI). **Method:** Post-9/11 veterans ($N = 254$, 86.22% male) completed the Wechsler Adult Intelligence Scale (WAIS-IV) and Trail Making Test (TMT). The Clinician-Administered PTSD Scale (CAPS-5), Mid-Atlantic MIRECC Assessment of TBI, and the Salisbury Blast Interview evaluated PTSD diagnosis/severity, deployment TBI history/severity, and blast-exposure history/severity, respectively. **Results:** Veterans with mild deployment TBI had overall significantly lower T scores on the WAIS-IV Verbal Comprehension Index ($d = .13$), Working Memory Index ($d = .30$), and Processing Speed Index ($d = .25$); the Trail Making Test A (TMT-A; $d = .50$); and the Trail Making Test B (TMT-B; $d = .57$). Mild deployment TBI was significantly associated with TMT-A ($\Delta R^2 = .05$, $p < .001$) and TMT-B ($\Delta R^2 = .03$, $p = .001$) performance. Blast-pressure severity moderated the association between mild deployment TBI and TMT-A ($\Delta R^2 = .02$, $p = .039$, $B = -2.01$). **Conclusion:** Blast-pressure severity exacerbated the effects of mild TBI on a simple attention task, such that participants with TBI had gradual decrements in attention as blast severity increased. Veterans who incur a TBI and are exposed to blasts during deployment may experience persisting difficulties with cognitive functioning as a result of alterations in basic attention abilities.

Key Points

Question: Does experiencing a blast/explosion during deployment affect cognitive functioning beyond other mental health factors? **Findings:** Exposure to a blast/explosion was not a primary factor in cognitive outcomes but exacerbated the negative effects of other conditions on cognitive outcomes. **Importance:** Exposure to blast/explosions during deployment may contribute to lower cognitive functioning when other conditions are present. **Next Steps:** Identifying specific characteristics of blast exposure (e.g., number of exposures, distance) that are predictive of functional outcomes will be important in elucidating how exposure to blasts affects veterans long term.

Keywords: blast, veteran, cognition, posttraumatic stress disorder, traumatic brain injury

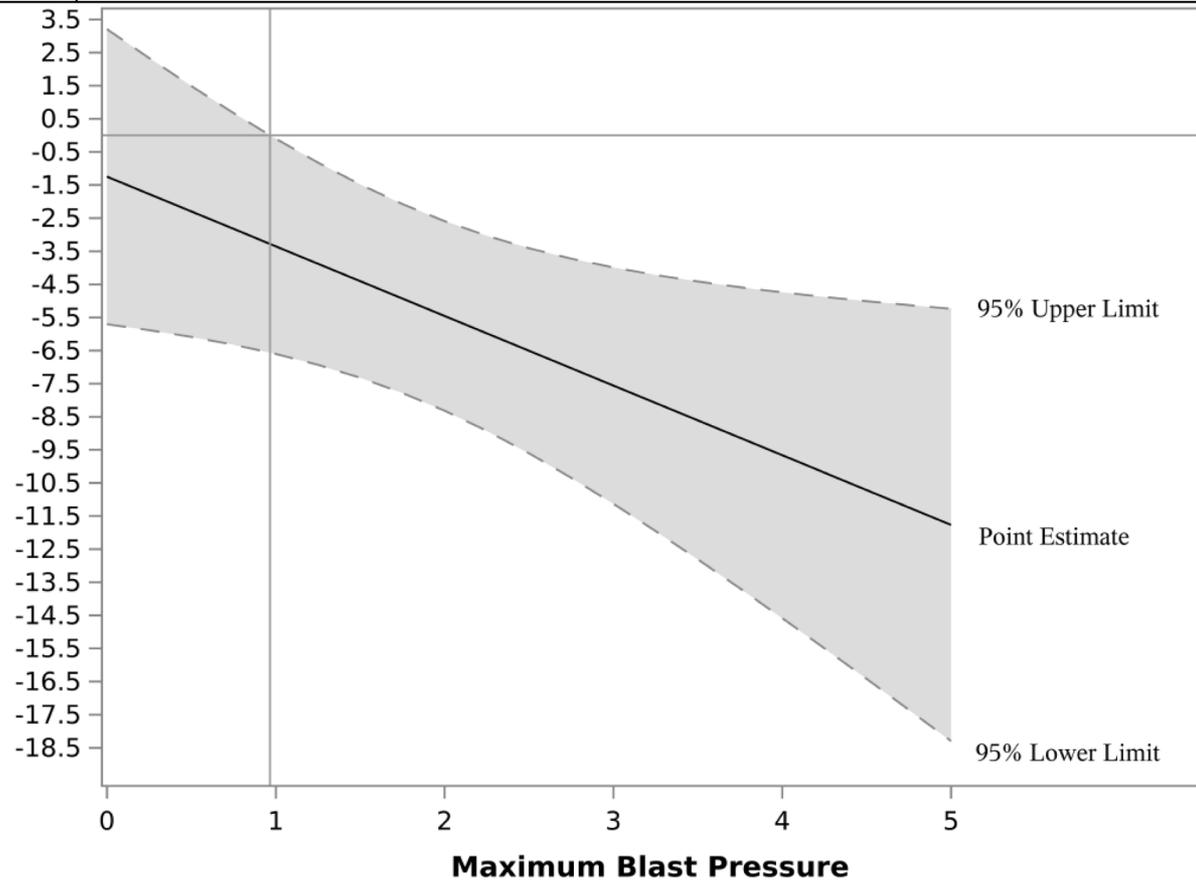
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Conditional Effect of Deployment TBI on TMT-A



Cognitive Outcomes



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Influence of Blast Exposure on Cognitive Functioning in Combat

