



Traumatic Brain Injury Data and Learning Systems

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Introduction & Aims

- Traumatic Brain Injury (TBI) considered a “signature injury of the wars in Afghanistan and Iraq.”
- Since 2000 an estimated 468,424 SMs have been diagnosed with at least one TBI.
- Initial TBI data evaluated TBI diagnosis
- Subsequent questions to improve early care and care planning have emerged.
 - 2 Examples of Surveillance efforts to answer TBI related questions





DOD Numbers for Traumatic Brain Injury Worldwide — Totals

2000–2023 Q1

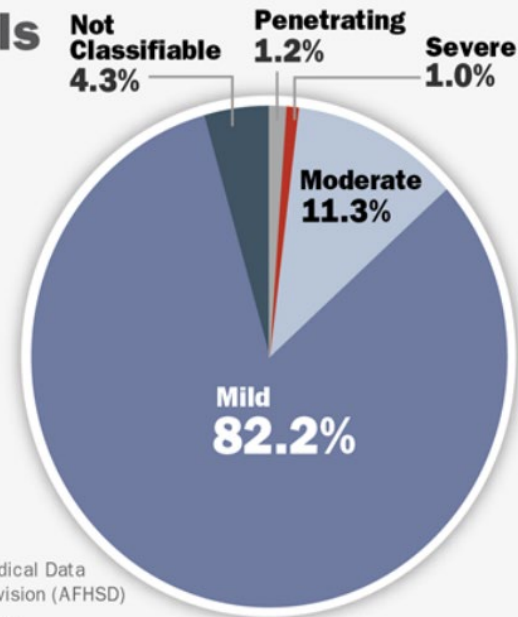
Penetrating	5,717
Severe	4,741
Moderate	54,090
Mild	394,591
Not Classifiable	20,814

Total - All Severities 479,953

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

Prepared by the Traumatic Brain Injury Center of Excellence (TBICoE)

**Percent may not add to 100% due to rounding*



2000–2023 Q1, as of May 9, 2023

<https://health.mil/Military-Health-Topics/Centers-of-Excellence/Traumatic-Brain-Injury-Center-of-Excellence/DOD-TBI-Worldwide-Numbers>



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Example 1 – Military Occupational Specialty (MOS)

Objectives:

- Identify associations between Military occupations and Traumatic Brain Injury (TBI).
- Determine if any occupations pose higher risks of sustaining a TBI.
- Establish methodological foundations for continued monitoring of TBI rates and changes in TBI-related occupational risk.



Analysis Team

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- Tajrina Hai MHS
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Methods:

- 171,801 SMs identified that sustained their first lifetime TBI between January 2012 and December 2019 using the AFHSD database of SMs with TBI.
- Occupational specialty obtained from the Defense Eligibility and Enrollment System (DEERS) Population/Beneficiary Level database.
- Date of injury was used to assign DEERS Occupation Code.
- The total SMs in occupational group in March of year was used as measure of Military wide SMs at risk per occupational group (denominator).
- Legacy codes were matched to current codes and standardized codes between Services using the DoD Occupational Conversion Index.
- A total of 158,115 SMs with first lifetime TBIs matched to one occupational code. SMs not matched to an occupation were excluded.



Results:

- Between 2012–2019, the average rate of first lifetime TBIs was 12.8 per 1,000 exposed SMs across all occupational groups.
- Across all occupational groups over the study period, the rates ranged from 39.3 TBIs per 1,000 SMs in occupational group for Special Forces SMs, followed by Unit Supply at 32.0 TBIs per 1,000 SMs in group to a low of those with Missile Fuel and Petroleum occupational designations at 17.5 TBIs per 1,000.
- Importantly, occupations at high risk of TBI seem to change with shifts in operational speed and intensity (OPTEMPO), deployments and engagement type.

