Department of Veterans Affairs
Rehabilitation Research & Development Service
Traumatic Brain Injury National Network Research Center

MILD TRAUMATIC BRAIN INJURY AND BLAST EXPOSURE IN CONTEXT: DEPLOYMENT TRAUMA IN POST 9/11 VETERANS

Brain Injury Commission
Massachusetts State House

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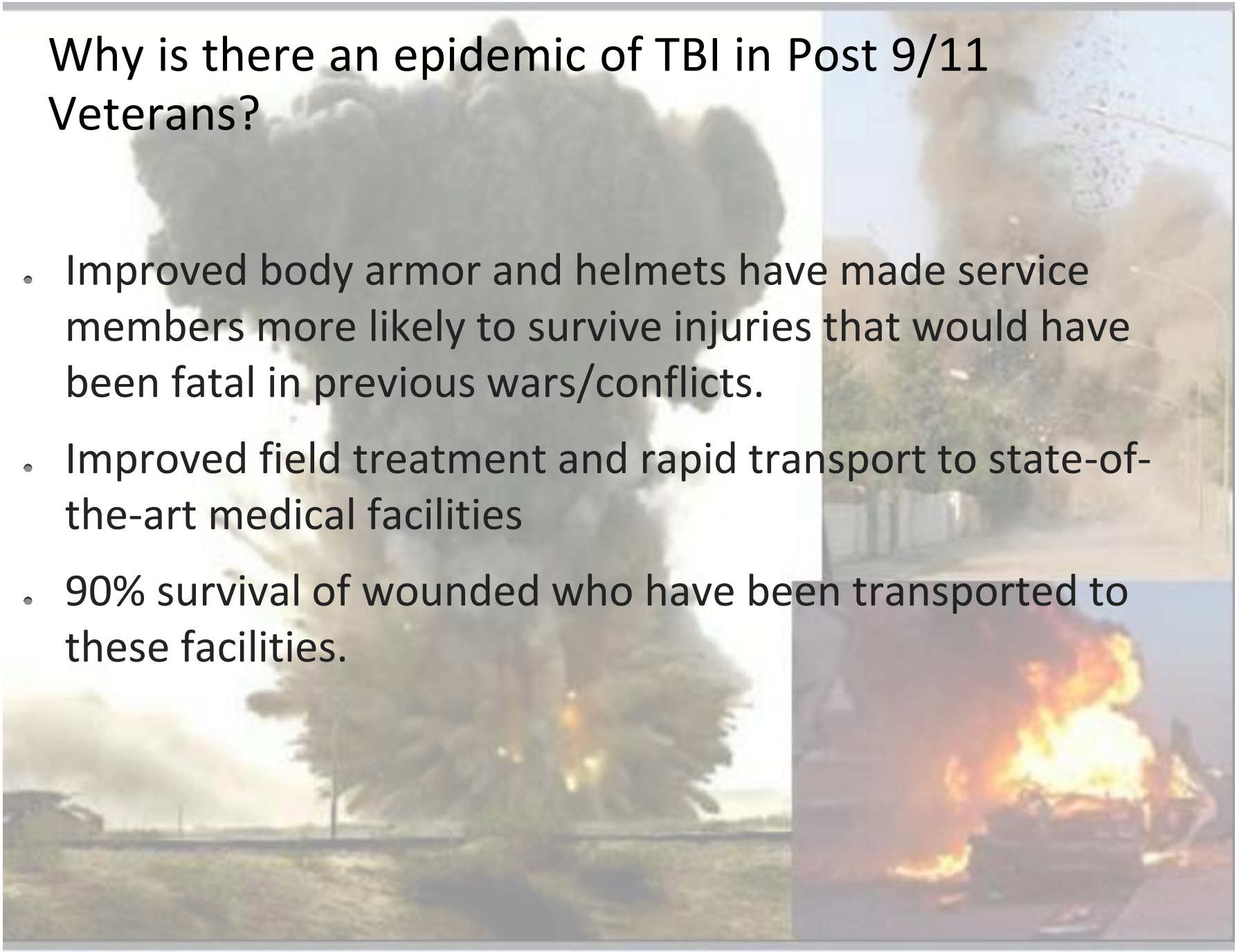
Why is there an epidemic of TBI in Post 9/11 Veterans?