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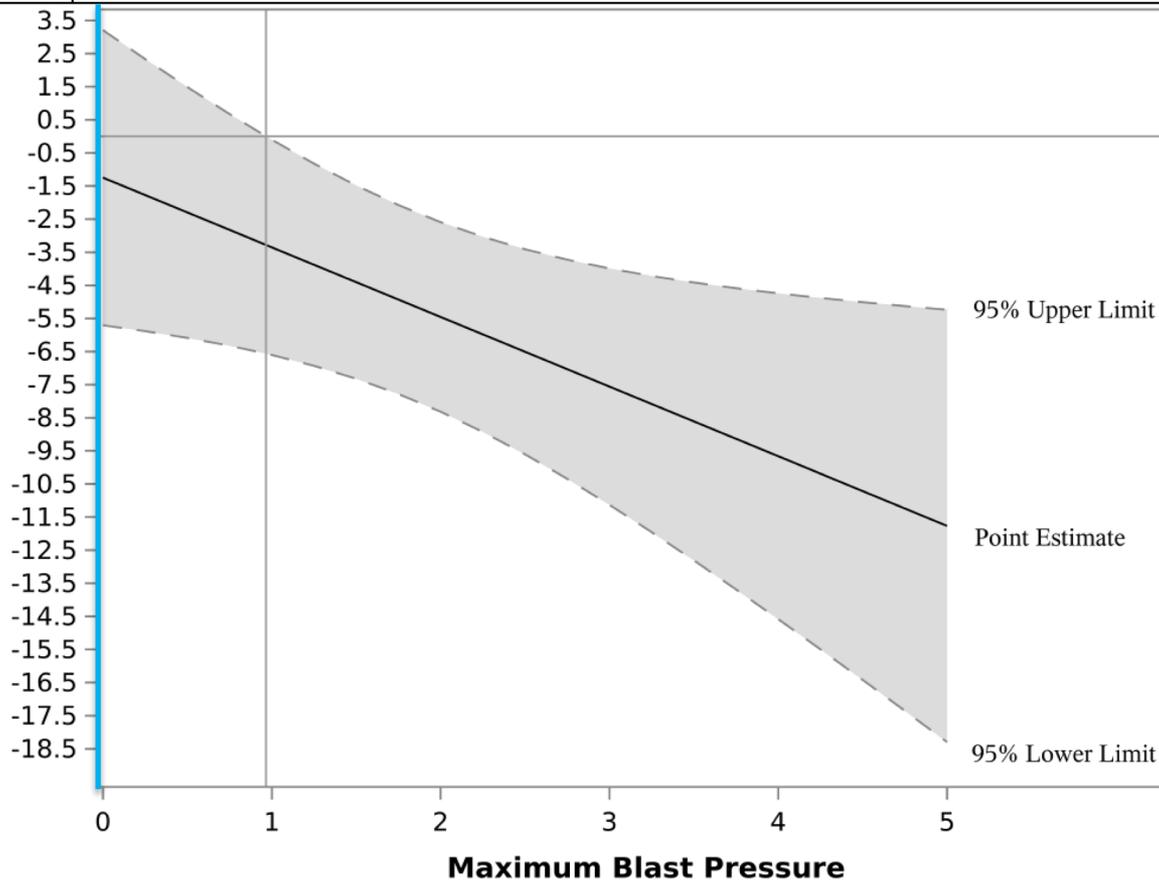
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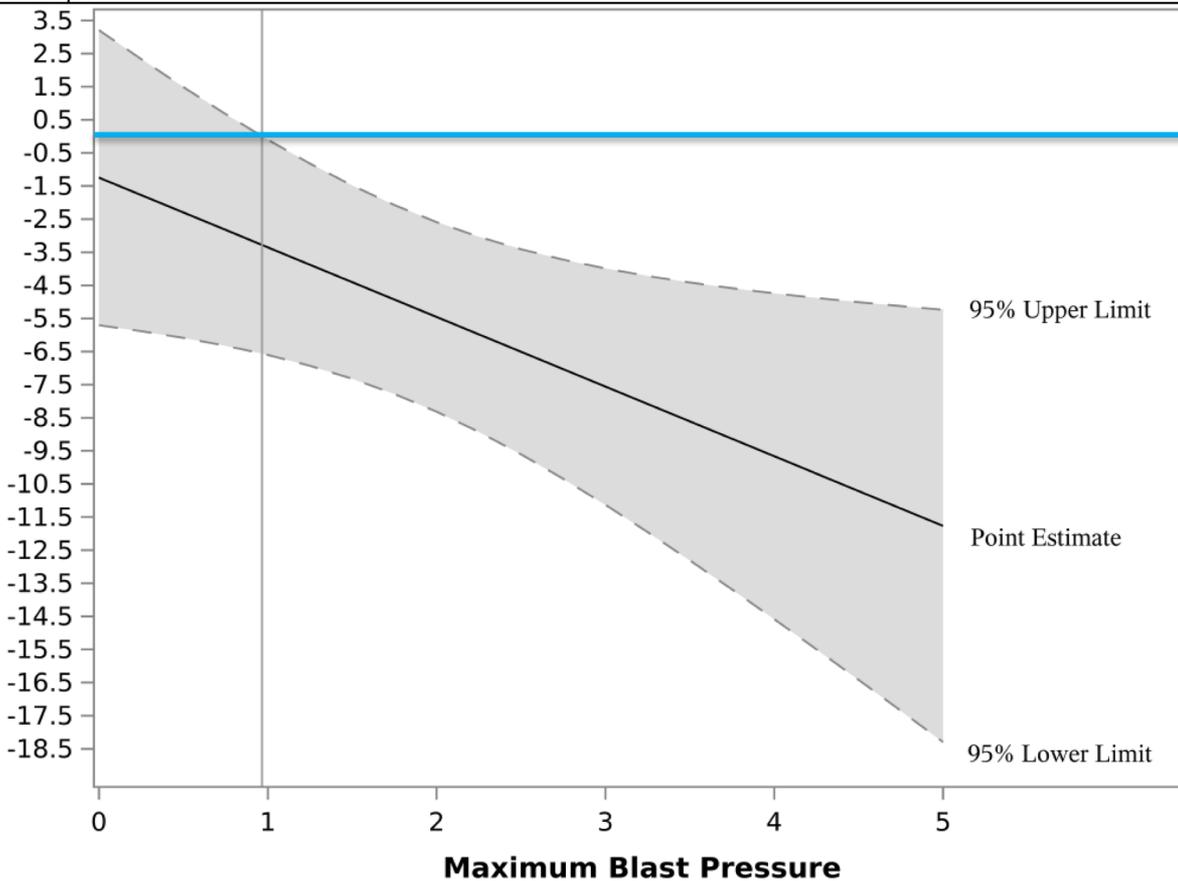
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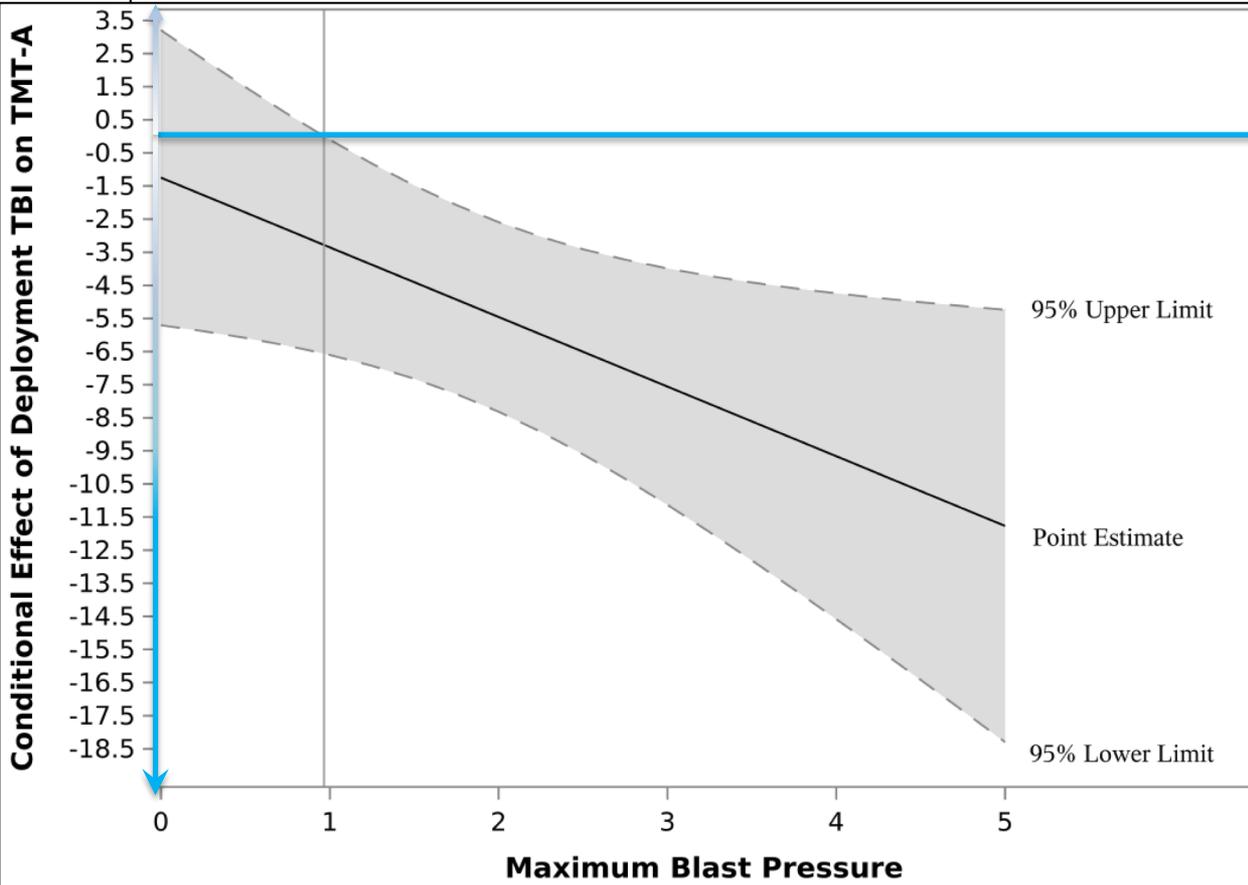