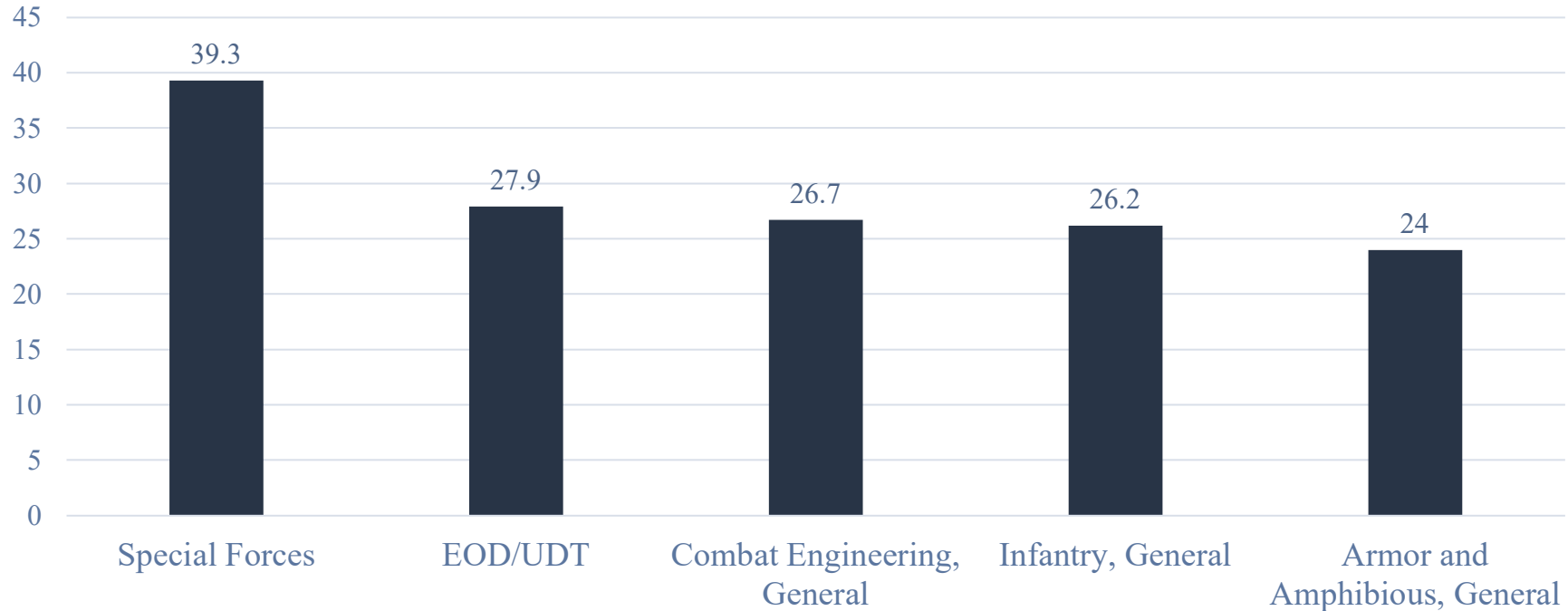


Results cont.:

- At start of study period (2012), a noticeable shift occurred in occupations with highest TBI rates in contrast to the end of the period.
- Highest 2012 TBI rates were: combat engineering, infantry, combat operations control and Armor and Amphibious occupations. Rates dropped significantly at end of study period.
- By 2019, Special Forces occupations and EOD/Underwater Demolition Teams (UDT) occupations were the riskiest TBI occupations groups: 71.3 TBIs/1,000k SMs & 38.6 TBIs/1,000 SMs, respectively.
- Temporally, from 2012 to 2014 there was a gradual decline, across occupations, in risk of sustaining TBI followed by an increase observed in 2015, with a diverging uptick in 2019 for Special Forces and EOD/UDT Service members.



Figure 1. Top 5 Occupations According to TBI Rate (2012-2019): Unique TBIs per 1000 SMs in Occupation group*



Discussion and Limitations:

- The DoD TBI case definition includes an “incidence rule” whereby an SM has only one TBI counted per lifetime (their first), regardless of time in the Military because of the inability of surveillance methodologies to capture SM’s subsequent TBIs.
- Because of this limitation, the data likely underestimates the true risk of a TBI according to SM’s occupation, especially if certain groups, e.g., Special Forces, are more likely to sustain multiple TBIs during their time in service.
- The study results are an approximate indicator of the within occupational changes in risk, allowing for comparisons of changes in TBI incidence within occupational group by year.
- The results also allow for an approximate indicator of risk of sustaining first lifetime TBI according to occupational groups.
- Findings support the development of clinical recommendations or Military Occupational Specialty (MOS) based Fact Sheets on TBI screening and inform leaders of high risk groups.