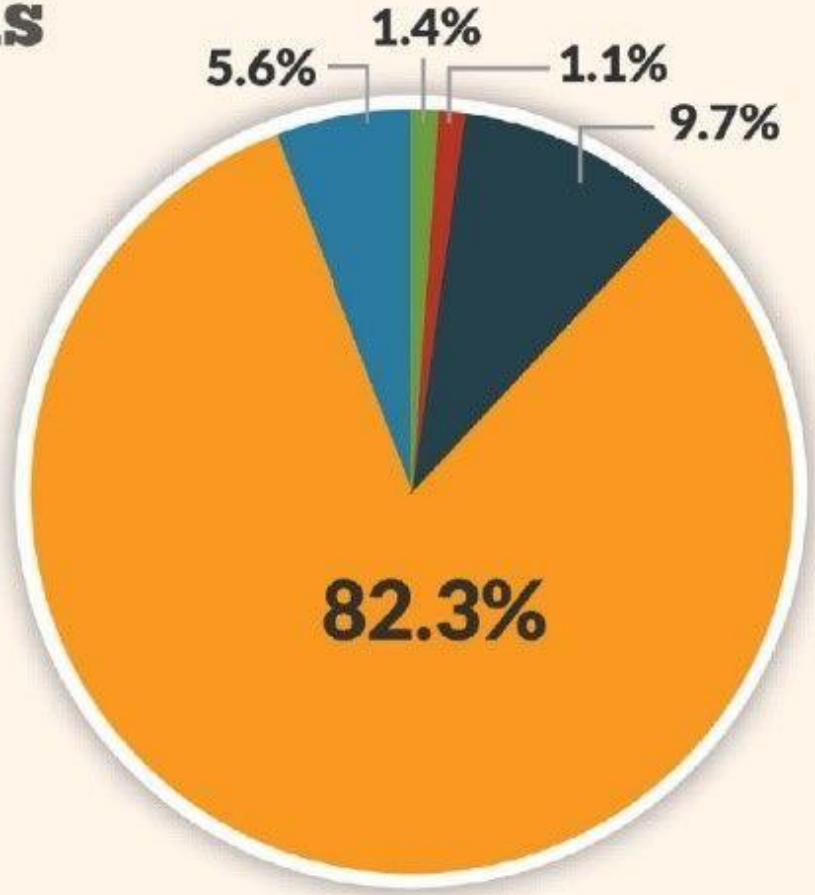


- Improved body armor and helmets have made service members more likely to survive injuries that would have been fatal in previous wars/conflicts.
- Improved field treatment and rapid transport to state-of-the-art medical facilities
- 90% survival of wounded who have been transported to these facilities.

DoD Numbers for Traumatic Brain Injury
Worldwide – Totals

2000 - 2018 Q1

Penetrating	5,215
Severe	4,067
Moderate	37,424
Mild	315,897
Not Classifiable	21,344
Total - All Severities	**383,947**



Source: Defense Medical Surveillance System (DMSS), Theater Medical Data Store (TMDS) provided by the Armed Forces Health Surveillance Center (AFHSB)

Prepared by the Defense and Veterans Brain Injury Center (DVBIC)

2000 - 2018 Q1, as of June 21, 2018

*Percentages do not add up to 100% due to rounding

The DoD reports TBI is the most common type of physical Injury sustained by OEF/OIF/OND Service Members.

- Over 383,900 diagnosed between 2000-2018 Q1.
- 75% of all military TBIs are caused by explosive weaponry, as are 73% of all military fatalities.

Setting the stage for complex physical and psychological illness:

Blasts produce simultaneous physical and psychological trauma

Post-traumatic Stress Disorder 2000-Dec 2012

"Mild" TBI 2000-Aug 2012

Figure 1. Annual Post-Traumatic Stress Disorder Diagnoses in All Services
(as of December 7, 2012)

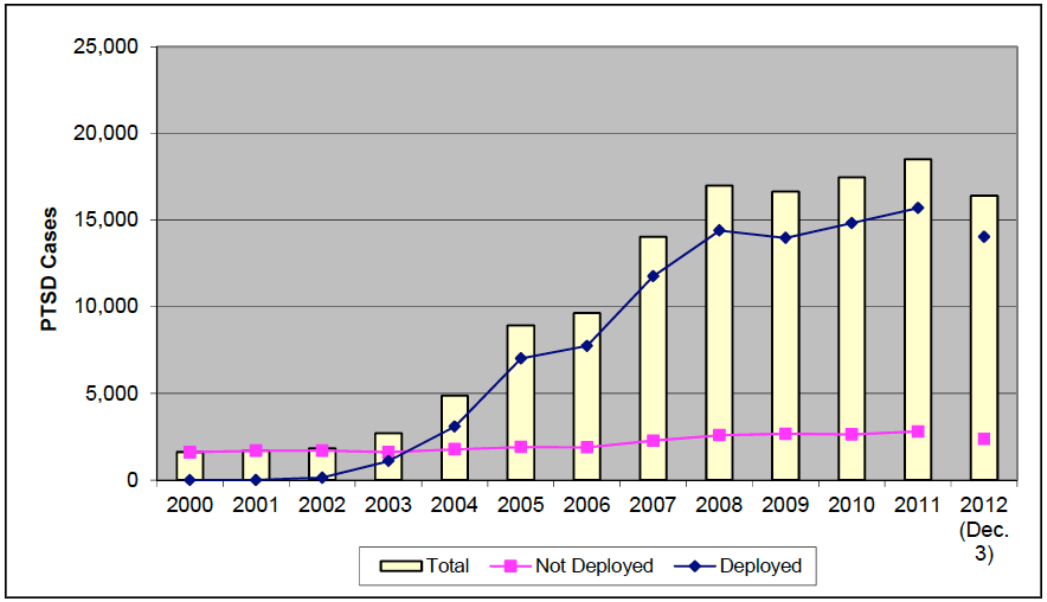
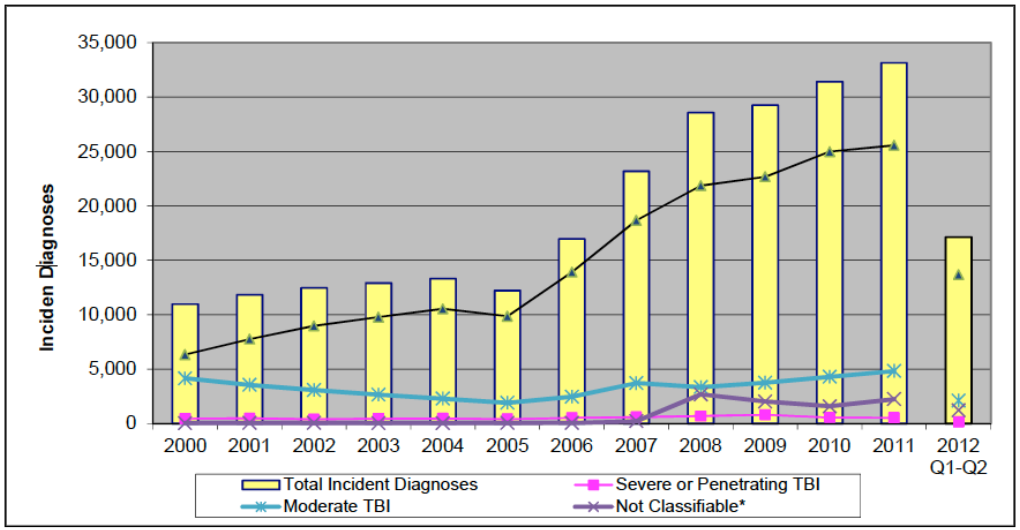


Figure 3. Traumatic Brain Injury (TBI) 2000-2012 Q2
(as of August 20, 2012)



Source: CRS communication with Dr. Michael Carino, Army Office of the Surgeon General, December 13, 2012. Data source is the Defense Medical Surveillance System (DMSS), Defense and Veterans Brain Injury Center, http://www.dvbic.org/dod-worldwide-numbers-tbi.