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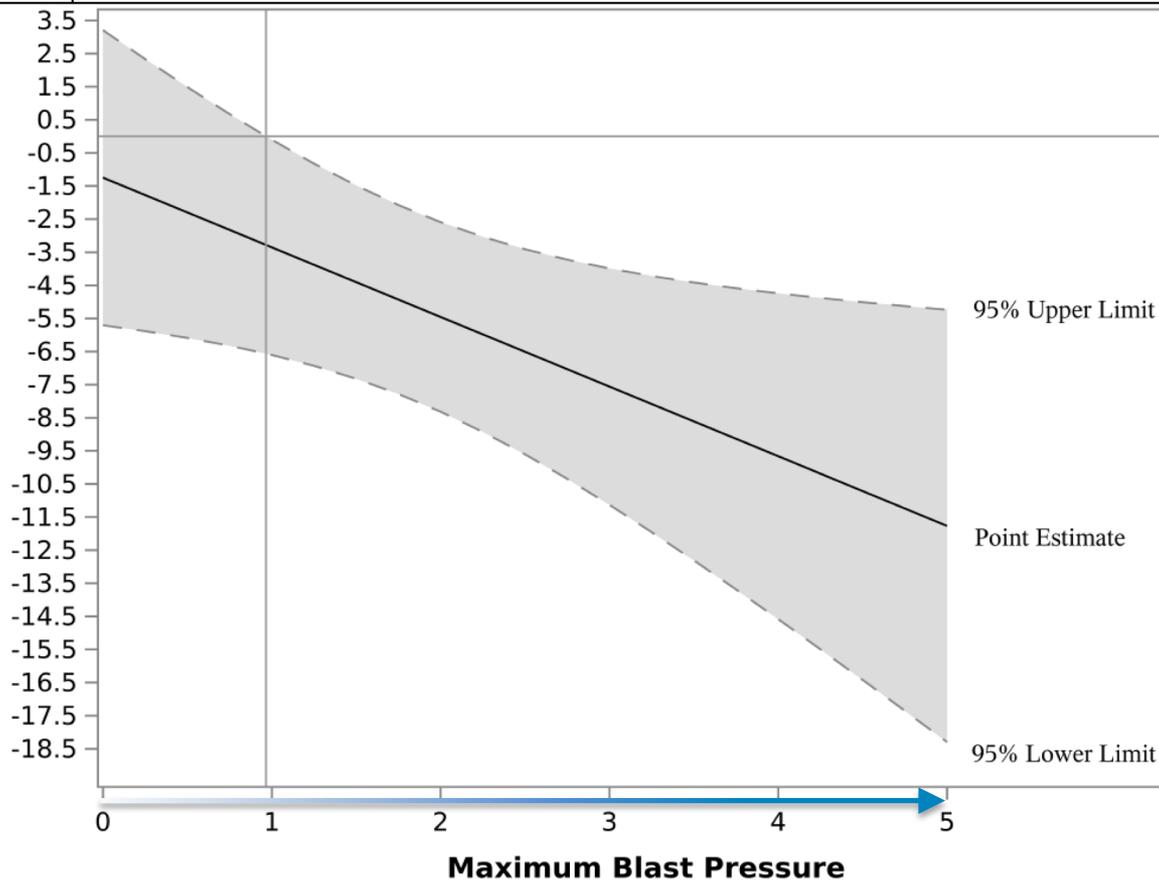
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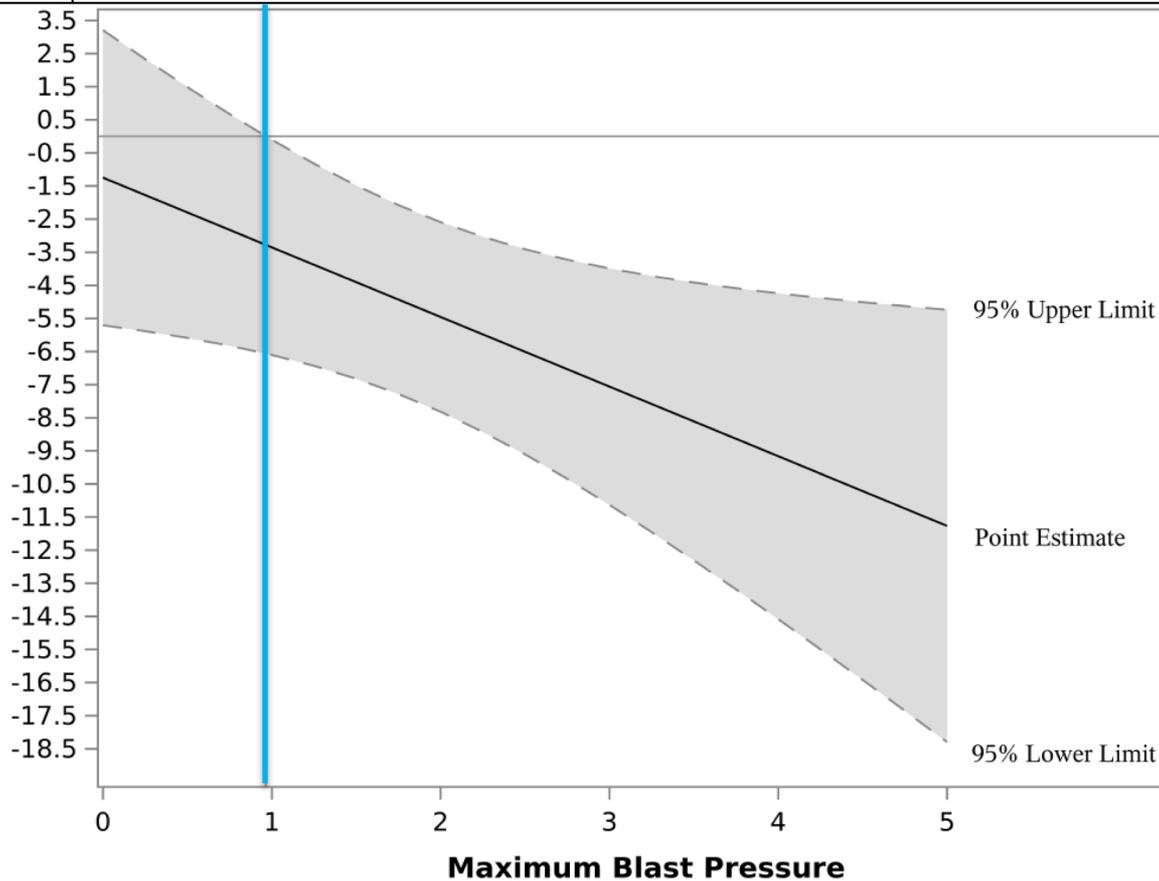
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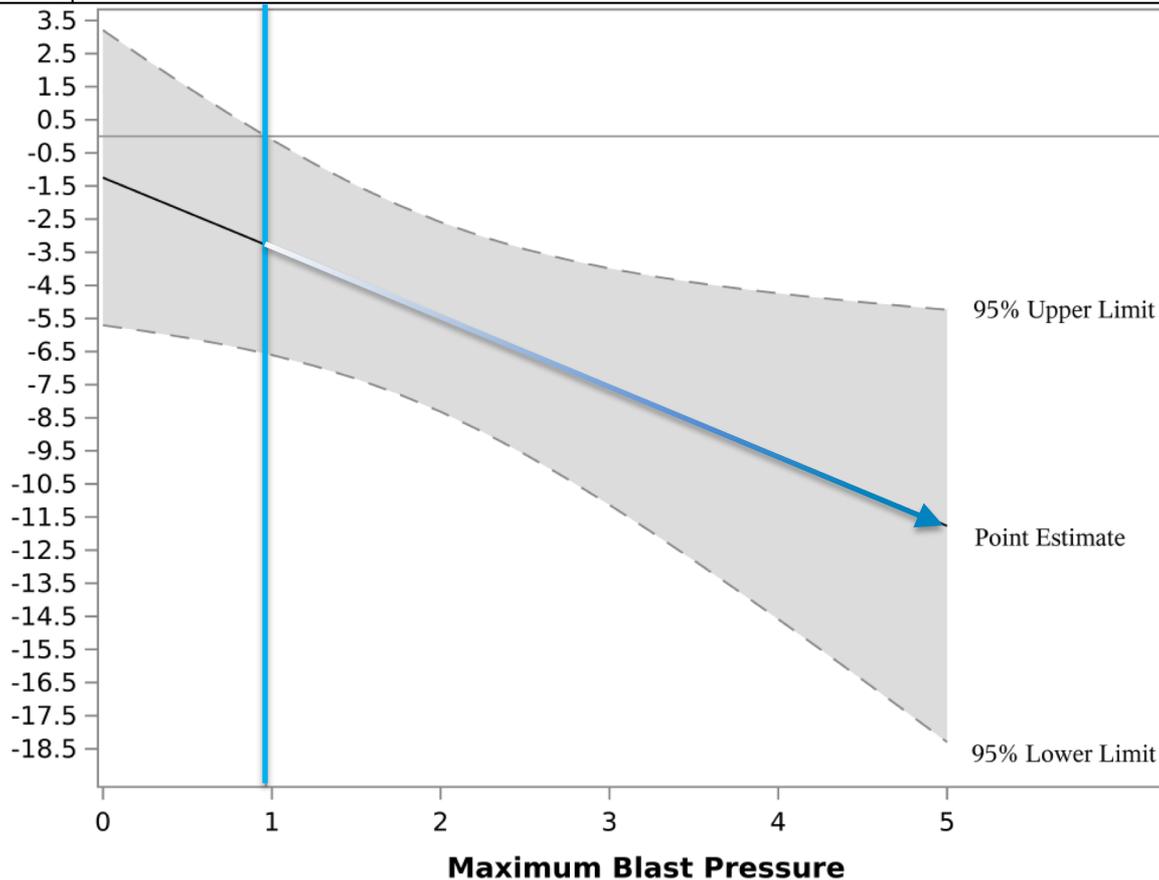
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Behavioral Summary

