

**A prediction model of military combat and
training
exposures on VA service-connected disability: a
CENC study**

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Tank Blast Exposure



Artillery Exposure



Mine Clearing Line Charge



Outline

- Background
- Objective
- Methods
- Results
- Discussion
- Questions

Background

Traumatic Brain Injury (TBI)¹

- An event in which an external force such as a bump, blow, or jolt to the head disrupts the normal function of the brain and causes immediate alteration of consciousness.
- Categorized as mild, moderate, or severe, based on the length of time of lost or altered consciousness, or post-traumatic amnesia, at the time of the event.²
- Associated with physical, cognitive, behavioral and emotional dysfunction, including personality changes and depression.¹

Background

US Military Service Members/Veterans

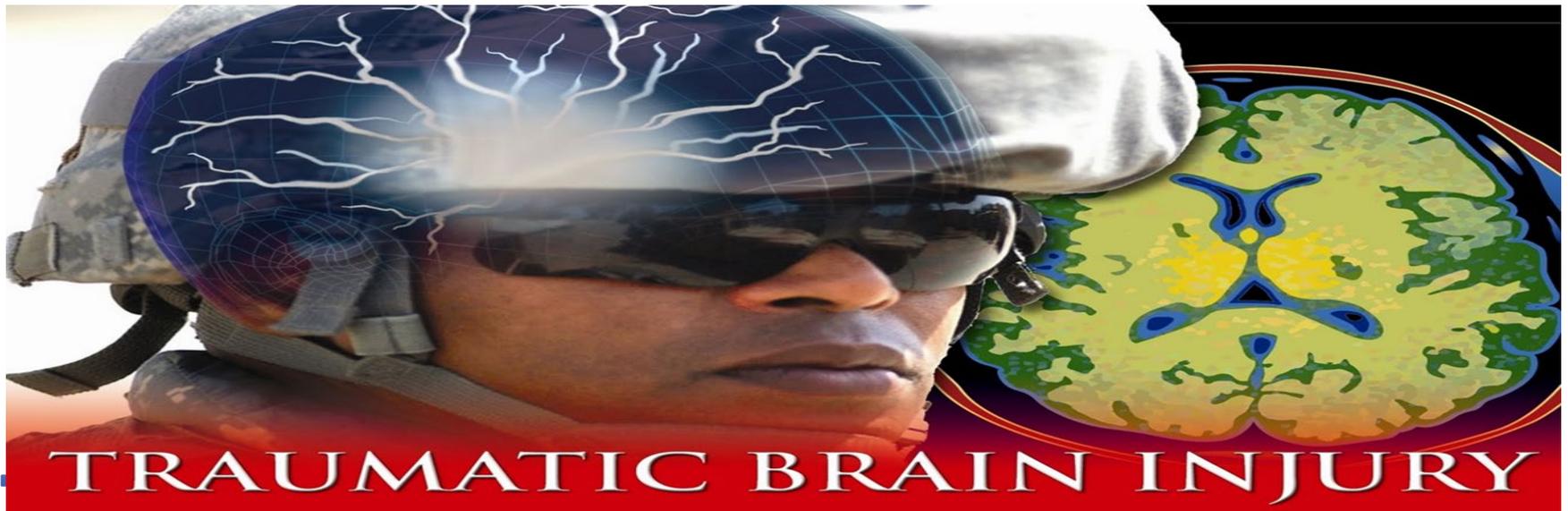
- Since 2000, ~384,000 Service Members diagnosed with TBI.³
 - 82% categorized as mild TBI (mTBI), also known as concussion.
 - While deployed, at increased risk for:^{4,5}
 - Blast-related (BR) Injuries: improvised explosive devices (IEDs), land mines, mortar rounds, and rocket-propelled grenades.
 - Non-blast-related (NBR) Injuries: motor vehicle accidents, falls, assaults
 - Many OEF/OIF/OND combat veterans who incurred ≥ 1 mTBIs experience persistent symptoms for which they are seeking healthcare, but administrative data does not contain mechanism.⁶⁻⁹
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Background