TRACTS Mission:

- To conduct multidisciplinary, clinical research aimed at understanding the complex pathophysiology associated with co-occurring TBI and related stress disorders

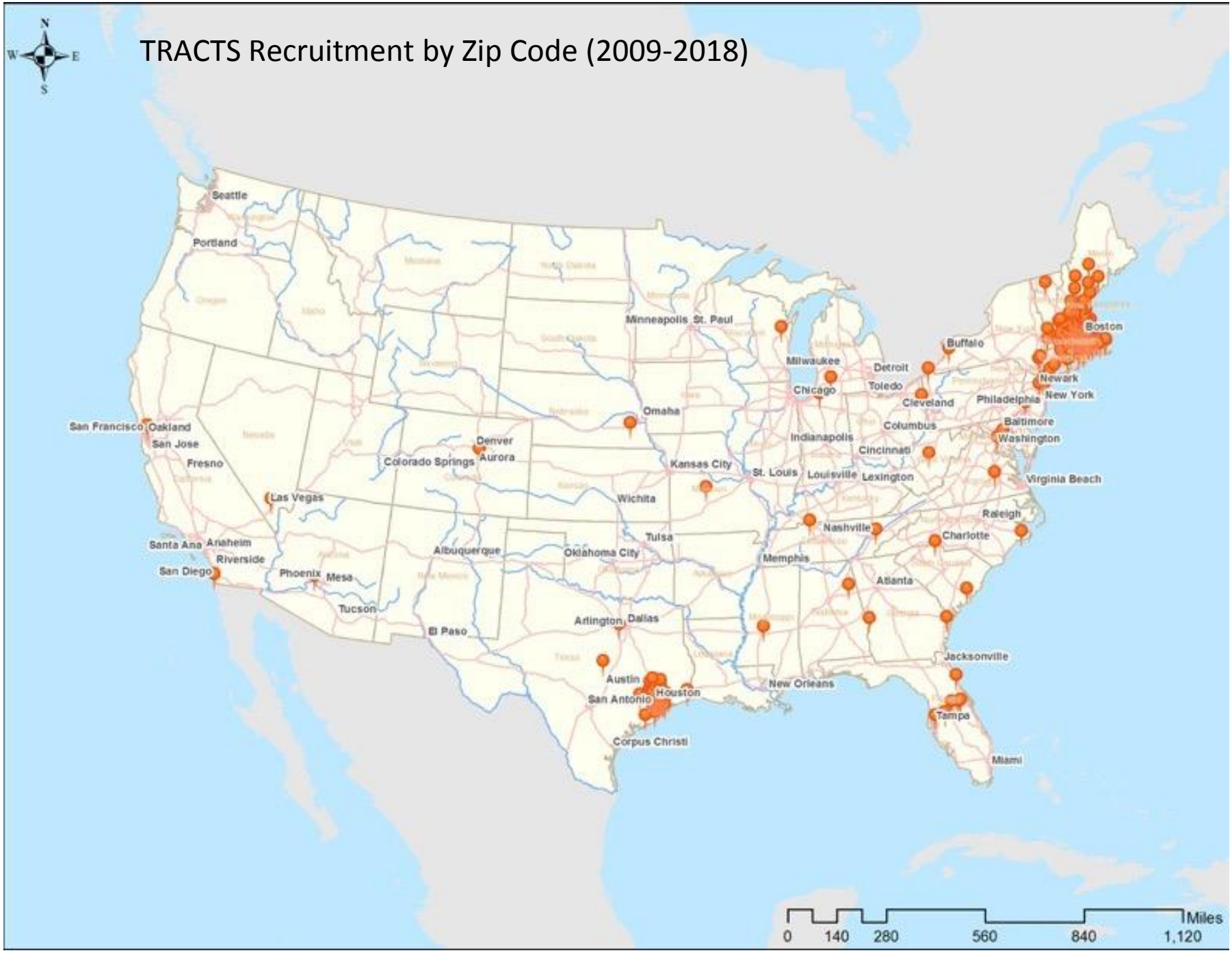
- To develop effective treatment opportunities for OEF/OIF/OND Veterans with multiple co-occurring conditions.

TRACTS is a VA Rehabilitation Research and Development Traumatic Brain Injury National Network Research Center (B9254-C)

Recruitment

- Majority of participants recruited through a full-time recruitment specialist who attends:
  - Yellow Ribbon events
  - Task Force meetings
  - Other events involving US Air National Guard, Marine and Marine Reserves, and Army and Army Reserve Units
- Remaining participants recruited through:
  - Flyers posted in the VA medical center
  - Word of mouth from other TRACTS participants

TRACTS Recruitment by Zip Code (2009-2018)



TRACTS LONGITUDINAL COHORT STUDY:

Site	Baseline	*Time 2 (+1-2 yrs)	Time 3 (+5 yrs)	Deployed
Boston (2010)	651	381	41	605
Houston (2015)	180	69	0	180
Total	**831**	**450**	**41**	**785**