Cognitive Function

- Attention
- Executive function
- Altered by blast exposure

Symptom Report

- Posttraumatic stress symptoms
- Depressive
- Sleep
- Neurobehavioral
- Pain
- Substance use

Psychiatric Diagnoses

- Posttraumatic Stress Disorder
- Depression
- Alcohol Use Disorder

Neuroimaging: Structural Volume

J Head Trauma Rehabil
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Brain Volume in Veterans: Relationship to Posttraumatic Stress Disorder and Mild Traumatic Brain Injury

Sarah L. Martindale, PhD; Ramona Rostami, PhD; Robert D. Shura, PsyD;
Katherine H. Taber, PhD; Jared A. Rowland, PhD

Objective: Clarify associations between diagnosis of posttraumatic stress disorder (PTSD) and deployment traumatic brain injury (TBI) on salient regional brain volumes in returning combat veterans. **Participants:** Iraq and Afghanistan era combat veterans, $N = 163$, 86.5% male. **Main Measures:** Clinician-administered PTSD Scale (CAPS-5), Mid-Atlantic MIRECC Assessment of TBI (MMA-TBI), magnetic resonance imaging. **Methods:** Hierarchical regression analyses evaluated associations and interactions between current and lifetime PTSD diagnosis, deployment TBI, and bilateral volume of hippocampus, anterior cingulate cortex, amygdala, orbitofrontal cortex, prefrontal, and insula. **Results:** Deployment TBI was associated with lower bilateral hippocampal volume ($F = .007$, $.032$) and right medial orbitofrontal cortex volume ($P = .006$). Neither current nor lifetime PTSD diagnosis was associated with volumetric outcomes beyond covariates and deployment TBI. **Conclusion:** History of deployment TBI is independently associated with lower volumes in hippocampus and medial orbitofrontal cortex. These results support TBI as a potential contributing factor to consider in reduced cortical volume in PTSD. **Key words:** anterior cingulate cortex; brain volume; hippocampus; PTSD; TBI; veteran

Author Affiliations: Mid-Atlantic Mental Illness Research, Education, and Clinical Center (MIRECC), Research & Academic Affairs Service Line (Dr. Martindale, Taber, and Rowland), and Mental Health & Behavioral Sciences Service Line (Dr. Rostami and Shura), Salisbury VA Medical Center, Salisbury, North Carolina; Departments of Physiology & Pharmacology (Dr. Martindale), Neurology (Dr. Shura), and Neurobiology & Anatomy (Dr. Rowland), Wake Forest School of Medicine, Winston-Salem, North Carolina; Division of Biomedical Sciences, Via College of Osteopathic Medicine, Blacksburg, Virginia (Dr. Taber), and Department of Physical Medicine & Rehabilitation, Baylor College of Medicine, Houston, Texas (Dr. Taber). Dr. Rostami is now with the Edith Nourse Rogers Bechtel VA Medical Center, Bedford, Massachusetts.

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Corresponding Author: Sarah L. Martindale, PhD, Research & Academic Affairs Service Line, Salisbury VA Medical Center, 1601 Brenner Ave (11M), Salisbury, NC 28144 (Sarah.Martindale-Spahr@va.gov)

POSTTRAUMATIC STRESS DISORDER (PTSD) is one of the most commonly diagnosed psychiatric disorders among veterans who have deployed in support of Operation Enduring Freedom/Operation Iraqi Freedom/Operation New Dawn (OEF/OIF/OND), with prevalence rates estimated at 13.8%.^{1,2} In addition to PTSD, service members experience many events that can lead to a traumatic brain injury (TBI) during deployment. Veterans with mild TBI acquired during combat are 2.37 times more likely to meet criteria for PTSD,³ and those with PTSD are more likely to report postconcussive symptoms persisting at 5 or more months after the injury.

Evidence links PTSD to several brain structures through functional connections and structural volumes as both potential risk factors and outcomes. Structures most commonly implicated are involved in emotional processing, including hippocampus, amygdala, anterior cingulate cortex (ACC), prefrontal cortex, and insula.⁴⁻⁷ Prevailing evidence supports differences in neuroanatomical structural volume as a premorbid risk

TABLE 2 Hierarchical regressions ($N = 163$)^a

Model	ANOVA			Model change		Parameter estimates					
	R ²	F	P	ΔR ²	P	B	SEB	t	P	LLCI	ULCI
L Hippocampus											
Model 1											
Current PTSD	0.063	3.55	.016	0.008	.509	-0.18	0.50	-0.35	.723	-1.16	0.81
Lifetime PTSD						-0.07	0.45	-0.14	.886	-0.96	0.83
Model 2											
Current PTSD	0.090	3.91	.005	0.027	.032	0.06	0.50	0.12	.904	-0.93	1.05
Lifetime PTSD						0.16	0.46	0.35	.726	-0.75	1.07
Deployment TBI						-0.88	0.40	-2.18	.031	-1.67	-0.08
R Hippocampus											
Model 1											
Current PTSD	0.038	2.07	.106	0.009	.477	-0.16	0.51	-0.31	.758	-1.17	0.85
Lifetime PTSD						0.04	0.47	0.09	.926	-0.88	0.97
Model 2											
Current PTSD	0.082	3.54	.009	0.044	.007	0.15	0.51	0.29	.771	-0.87	1.17
Lifetime PTSD						0.34	0.47	0.72	.474	-0.59	1.27
Deployment TBI						-1.14	0.41	-2.77	.006	-1.96	-0.33
L Rostral ACC											
Model 1											
Current PTSD	0.002	0.19	.827	—	—	0.03	0.56	0.05	.963	-1.07	1.13
Lifetime PTSD						-0.29	0.53	-0.55	.585	-1.35	0.76
Model 2											
Current PTSD	0.014	0.77	.513	0.012	.166	0.23	0.57	0.40	.692	-0.91	1.36
Lifetime PTSD						-0.12	0.55	-0.23	.822	-1.20	0.96
Deployment TBI						-0.66	0.48	-1.39	.167	-1.60	0.28
R Rostral ACC											
Model 1											
Current PTSD	0.035	1.92	.129	0.009	.529	0.47	0.46	1.02	.312	-0.44	1.38
Lifetime PTSD						-0.08	0.43	-0.20	.844	-0.93	0.76
Model 2											
Current PTSD	0.035	1.43	.226	0.000	.898	0.48	0.48	1.01	.312	-0.46	1.42
Lifetime PTSD						-0.07	0.44	-0.16	.871	-0.95	0.80
Deployment TBI						-0.05	0.39	-0.12	.902	-0.81	0.72
L Caudal ACC											
Model 1											
Current PTSD	0.031	1.71	.166	0.004	.698	-0.03	0.57	-0.06	.956	-1.16	1.10
Lifetime PTSD						-0.43	0.54	-0.80	.428	-1.49	0.64

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Neuroimaging: Structural Volume

Brain Volume Relationship Disorder and Injury

Sarah L. Martindale, PhD
Katherine H. Taber, PhD

Objective: Clarify association brain injury (TBI) on salient era combat veterans, $N = 14$ Atlantic MIRECC Assessment analyses evaluated association bilateral volume of hippocampus
Results: Deployment TBI was orbital frontal cortex volume outcomes beyond covariate associated with lower volume potential contributing factor brain volume, hippocampus, PTSD

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insula.^{4,7} Prevailing evidence supports differences in neuroanatomical structural volume as a premorbid risk

DOI: 10.1097/ITR.0000000000000559

Model	ANOVA			Model change		
	R^2	F	P	ΔR^2	P	
L Hippocampus						
Model 1						
Current PTSD	0.063	3.55	.016	0.008	.509	
Lifetime PTSD						
Model 2	0.090	3.91	.005	0.027	.032	
Current PTSD						
Lifetime PTSD						
Deployment TBI						
Parameter estimates						
L Hippocampus	B	SEB	t	P	LLCI	ULCI
Model 1						
Current PTSD	-0.18	0.50	-0.35	.723	-1.16	0.81
Lifetime PTSD	-0.07	0.45	-0.14	.886	-0.96	0.83
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Current PTSD	0.06	0.50	0.12	.904	-0.93	1.05
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Neuroimaging: Structural Volume