- The Department of Veterans Affairs (VA) defines service connected disability (SCD) as a disability from a disease or injury that arose in, was aggravated by, or otherwise is causally related to military service.¹⁰
- The VA spent \$64.71 billion in disability compensation to about 4.4 million veterans during the 2016 fiscal year.¹⁰
- A combined disability rating consists of all SCD conditions which can range from 0% to 100% for the most disabling and compensated service-connected conditions.¹¹
- Veterans assigned with %SCD <50 must make co-payments for VA health services, unless they meet other income and military circumstance conditions.¹²
- Approximately 76% of veterans with a 100% SCD rating have used VA health services.¹²

Objective

- The aim of this study is to create and test a model of the top military and combat-related exposures that predict %SCD ≥ 50 (yes/no) among a cohort of veterans with combat deployment in Operations Enduring Freedom (OEF), Iraqi Freedom (OIF) and/or New Dawn (OND), with or without a history of mild Traumatic Brain Injury (mTBI).



Poll Question

What is your interest in Veteran TBI?

- Clinical Provider
- Compensation and Pension Provider
- Health Services Researcher
- Basic Sciences Researcher
- Clinical Sciences Researcher

Methods

Setting and Participants

CENC Longitudinal Cohort Study

- Enrollment began in 2015 (Walker et al 2016)¹³
- 4 VA Medical Centers: Houston, TX; Richmond, VA; San Antonio, TX; and Tampa, FL
- Eligibility: (1) ≥ 18 years, (2) combat deployed to OEF/OIF/OND after 2001, and (3) exposed to combat (based on scores of ≥ 1 on any item from the Deployment Risk and Resiliency Inventory Section D (DRRI-2-D))
- Excluded histories of: (1) moderate/severe TBI or (2) major neurologic or psychiatric disorder that significantly decreased daily functioning

Methods

Identifying mTBI and SCD

- Lifetime potential concussive events (PCE) - Assessed using a modified version of the Ohio State University TBI Identification Method (OSU TBI-ID).¹⁴
- Virginia Commonwealth University Retrospective Concussion Diagnostic Interview (VCU rCDI) - Used to potentially diagnose each BR and NBR PCE as an mTBI based on the DoD/VA common definition. (Walker et al. 2015)¹⁵
- The outcome of interest was %SCD - obtained from the VA Computerized Patient Record System (CPRS) Total Percent Service Connected Disability (%SCD) field.
- For modeling, the %SCD was dichotomized at $\geq 50\%$, since this is the cutoff for access to and utilization of VHA health services without co-payment.