*Return rate = 63%

TRACTS Assessment Core

Medical/Blood-based Biomarkers	Neuropsych Domains	Affective/Psychosocial	Blast/TBI	Neuroanatomy S/F MRI
Blood Chemistry	Simple/Divided Attention	PTSD: CAPS & PCL-C	Boston Assessment of TBI-Lifetime	Cortical Volume
GWAS/Methylation	Information Processing Speed	DSM-IV AXIS I: SCID	Ohio State University TBI ID	Cortical Thickness
Neuro-steroids/hormones	Executive Function	Traumatic Life Events Questionnaire	Neurobehavioral Symptom Inventory	Diffusion Tensor
Inflammatory Markers	Declarative/Procedural Memory	Deployment Risk & Resiliency Inventory		Resting-State Networks
Quanterix SIMOA (NFL, T-Tau, AB40, AB42 BDNF, pNF-heavy, IL-6, IL-10, TNF alpha, NSE)	Pre-morbid Function	Depression, Anxiety & Stress Scale-21		Functional Connectivity
	Perception	Pittsburgh Sleep Quality Index		Task-Based fMRI
	Symptom Validity	McGill Pain Questionnaire		
	Psychomotor Speed	Alcohol, Nicotine		
		Sickness Impact Profile		

J Head Trauma Rehabil

The Boston Assessment of Traumatic Brain Injury–Lifetime (BAT-L) Semistructured Interview: Evidence of Research Utility and Validity

Catherine Brawn Fortier, PhD; Melissa M. Amick, PhD; Laura Grande, PhD; Susan McGlynn, PhD; Alexandra Kenna, PhD; Lindsay Morra, BA; Alexandra Clark, BA; William P. Milberg, PhD; Regina E. McGlinchey, PhD

Objective: Report the prevalence of lifetime and military-related traumatic brain injuries (TBIs) in Operation Enduring Freedom and Operation Iraqi Freedom (OEF/OIF) veterans and validate the Boston Assessment of TBI–Lifetime (BAT-L). **Setting:** The BAT-L is the first validated, postcombat, semistructured clinical interview to characterize head injuries and diagnose TBIs throughout the life span. **Participants:** Community-dwelling convenience sample of 131 OEF/OIF veterans. **Design:** TBI criteria (alteration of mental status, posttraumatic amnesia, and loss of consciousness) were evaluated for all possible TBIs, including a novel evaluation of blast exposure. **Main Measures:** BAT-L, Ohio State University TBI Identification Method (OSU-TBI-ID). **Results:** About 67% of veterans incurred a TBI in their lifetime. Almost 35% of veterans experienced at least 1 military-related TBI; all were mild in severity, 40% of them were due to blast, 50% were due to some other (ie, blunt) mechanism, and 10% were due to both types of injuries. Predeployment TBIs were frequent (45% of veterans). There was strong correspondence between the BAT-L and the OSU-TBI-ID (Cohen $\kappa = 0.89$; Kendall τ-b $= 0.95$). Interrater reliability of the BAT-L was strong (κs >0.80). **Conclusions:** The BAT-L is a valid instrument with which to assess TBI across a service member's lifetime and captures the varied and complex nature of brain injuries across OEF/OIF veterans' life span. **Key words:** *assessment, blast, OEF/OIF, traumatic brain injury (TBI), veterans*

Fortier, C. B., Amick, M. M., Grande, L., McGlynn, S., Kenna, A., Morra, L., . . . McGlinchey, R. E. (2014). The Boston Assessment of Traumatic Brain Injury-Lifetime (BAT-L) semistructured interview: evidence of research utility and validity. *J Head Trauma Rehabil, 29*(1), 89-98. doi: 10.1097/HTR.0b013e3182865859

Fortier, C. B., Amick, M. M., Kenna, A., Milberg, W. P., & McGlinchey, R. E. (2015). Correspondence of the Boston Assessment of Traumatic Brain Injury-Lifetime (BAT-L) clinical interview and the VA TBI screen. *J Head Trauma Rehabil, 30*(1), E1-7. doi: 10.1097/HTR.0000000000000008

BAT-L Assessment Approach

- TBI is assessed during 3 time epochs:
  - (1) Pre-Military
  - (2) Military
  - (3) Post-Military
- Evaluate 3 most severe injuries in each epoch
- Open-ended questioning & “Forensic Approach”
- Factors related to estimation of AMS queried
- Occurrence and duration of neurobehavioral symptoms following each injury recorded

TBI Severity is Rated According to DOD Criteria

Criteria	Mild	Moderate	Severe
Loss of Consciousness	0 - 30 minutes	>30 minutes and <24 hours	> 24 hours
Alteration of Mental Status	0 - 24 hours	>24 hours; severity based on other criteria	
Post Traumatic Amnesia	0 - 1 day	> 1 day and <7 days	> 7 days
Glascow Coma Scale	13 - 15	9 - 12	<9

TBI Severity (BAT-L) in Deployed TRACTS Participants (n=456)