Brain Volume
Relationship
Disorder and
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Objective: Clarify association between brain injury (TBI) on salient era combat veterans, $N = 14$. Atlantic MIRECC Assessment analyses evaluated association bilateral volume of hippocampus.
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Lifetime PTSD						
Deployment TBI						
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Current PTSD	-0.16	0.51	-0.31	.758	-1.17	0.85
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Neuroimaging: Structural Volume

Brain Volume
Relationship
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DOI: 10.1097/ITR.0000000000000559

Model	ANOVA			Model change		
	R^2	F	P	ΔR^2	P	
R Medial OFC						
Model 1						
Current PTSD	0.053	2.95	.034	0.003	.778	
Lifetime PTSD						
Model 2	0.097	4.24	.003	0.044	.006	
Current PTSD						
Lifetime PTSD						
Deployment TBI						
	Parameter estimates					
R Medial OFC	B	SEB	t	P	LLCI	ULCI
Model 1						
Current PTSD	0.40	0.65	0.62	.537	-0.89	1.70
Lifetime PTSD	0.31	0.63	0.49	.627	-0.94	1.56
Model 2						
Current PTSD	0.86	0.66	1.30	.197	-0.45	2.16
Lifetime PTSD	0.74	0.64	1.16	.246	-0.52	2.00
Deployment TBI	-1.55	0.56	-2.78	.006	-2.65	-0.45

LLCI
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Neuroimaging: Structural Volume

J Head Trauma Rehabil
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Brain Volume in Veterans: Relationship to Posttraumatic Stress Disorder and Mild Traumatic Brain Injury

Sarah L. Martindale, PhD; Ramona Rostami, PhD; Robert D. Shura, PsyD;
Katherine H. Taber, PhD; Jared A. Rowland, PhD

Objective: Clarify associations between diagnosis of posttraumatic stress disorder (PTSD) and deployment traumatic brain injury (TBI) on salient regional brain volumes in returning combat veterans. **Participants:** Iraq and Afghanistan era combat veterans, $N = 163$, 86.5% male. **Main Measures:** Clinician-administered PTSD Scale (CAPS-5), Mid-Atlantic MIRECC Assessment of TBI (MMA-TBI), magnetic resonance imaging. **Methods:** Hierarchical regression analyses evaluated associations and interactions between current and lifetime PTSD diagnosis, deployment TBI, and bilateral volume of hippocampus, anterior cingulate cortex, amygdala, orbitofrontal cortex, precuneus, and insula. **Results:** Deployment TBI was associated with lower bilateral hippocampal volume ($F = .007$, $.032$) and right medial orbitofrontal cortex volume ($P = .006$). Neither current nor lifetime PTSD diagnosis was associated with volumetric outcomes beyond covariates and deployment TBI. **Conclusion:** History of deployment TBI is independently associated with lower volumes in hippocampus and medial orbitofrontal cortex. These results support TBI as a potential contributing factor to consider in reduced cortical volume in PTSD. **Key words:** anterior cingulate cortex, brain volume, hippocampus, PTSD, TBI, veteran

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Evidence links PTSD to several brain structures through functional connections and structural volumes as both potential risk factors and outcomes. Structures most commonly implicated are involved in emotional processing, including hippocampus, amygdala, anterior cingulate cortex (ACC), prefrontal cortex, and insula.⁴⁻⁷ Prevailing evidence supports differences in neuroanatomical structural volume as a premonitory risk

TABLE 3 Moderation analyses ($N = 163$)^a

TBI interaction model	Model change		Parameter estimates					
	ΔR^2	P	B	SEB	t	P	LLCI	ULCI
L Hippocampus								
Current PTSD	0.001	.739	0.29	0.88	0.33	.739	-1.44	2.03
Lifetime PTSD	0.002	.569	-0.49	0.85	-0.57	.569	-2.17	1.20
R Hippocampus								
Current PTSD	0.003	.474	0.64	0.90	0.72	.474	-1.13	2.42
Lifetime PTSD	0.002	.591	0.47	0.87	0.54	.591	-1.25	2.20
L Rostral ACC								
Current PTSD	0.000	.795	-0.27	1.04	-0.26	.795	-2.32	1.78
Lifetime PTSD	0.004	.445	0.76	0.99	0.77	.445	-1.20	2.71
R Rostral ACC								
Current PTSD	0.002	.626	-0.41	0.84	-0.49	.626	-2.07	1.25
Lifetime PTSD	0.001	.629	-0.39	0.81	-0.48	.629	-1.99	1.20
L Caudal ACC								
Current PTSD	0.008	.257	-1.19	1.04	-1.14	.257	-3.25	0.87
Lifetime PTSD	0.009	.219	1.23	1.00	1.23	.219	-0.74	3.20
R Caudal ACC								
Current PTSD	0.006	.349	-1.00	1.07	-0.94	.349	-3.11	1.10
Lifetime PTSD	0.001	.691	0.41	1.02	0.40	.691	-1.61	2.43
L Amygdala								
Current PTSD	0.032	.020	1.02	0.43	2.35	.020	0.16	1.88
Lifetime PTSD	0.000	.769	-0.11	0.43	-0.27	.769	-0.96	0.73
R Amygdala								
Current PTSD	0.017	.091	0.82	0.48	1.70	.091	-0.13	1.78
Lifetime PTSD	0.000	.822	-0.11	0.48	-0.23	.822	-1.05	0.83
L Lateral OFC								
Current PTSD	0.000	.810	0.37	1.56	0.24	.810	-2.70	3.45
Lifetime PTSD	0.001	.703	0.57	1.49	0.38	.703	-2.37	3.51
R Lateral OFC								
Current PTSD	0.013	.139	2.31	1.56	1.49	.139	-0.76	5.39
Lifetime PTSD	0.011	.172	-2.06	1.50	-1.37	.172	-5.02	0.90
L Medial OFC								
Current PTSD	0.002	.625	0.61	1.24	0.49	.625	-1.83	3.04
Lifetime PTSD	0.014	.131	1.78	1.17	1.52	.131	-0.54	4.10
R Medial OFC								
Current PTSD	0.008	.234	1.43	1.20	1.20	.234	-0.93	3.79
Lifetime PTSD	0.001	.777	-0.33	1.15	-0.28	.777	-2.59	1.94
L Precuneus								
Current PTSD	0.000	.986	0.05	2.53	0.02	.986	-4.94	5.04
Lifetime PTSD	0.005	.377	2.11	2.38	0.89	.377	-2.60	6.82
R Precuneus								
Current PTSD	0.002	.556	1.54	2.60	0.59	.556	-3.60	6.67
Lifetime PTSD	0.007	.280	2.67	2.47	1.08	.280	-2.20	7.55
L Insula								
Current PTSD	0.001	.755	-0.51	1.64	-0.31	.755	-3.74	2.72
Lifetime PTSD	0.000	.909	-0.18	1.57	-0.11	.909	-3.27	2.91
R Insula								
Current PTSD	0.005	.371	-1.39	1.55	-0.90	.371	-4.46	1.67
Lifetime PTSD	0.001	.653	0.67	1.49	0.45	.653	-2.27	3.61

Neuroimaging: Structural Volume

Brain Volume in Veterans: Relationships with Disorders and Injury

J Hoar Trauma Rehabil
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TBI interaction model	Model change		Parameter estimates					
	ΔR^2	P	B	SEB	t	P	LLCI	ULCI
L Amygdala								
Current PTSD	0.032	.020	1.02	0.43	2.35	.020	0.16	1.88
Lifetime PTSD	0.000	.789	-0.11	0.43	-0.27	.789	-0.96	0.73