Potential Combat and Training Exposures

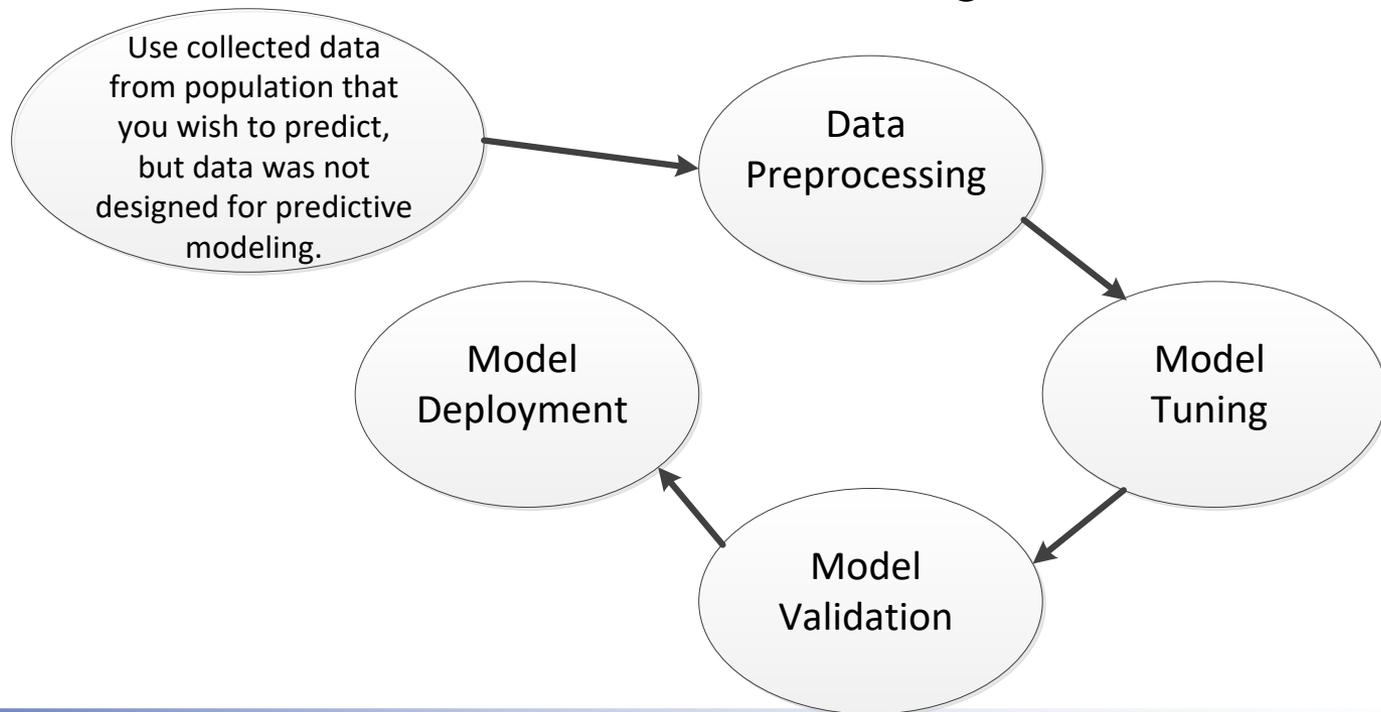
Total months combat-related deployment	Count of PCEs from motor vehicle accident (while deployed)
Loss of Consciousness (LOC) Total Time Unconscious from any uncontrolled blast (while deployed or non-deployed)	Count of PCEs from Other Cause (while deployed)
How many times nearby controlled detonation during deployment	Count of PCEs from Unknown Cause (while deployed)
Total number of blast exposures (while deployed or non-deployed & including controlled and uncontrolled)	Count of PCEs from Artillery
Number of controlled detonations experienced (while deployed or non-deployed)	Count of PCEs from Bombs
Total number of uncontrolled blast and impact exposures (while deployed or not)	Count of PCEs from C4
Count of Controlled Blasts during Non-Deployment	Count of PCEs from all Grenades, including Rocket Propelled Grenades
Count of uncontrolled blast where dazed (while deployed or non-deployed)	Count of PCEs from IED
Total number of PCE(s) not including controlled blasts (while deployed)	Count of PCEs from Land Mine

Potential Combat and Training Exposures

Count of PCEs from impact where Dazed (while deployed)	Count of PCEs from mix of explosives
Count of PCEs from Fall (while deployed)	Count of PCEs from mortar
Count of PCEs from a Hit (while deployed)	Count of PCEs from Rocket/Missile
Count of PCEs from physical assault (while deployed)	Count of PCEs from Training
Number of Exposures Resulting in mTBI with PTA (while deployed)	Count of mTBI from uncontrolled blast with LOC (while deployed or not)
Number of Exposures resulting in LOC and mTBI (while deployed)	Count of mTBIs from Impact with LOC (while deployed)
Number of combat mTBIs	

ML Methods

- The machine language (ML) model building process used in this analysis was developed to identify a possible model type and predictor set possible predictors for further study. The predictive modeling process included: data preprocessing, model tuning on training data, model validation on test data, and assessment of best models on entire data using cross-validation.



Methods

- Other variables included in the ML models were: age, gender, service branch and rank, study site, PHQ-9 for depression diagnosis, DRRI-2-D Combat Exposure questions.
- Initially, the analysis dataset had 359 records, but 18 records were removed for missing data (5.1%).
- The best-tuned models were determined using 10-fold cross validation and AUC criteria for ranking.
- All models maintained a 10-fold cross-validation based AUC value of 0.70 or higher. The reduced Random Forest (Best 30) model had the highest test AUC value of 0.78.
- The best model was the reduced Random Forest (Best 30), which does not generate easily interpreted parameters. However, the predictors used in a Random Forest can be listed in order of importance, as measured in terms of effect on predictive accuracy.