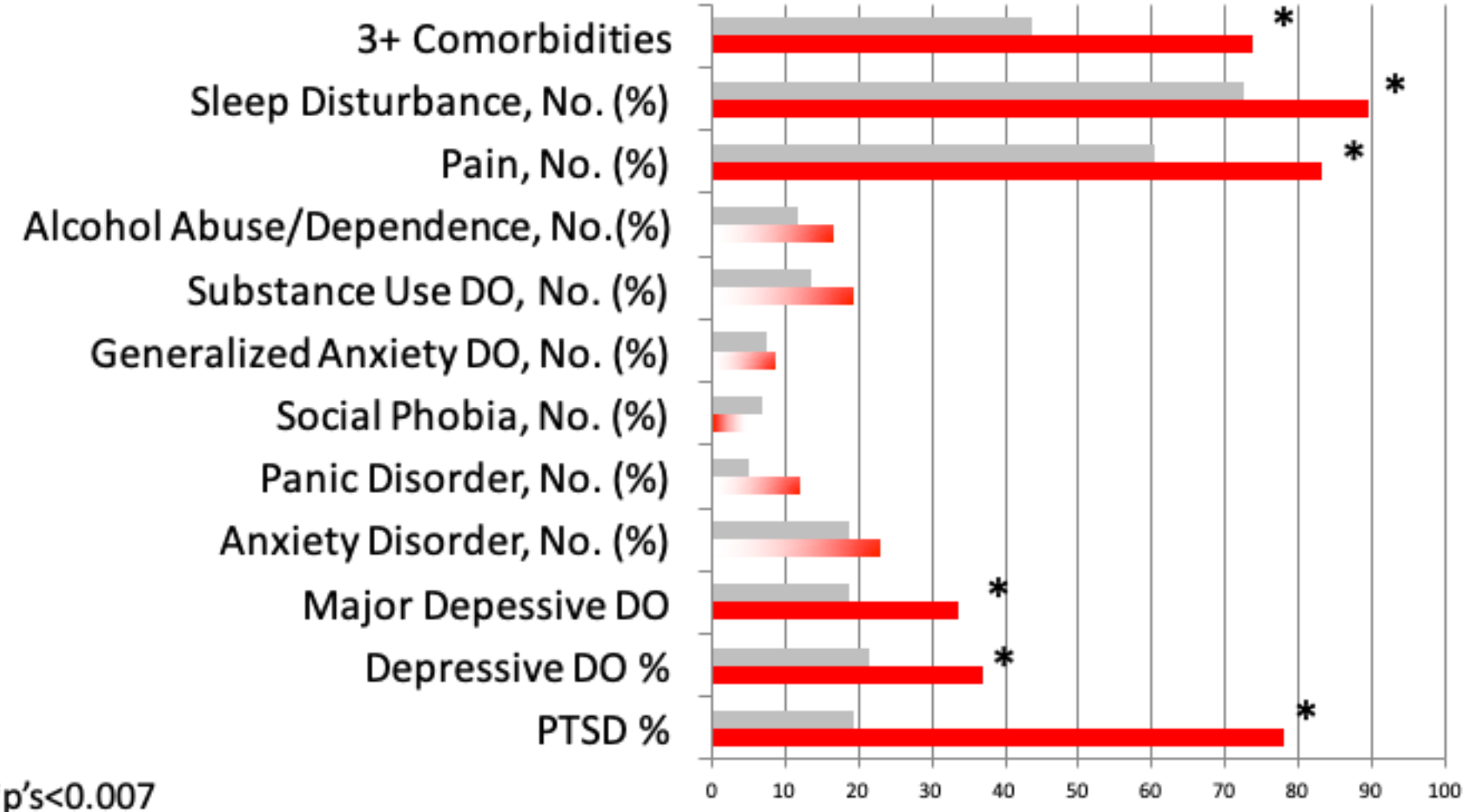
	Deployment Blast	**Military "Other"**	**Pre-Deployment**	**Post-Deployment**
Mild	142 (31%) (27 with multiple)	123 (27%) (32 with multiple)	188 (41%) (70 with multiple)	35 (8%) (3 with multiple)
Moderate	2	3	11	1
Severe	1	0	2	1

Blast exposure in first 605 deployed TRACTS participants (BATL-Assessment)

	< 10 meters	**11 – 25 meters**	**26-100 meters**	**Total Blast Exposures < 100 meters**
Number of Service Members Exposed (%)	270 (44.6%)	270 (44.6%)	432 (71.4%)	483 (79.8%)
Mean Blasts per Service Member (SD)	5.3 (48.8)	3.7 (12.6)	28.8 (100.9)	37.2 (118.7)
Median Blasts per Service Member (IQR)	1 (0, 2)	1 (0, 3)	3 (1, 12)	5 (2, 21)
Range of Blasts per Service Member	0 – 999	0 – 204	0 – 999	0 – 1102

Longitudinal Cohort Study (analysis n=511)

- mTBI is a polymorbid condition in Post 9/11 Veterans.
- Very few (8% of TRACTS cohort) have mTBI without a co-occurring clinical condition
- When a mTBI is diagnosed (red; n=241), there is a significantly greater percentage of cases* with



*p's<0.007

Journal of Traumatic Stress
February 2015, *28*, 25–33

ISTSS International Society for Traumatic Stress Studies

Deployment-Related Psychiatric and Behavioral Conditions and Their Association with Functional Disability in OEF/OIF/OND Veterans

Sara M. Lippa,[1,2] Jennifer R. Fonda,[1,3] Catherine B. Fortier,[1,4] Melissa A. Amick,[1,5] Alexandra Kenna,[1] William P. Milberg,[1,4] and Regina E. McGlinchey[1,4]

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Understanding the factors that influence veterans' functional outcome after deployment is critical to provide appropriately targeted care. Mild traumatic brain injury (mTBI) and posttraumatic stress disorder (PTSD) have been related to disability, but other psychiatric and behavioral conditions are not as well examined. We investigated the impact of deployment-related psychiatric and behavioral conditions on disability among 255 OEF/OIF/OND service members and veterans. Structured clinical interviews assessed TBI and the psychiatric conditions of depression, PTSD, anxiety, and substance use. Self-report questionnaires assessed disability and the behavioral conditions of sleep disturbance and pain. Over 90% of participants had a psychiatric and/or behavioral condition, with approximately half presenting with $\geq$ 3 conditions. Exploratory factor analysis revealed 4 clinically relevant psychiatric and behavioral factors which accounted for 76.9% of the variance: (a) depression, PTSD, and military mTBI (deployment trauma factor); (b) pain and sleep (somatic factor); (c) anxiety disorders, other than PTSD (anxiety factor); and (d) substance abuse or dependence (substance use factor). Individuals with the conditions comprising the deployment trauma factor were more likely to be substantially disabled than individuals with depression and PTSD, but no military mTBI, $OR = 3.52$; 95% CI [1.09, 11.37]. Depression, PTSD, and a history of military mTBI may comprise an especially harmful combination associated with high risk for substantial disability.