Brain volume, hippocampus, PTSD, TBI, veteran

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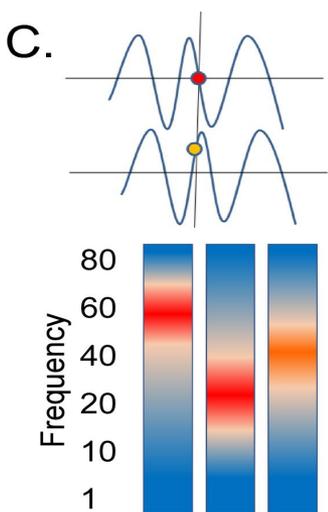
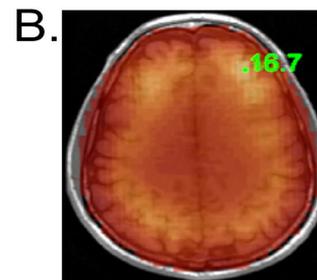
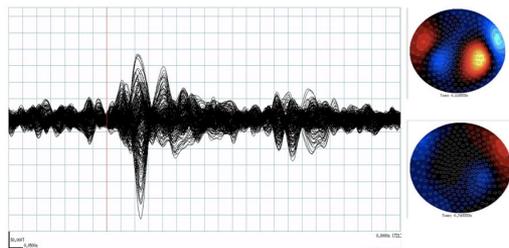
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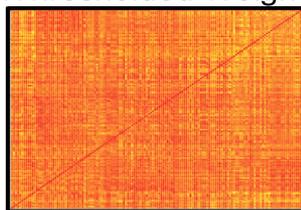
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Lifetime PTSD	0.000	.822	-0.11	0.48	-0.23	.822	-1.05	0.83
L Lateral OFC								
Current PTSD	0.000	.810	0.37	1.56	0.24	.810	-2.70	3.45
Lifetime PTSD	0.001	.703	0.57	1.49	0.38	.703	-2.37	3.51
R Lateral OFC								
Current PTSD	0.013	.139	2.31	1.56	1.49	.139	-0.76	5.39
Lifetime PTSD	0.011	.172	-2.06	1.50	-1.37	.172	-5.02	0.90
L Medial OFC								
Current PTSD	0.002	.625	0.61	1.24	0.49	.625	-1.83	3.04
Lifetime PTSD	0.014	.131	1.78	1.17	1.52	.131	-0.54	4.10
R Medial OFC								
Current PTSD	0.008	.234	1.43	1.20	1.20	.234	-0.93	3.79
Lifetime PTSD	0.001	.777	-0.33	1.15	-0.28	.777	-2.59	1.94
L Precuneus								
Current PTSD	0.000	.986	0.05	2.53	0.02	.986	-4.94	5.04
Lifetime PTSD	0.005	.377	2.11	2.38	0.89	.377	-2.60	6.82
R Precuneus								
Current PTSD	0.002	.556	1.54	2.60	0.59	.555	-3.60	6.67
Lifetime PTSD	0.007	.280	2.67	2.47	1.08	.280	-2.20	7.55
L Insula								
Current PTSD	0.001	.755	-0.51	1.64	-0.31	.755	-3.74	2.72
Lifetime PTSD	0.000	.909	-0.18	1.57	-0.11	.909	-3.27	2.91
R Insula								
Current PTSD	0.005	.371	-1.39	1.55	-0.90	.371	-4.46	1.67
Lifetime PTSD	0.001	.653	0.67	1.49	0.45	.653	-2.27	3.61

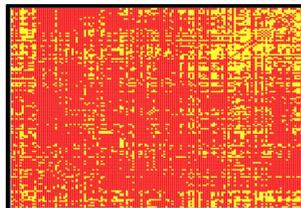
Neuroimaging: Networks



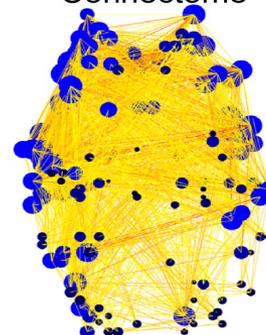
D. UnThresholded Weighted



Thresholded Binarized



E. Participant Specific Connectome

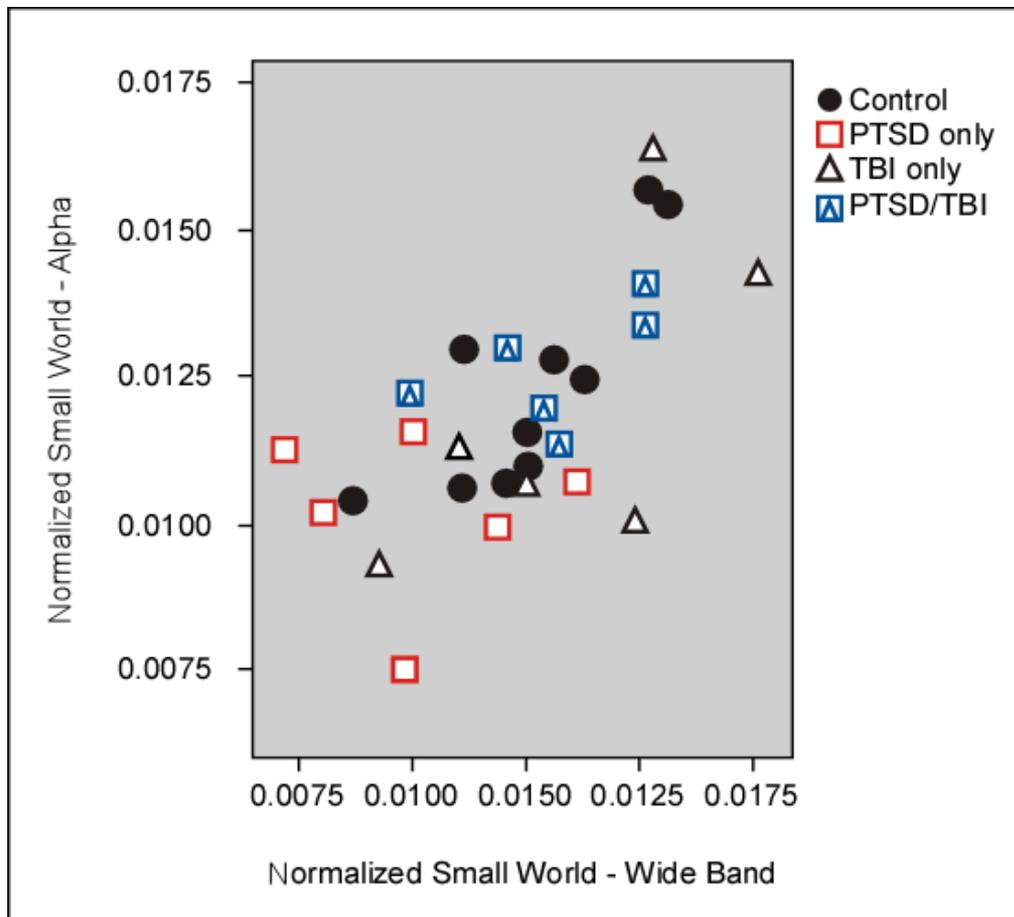
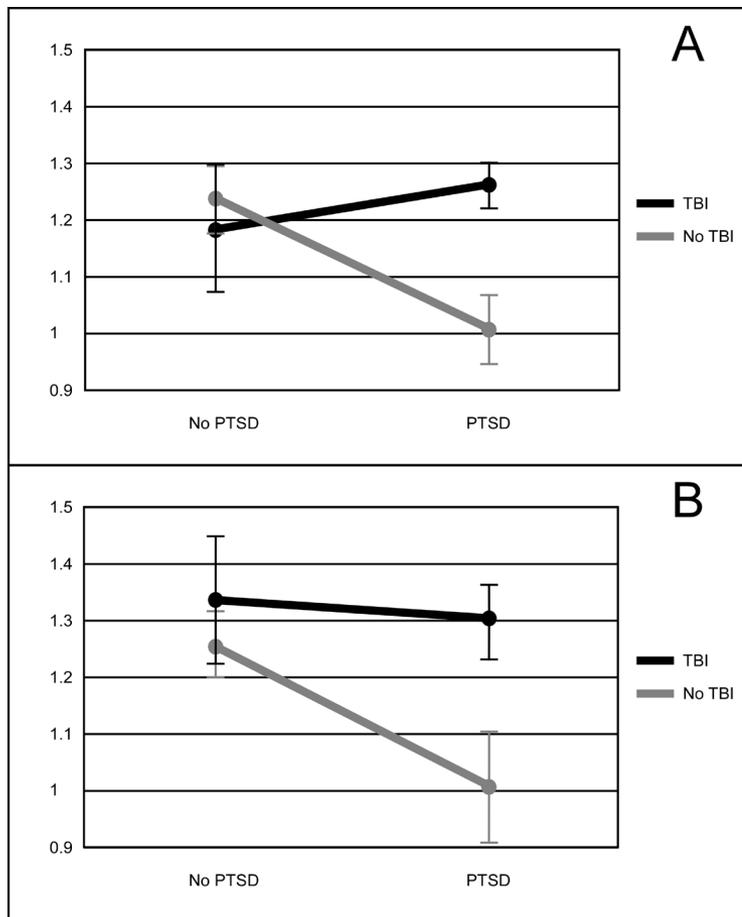