Descriptive Statistics

- 13% of veterans were female
- 88% were enlisted
- 68% had served in the Army
- 73% reported exposure to land/water mines, booby traps, or roadside bombs
- 89% reported exposure to hostile incoming fire
- 69% reported being in a convoy under attack
- 97% veterans reported at least one PCE
- 62% reported a mTBI with PTA and LOC while deployed
- 84% veterans reported at least one mTBI from blast exposure during military service

Importance Ranking of SCD Predictors

Predictor Name	Order of Importance	Predictor Type
Age at baseline	1	Demo
Number of controlled detonations experienced (while deployed or non deployed)	2	General Blast & Detonation
Total number of blast exposures (while deployed or non deployed & including controlled and uncontrolled)	3	General Blast & Detonation
You were never injured in a combat related incident while deployed	4	DRRI-2-D
Total number of uncontrolled blast and impact exposures (while deployed or non deployed)	5	General Blast & Detonation
Accessed at Study Site 2	6	Demo
Total number of PCE(s) not including controlled blasts (while deployed)	7	General Blast & Detonation
Count of PCEs from C4	8	Specific Exposures
You were injured once or twice in a combat related incident while deployed	9	DRRI-2-D
Count of PCEs from uncontrolled blast where dazed	10	General Blast & Detonation
Number of combat related mTBIs experienced	11	mTBI
Count of PCEs from IED	12	Specific Exposures
You were never involved in searching/clearing homes buildings, or other locations while deployed	13	DRRI-2-D
You are or were an Army service member	14	Service
You never witnessed enemy combatants being seriously wounded or killed while deployed	15	DRRI-2-D

Importance Ranking of SCD Predictors

Count of PCEs from Fall (DEPLOYED ONLY)	16	Specific Exposures
Count of PCEs from mortar	17	Specific Exposures
You were exposed a few times a week to hostile incoming fire while deployed	18	DRRI-2-D
You were never exposed to friendly incoming fire while deployed	19	DRRI-2-D
You were exposed to friendly incoming fire once or twice while deployed	20	DRRI-2-D
mTBI From Blast	21	TBI
You went on combat patrols a few times a week while deployed	22	DRRI-2-D
PHQ 9 based recognition of Depression	23	Clinical
You encountered land or water mines, booby traps, or roadside bombs several times.	24	DRRI-2-D
Count of PCEs from All Grenades, Including Rocket Propelled Grenades	25	Specific Exposures
Count of PCEs from mix of explosives	26	Specific Exposures
You were exposed a few times a month to hostile incoming fire while deployed	27	DRRI-2-D
You were exposed to hostile incoming fire a few times a week while deployed	28	DRRI-2-D
You were a Marine service member	29	Service
You went on combat patrols once or twice while deployed	30	DRRI-2-D

Poll Question

Which combat or training exposure ranks highest in importance in predicting greater or equal to 50% service connected disability?

- IED Blast
- Uncontrolled Detonations
- Controlled Detonations
- Rocket Launchers
- Incoming Missiles

Main Conclusions

- Using a novel model testing algorithm, we found that the most important predictors of VA %SCD ≥ 50 was number of controlled detonations, followed by uncontrolled blasts that occur in combat deployment or non-deployment (e.g. military training) settings.
- Our findings are consistent with breachers studies conducted by Walter Reed and the U.S. Army.¹⁶⁻¹⁸
- Tate et al. found that repetitive low level blast exposure was associated with a brain biomarker response, poorer cognitive performance, and impairments, after multiple blasts.¹⁶ Their follow-up study suggests that changes in training doctrine which reduced blast overpressure exposure to <4 psi, may have mitigated measurable effects associated with long-term, low-level blast exposure.¹⁷
- A U.S. Army study of peak overpressure from various exposures found that the current minimum safe distance calculations are often inaccurate as true environmental exposure can consistently exceed the 4 psi incident safe threshold prescribed by U.S. Army doctrine.¹⁸

Limitations

- Combat and Training Exposures are self-reported.
- Methods only allow for ranking of importance of exposures.
- Traditional magnitude effects of exposures on SCD not examined.
- Traditional tests of significance not examined.
- Limited to 4 VAs
- Limited to OEF/OIF/OND Veterans

Strengths

- Rigorous and standardized method for categorizing mTBI
- Combat and Training Exposures identified rigorously
- ML methods allow for including a large number of combat and training exposures.
- Can provide valuable information to both VA and DoD for planning and policy.
- Findings are consistent with studies of breachers regarding PSI exposures.

Future Directions

- Improve coordination and feedback with DoD and the Military Health System
 - Feedback to DoD on exposures within its control (e.g., controlled detonations) may facilitate ways to lessen or prevent its long-term effects.
 - LIMBIC funded to study exposures in 8 VAs and 4 Military Treatment Facilities with at least 3000 Veterans and service members.

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Thanks to our Military Veterans



Questions?

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