Psychiatric and Behavioral Clusters (n=255)

	Factor 1	Factor 2	Factor 3	Factor 4
mTBI	**0.431**	0.349	-0.093	-0.532
Moc Disor			0.01	0.049
PTSD	**0.692**	0.405	0.153	-0.004
Pain	-0.001	**0.863**	-0.102	-0.02
Sleep				0.136
Alcohol Abuse/Dependence	0.322	-0.05	**0.659**	-0.041
Other Abuse/Dependence	-0.147	0.085	**0.833**	0.023
Anxiety Disorder	0.142	0.173	-0.053	

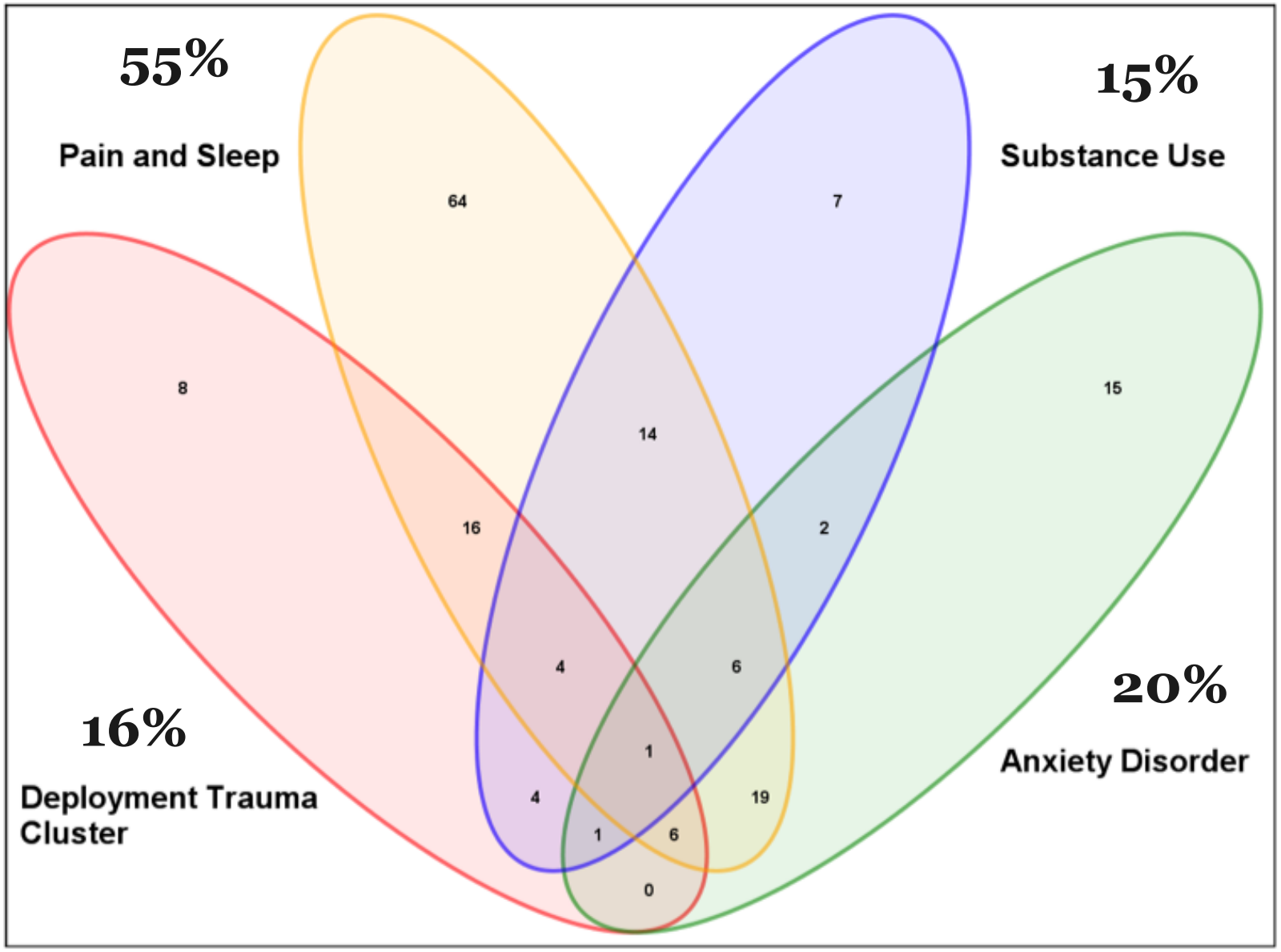
Deployment Trauma Phenotype

Pain/Sleep Factor

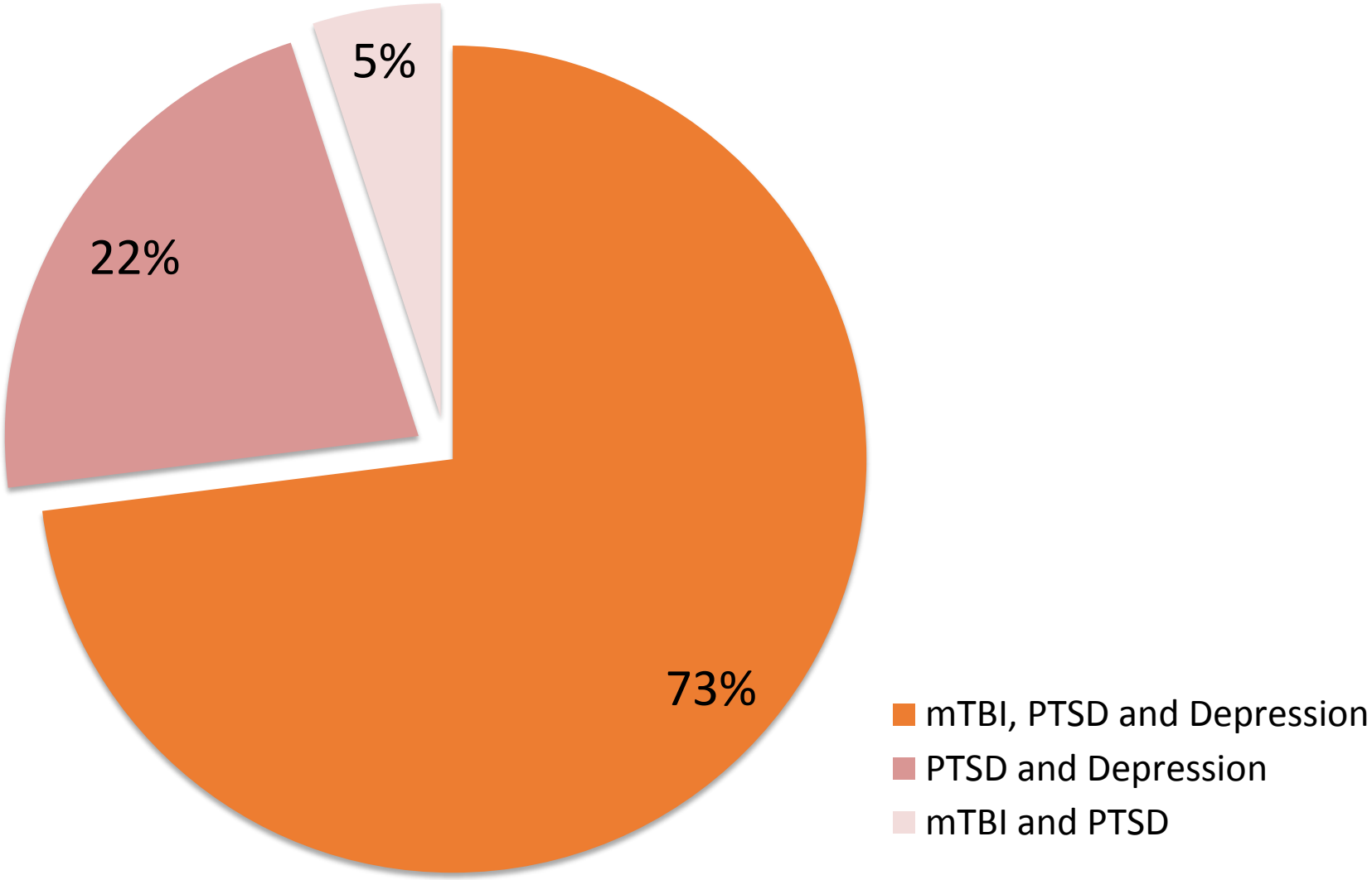
Substance Abuse Cluster

Anxiety Cluster

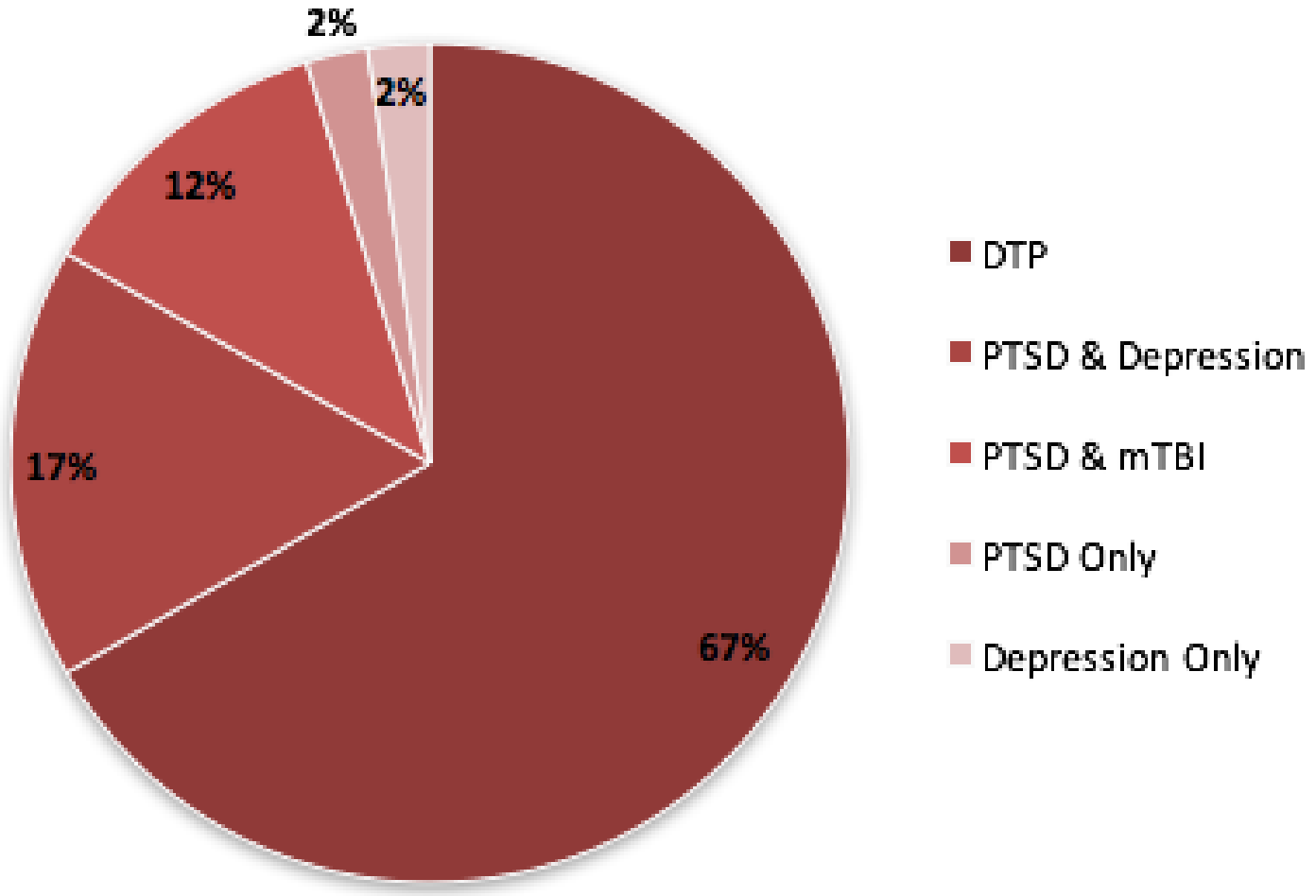
- **Psychiatric and Behavioral Clusters (n=255)**