Metrics

Clustering Coefficient = 0.15

Global Efficiency = 0.81

Neuroimaging: Networks



Neuroimaging: Networks

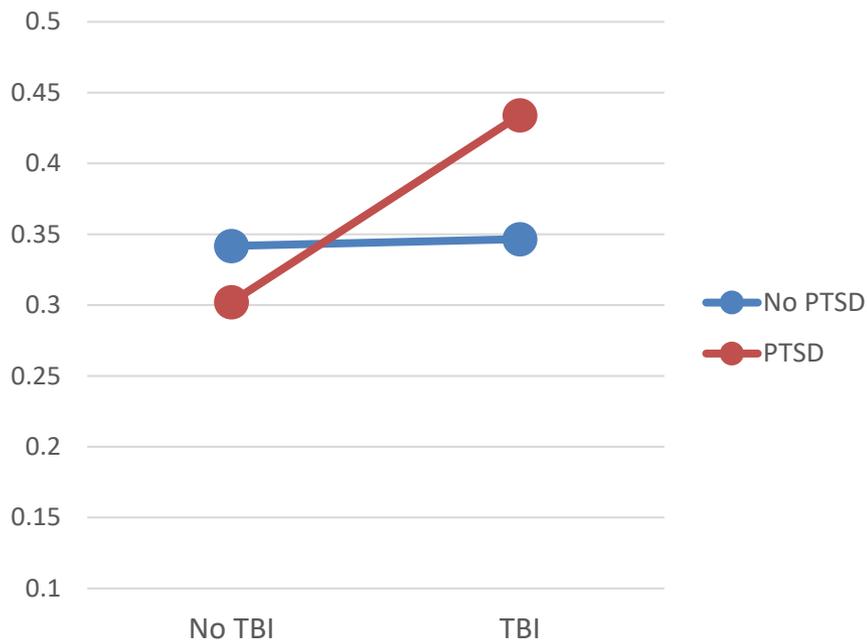
Non-Standardized Parameter Estimates

	Deployment TBI	PTSD	PTSD-TBI Interaction
Nodes	-2.01	9.64*	-14.32*
Average Degree	.203	-.534*	.813*
Theta Connections	.003	.230	.238
Global Efficiency	1.65	-7.07*	9.69
Modularity	.038	-.033	.083*
Cluster Coefficient	.005	-.040	.127*
Rich Club Coefficient	.039	-.077	.341

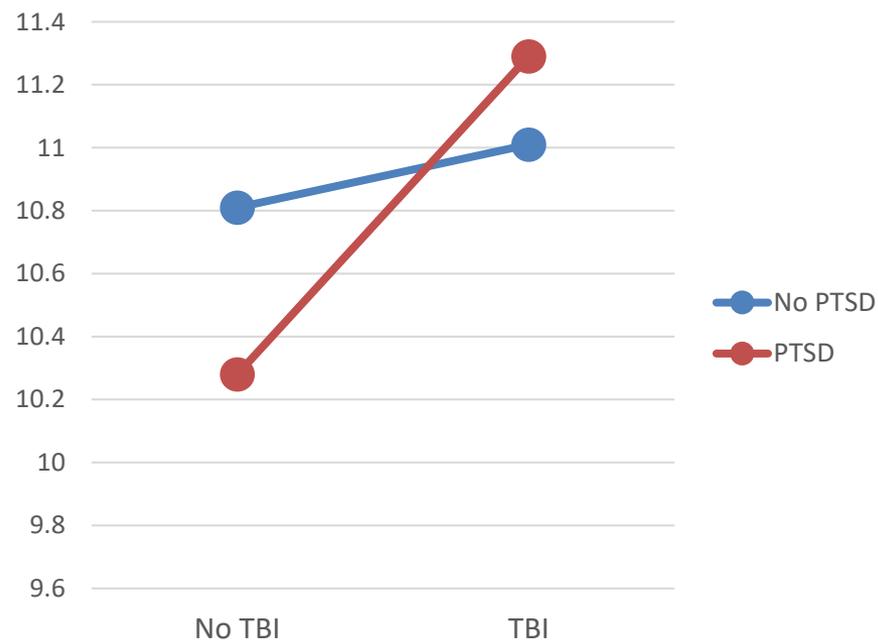
Note. $n = 181$, *significant following FDR correction at $p < .05$.

Neuroimaging: Networks

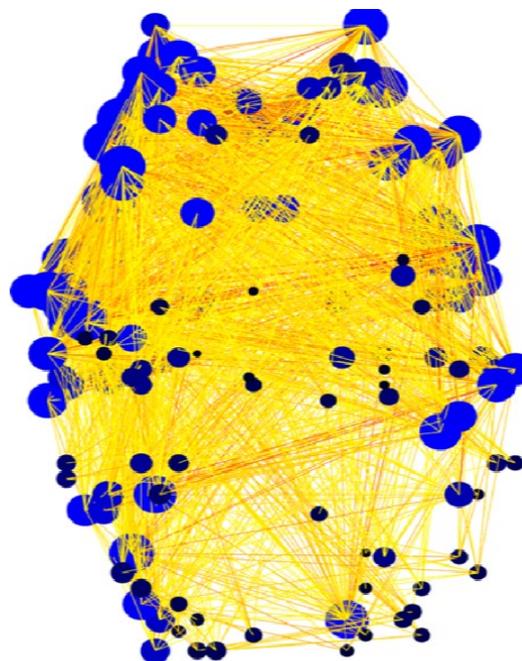
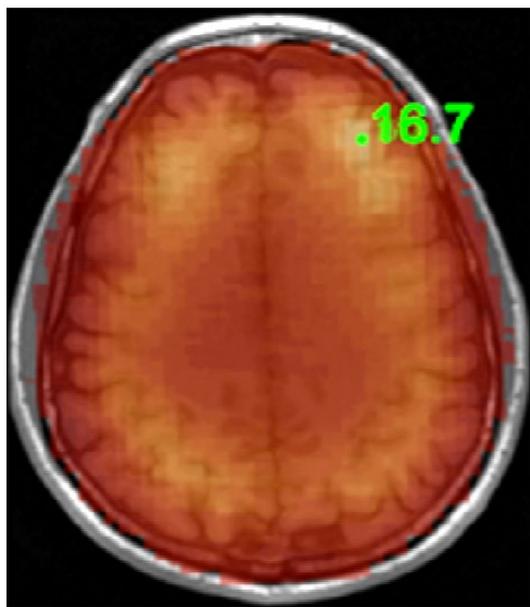
Clustering Coefficient



Average Degree



Summary



Conclusions



Deployment TBI is uniquely associated with negative outcomes.

Conclusions

Deployment TBI is uniquely associated with

Table 3 Outcome and covariate descriptive measures for aims 1 and 2

Measure	Total Sample (N=1399) Mean ± SD	Nondeployment TBI		Deployment TBI	
		– (n=835) Mean ± SD	+ (n=564) Mean ± SD	– (n=1071) Mean ± SD	+ (n=328) Mean ± SD
BDI-II	14.79±12.67	14.08±12.98	15.84±12.12	12.74±12.08*	21.50±12.24*
DTS	41.30±39.67	39.20±40.32	44.42±38.52	33.82±36.98*	65.73±38.37*
PSQI	9.57±4.90	9.29±4.96	9.98±4.77	8.78±4.75*	12.16±4.46*
AUDIT	5.11±6.00	4.65±5.63	5.79±6.44	4.76±5.75	6.24±6.45
DAST	1.08±2.82	0.94±2.62	1.28±3.07	1.03±2.82*	1.24±2.80* [†]
BPI [†]	3.34±2.51	3.22±2.61	3.50±2.38	3.05±2.51*	4.28±2.30*
CES	11.97±10.36	11.08±10.22	13.30±10.44	9.51±9.11*	20.02±10.12*

Conclusions

Deployment TBI is uniquely associated with

Table 3 Outcome and covariate descriptive measures for aims 1 and 2

Measur	Nondeployment TBI				Deployment TBI				Current PTSD Diagnosis			
	Non-Deployment TBI				Deployment TBI				- (n = 786)		+ (n = 613)	
	- (n = 835)	+ (n = 564)			- (n = 1071)	+ (n = 328)			n (%)	n (%)	φ	OR
BDI-II	Lifetime Diagnosis											
DTS	n (%)	n (%)	φ	OR	n (%)	n (%)	φ	OR	n (%)	n (%)	φ	OR
PSQI	344 (41.2)	265 (47.0)			404 (37.7)	205 (62.5)^c	.21	2.75	201 (25.6)	408 (66.6)	.38	5.50
AUDIT												
DAST	24 (2.9)	27 (4.8)			36 (3.4)	15 (4.6)			16 (2.0)	35 (5.7)^b	.08	2.39
BPI ⁺												
CES	204 (24.4)	182 (32.3)	.09	1.47	271 (25.3)	115 (35.1)^c	.09	1.59	147 (18.7)	239 (39.0)	.24	2.93
	3 (0.4)	11 (2.0)^c	.08	5.52	10 (0.9)	4 (1.2)			4 (0.5)	10 (1.6)		
	351 (42.0)	262 (46.5)			375 (35.0)	238 (72.6)	.32	4.91	-	-		
	16 (1.9)	13 (2.3)			23 (2.1)	6 (1.8)			25 (3.2)	4 (0.7)^b	-.09	0.07

Conclusions

Deployment TBI is uniquely associated with

Table 3 Outcome and covariate descriptive measures for aims 1 and 2

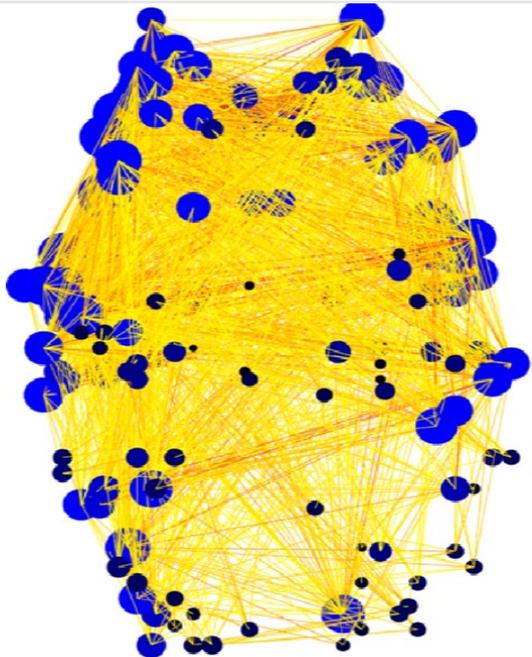
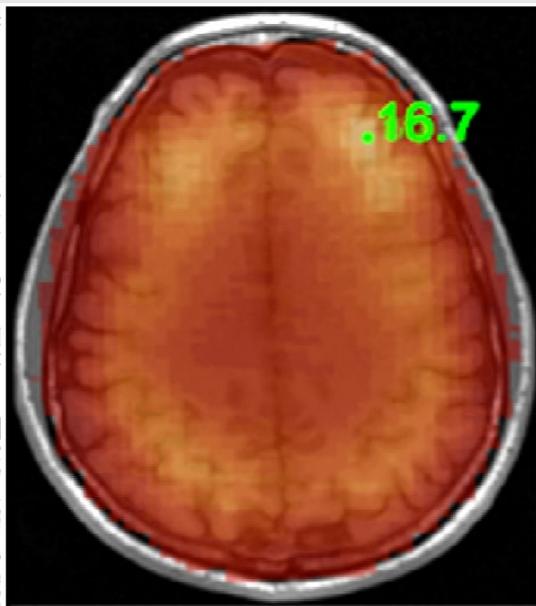
Measures	Nondeployment TBI				Deployment TBI				Current PTSD Diagnosis			
	Non-Deployment TBI		Deployment TBI		Non-Deployment TBI		Deployment TBI		Non-Deployment TBI		Deployment TBI	
	- (n = 835)	+ (n = 564)	- (n = 1071)	+ (n = 328)	- (n = 786)	+ (n = 613)	- (n = 786)	+ (n = 613)	- (n = 786)	+ (n = 613)	- (n = 786)	+ (n = 613)
BDI-II												
DTS												
PSQI												
AUDIT												
DAST												
BPI ⁺												
CES												
Lifetime Diagnosis	n (%)	n (%)	φ	OR	n (%)	n (%)	φ	OR	n (%)	n (%)	φ	OR
Major Depressive Disorder	344 (41.2)	265 (47.0)			404 (37.7)	205 (62.5)^e	.21	2.75	201 (25.6)	408 (66.6)	.38	5.50
Dysthymic Disorder	24 (2.9)	27 (4.8)			36 (3.4)	15 (4.6)			16 (2.0)	35 (5.7)^b	.08	2.39
Alcohol Use Disorder	204 (24.4)	182 (32.3)	.09	1.47	271 (25.3)	115 (35.1)^e	.09	1.59	147 (18.7)	239 (39.0)	.24	2.93
Measures	Non-Deployment TBI		Deployment TBI		Non-Deployment TBI		Deployment TBI		Non-Deployment TBI		Deployment TBI	
	F	η _{sp} ²	F	η _{sp} ²	F	η _{sp} ²	F	η _{sp} ²	F	η _{sp} ²	F	η _{sp} ²
WAIS-IV PRI	1.47	.005	1.80	.006			4 (1.2)		4 (0.5)	10 (1.6)		
WAIS-IV VCI	0.00	< .001	4.88	.017			238 (72.6)	.32 4.91				
WAIS-IV WMI	0.01	< .001	5.62	.019								
WAIS-IV PSI	1.07	.004	4.09	.014								
TMT-A	0.19	.001	15.32	.049								
TMT-B	0.18	< .001	9.36	.031								
COWAT	0.15	< .001	4.14	.014								
Animal Naming	0.89	.003	1.60	.006			6 (1.8)		25 (3.2)	4 (0.7)^b	-.09	0.07

Conclusions

Deployment TBI is uniquely associated with

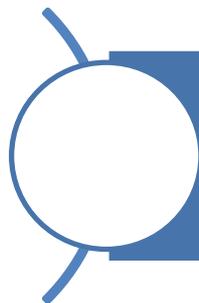
Table 3 Outcome and covariate descriptive measures for aims 1 and 2

Measure	Nondeployment TBI		Deployment TBI	
	ϕ	OR	F	η_{sp}^2
BDI-II	.38	5.50	1.80	.006
DTS	.08	2.39	4.88	.017
PSQI	.24	2.93	5.62	.019
AUDIT			4.09	.014
DAST				
BPI ⁺				
CES				
M				
W				
W				
W				
W				
TMT-A	0.19	.001	15.32	.049
TMT-B	0.18	< .001	9.36	.031
COWAT	0.15	< .001	4.14	.014
Animal Naming	0.89	.003	1.60	.006



ϕ	OR
.38	5.50
.08	2.39
.24	2.93
-.09	0.07

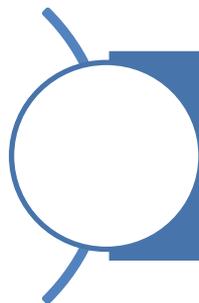
Conclusions



Deployment TBI is uniquely associated with negative outcomes.

1. Mechanisms of injury

Conclusions

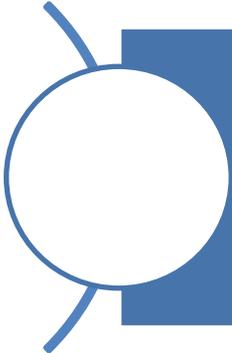


Deployment TBI is uniquely associated with negative outcomes.

1. Mechanisms of injury



Conclusions



Deployment TBI is uniquely associated with negative outcomes.

1. Mechanisms of injury
2. Deployment Environment

Conclusions

Deployment TBI is uniquely associated with negative outcomes.

1. Mechanisms of injury
2. Deployment Environment

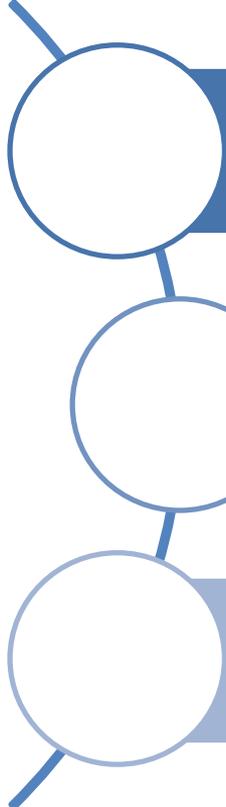


Conclusions

Deployment TBI is uniquely associated with negative outcomes.

The effect of Deployment TBI is not limited to the acute stage, but may have a stronger effect much later in the chronic stage.

Conclusions



Deployment TBI is uniquely associated with negative outcomes.

The effect of Deployment TBI is not limited to the acute stage, but may have a stronger effect much later in the chronic stage.

Negative outcomes are not a foregone conclusion.

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