Deployment Trauma Phenotype Associated with Substantial Disability (WHODAS overall score of ≥45 =22; 73%=16/22)



Current Total TRACTS n=435
Deployment Trauma Phenotype Associated with Substantial Disability (WHODAS overall score of ≥45 =42; 67%=28/42)



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The Deployment Trauma Phenotype and Employment Status in Veterans of the Wars in Iraq and Afghanistan

Melissa M. Amick, PhD; Mark Meterko, PhD; Catherine B. Fortier, PhD; Jennifer R. Fonda, PhD; William P. Milberg, PhD; Regina E. McGlinchey, PhD

Objectives: To determine the prevalence of comorbid mild traumatic brain injury (mTBI), posttraumatic stress disorder (PTSD), and depression, termed the deployment trauma phenotype (DTP), and its constituent diagnoses' impact on unemployment status in a national cohort of veterans. **Setting:** Retrospective analysis of the comprehensive TBI evaluation, a Veterans Affairs-wide protocol for assessing TBI, employment status, and psychiatric impressions. **Participants:** The final data set consisted of 48 821 veterans. **Main Outcomes and Measures:** Frequency of mTBI, PTSD, and depression in isolation and combinations and their association with unemployment status. **Results:** Age- and education-adjusted risk ratios (RRs) showed that the mTBI-only group was the least likely to be unemployed, RR = 0.65 (0.59–0.71). By contrast, the greatest likelihood of unemployment was associated with membership in the DTP group, RR = 1.45 (1.36–1.56), and the comorbid PTSD and depression group, RR = 1.39 (1.27–1.52). Furthermore, the DTP was nearly 3 times more prevalent (16.4%) in this sample compared with comorbid PTSD and depression (5.7%), indicating that the DTP conveys risk for unemployment to a significantly greater number of individuals. **Conclusions and Relevance:** The comorbid and interactive conditions of PTSD, depression, and mTBI, rather than mTBI in isolation, were linked to significant risk for unemployment in this veteran cohort. These findings suggest that multifaceted assessments and interventions to improve postdeployment reintegration are needed. **Key words:** *depression*, *employment*, *mTBI*, *PTSD*, *veterans*

Table 1: *Veteran Demographic and Clinical Characterization*

Age (years)	
Mean	**33.97**
Median	**31.00**
Std. Dev.	**8.56**
Gender (%)	
Male:	**94.25%**
Female:	**5.75%**
Marital Status (%)	
Married/Partnered	**49.89%**
Single (Never Married)	**27.64%**
Divorced/Separated	**22.26%**
Widowed	**0.21%**
Education Level (%)	
HS or Less	**62.57%**
Some Post-HS	**31.87%**
BA or More	**5.56%**
Clinical Diagnoses	
No Diagnoses	**18.72%**
mTBI- only	**16.60%**
PTSD-only	**8.72%**
Depression-only	**4.08%**
mTBI and PTSD	**24.25%**
mTBI and Depression	**5.57%**
PTSD and Depression	**5.68%**
mTBI, PTSD, and Depression	**16.37%**

Neurobehavioral Symptom Inventory-22

Clinical Diagnoses	Mean and SD
No mTBI, PTSD or Depression	30.21 (15.57)
mTBI-only	27.91 (13.61)
PTSD-only	33.04 (13.73)
Depression-only	33.95 (13.59)
mTBI and PTSD	36.52 (12.92)
mTBI and Depression	35.89 (12.81)
PTSD and Depression	37.94 (13.33)
mTBI, PTSD and Depression (DTP)	40.58 (12.32)

Overall Conclusions

- Mild TBI with no co-occurring psychological or physical injury does not produce lasting or significant cognitive or functional impairment.
- When mTBI co-exists with other conditions (which it most often does), it contributes to functionally devastating long-term effects. Attributing “PCS” to mTBI in this group is as likely to lead to negative or iatrogenic effects than it is to appropriate treatment.
- The context of the injury itself (i.e., blast) may be more critical in understanding long-term effects than the duration and/or symptoms that we currently use to diagnose concussion.
- Developmental and genetic factors make some individuals more vulnerable to the effects of trauma.
- The concept of a Deployment Trauma Phenotype may be a syndrome in that collectively its effect on function is much worse than any of the individual constituent or pairs of diagnoses.

TRANSLATIONAL RESEARCH CENTER FOR TBI AND STRESS DISORDERS
VA RR&D TBI NATIONAL NETWORK RESEARCH CENTER
VA BOSTON HEALTHCARE SYSTEM

https://www.researchgate.net/project/Translational-Research-Center-for-Traumatic-Brain-Injury-and-Stress-Disorders-TRACTS

https://heartbrain.hms.harvard.edu/