Implications:

1. Results may encourage medical communities to increase clinical care efforts with high-risk populations such as Special Forces, assess whether group specific protocols may be useful and/or engage in targeted clinical outreach for care, including follow-up protocols for high-risk groups.
2. Preventive strategies, targeted screening for underreported TBI, improvements in monitoring of operational risk (blast gauges, reporting requirements) and/or efforts to identify groups likely to benefit from TBI mitigation strategies.



Example 2 - Comorbidities Associated with Military Sustained Mild Traumatic Brain Injury

- SMs whose first lifetime mTBI occurred between October 1, 2016 and October 30, 2019 were included.
- Data from Military Health System Data Repository was used.
- Without making assumptions on causality, a group of 18 conditions often co-occurring with mTBI were identified through literature review and TBI subject matter expert consensus.



Analysis Team

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Methods

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Methods: Conditions co-occurring with mTBI

Condition or Condition Group	International Classification of Diseases-10-Clinical Modification Diagnosis Codes
Alcohol and Substance Abuse Disorders	F10.00-F10.99, F11.0-F11.99
Anxiety Disorders	F40.0-F41.9, F45.2-F45.4, R45.0, R45.1, R45.4-R45.7, R45.82
Cervicogenic Disorders	S13-S13.9XXS, M54.2
Cognitive Conditions	R41.0-R41.9, R45.87, R47-R47.9
Depression & Related Conditions	F32-F32.9, F34-F34.9, R4.3, R45.81, R45.83, R45.84, R45.86
Headache & Related Conditions	G43.001-G43.119, G43.70-G43.719, G43.90-G43.919, G44.0-G44.099, G44.201, G44.209, G44.211, G44.219, G44.221, G44.219, G44.301-G44.329, G44.4 -G44.41, G44.81-G44.89, M79.2, R51, M54.81
Hearing Related Conditions	H90.0-H90.A32, H91-H91.93, H93.11-H93.239
Nausea/Vomiting	R11-R11.2
Neuroendocrine Disorders	E23.0
Other Neurologic Conditions	R20.0-R20.9, R27.0, R48.2
Other Psychiatric Conditions	F23, F30.0-F30.9, F31.0-F31.9, F45-F45.9, F48-F48.9, R45, R45.8, R45.89
Post-Traumatic Stress Disorder	F43.0-F43.9
Psychosocial Conditions	T74-T74.01XS, T74.02-T74.02XS, T74.1-T74.12XS, T74.2-T74.22XS, T74.3- T74.32XS, T74.4 -T74.4XXS, T74.5-T74.52XS, T74.6-T74.62XS, T74.9-T74.92XS , T76-T76.92XS, Z55-Z55.9, Z56.9, Z59-Z59.9, Z62-Z62.9, Z63.0-Z63.9, Z65.4, Z65.5, Z69-Z69.82
Seizure-Related Conditions	G40-G40.B19
Sleep Related Conditions	F51-F51.9, G47- G47.9, Z72.820-Z72.9, R53.1, 53.8, 53.82, 53.83, G25.81
Suicidal Ideation/Homicidal Ideation	R45.85-R45.851, T14.91-T14.91XS
Vestibular Related Conditions	H81-H81.93, R26.0-R26.81, R42, I69.998
Visual Disturbances	H51.111-H52.5, H53.0-H53.9, H55.00, H55.81, H55.82



Methods continued

- Correlation analyses were used to determine the linear relationship between comorbidities across the different time intervals used in this study:
- Prior to mTBI diagnosis,
- First 30 days following mTBI,
- First 90 days following mTBI,
- First 180 days following mTBI.
- Changes in the period prevalence of comorbidities was calculated.



Results: Summary 1

- We identified 42,018 SMs with a first lifetime military sustained mTBI
- 32,592 (77.6%) had at least one co-occurring condition.
- Identified SMs were mostly male (81.4%), white (64.1%), junior enlisted officers (46.6%), and Soldiers (59.6%), 18-24 years old (46.1%), and 73.5% under 34 years old.
- Up to 180 days **prior** to sustaining an mTBI, the most frequently conditions were:

sleep-related conditions (21.7%)	headache related conditions (19.4%)	post-traumatic stress disorder (PTSD) (17.8%)
anxiety disorders (11.3%)	cervicogenic disorders (e.g., cervicalgia) (10.9%)	Nausea/Vomiting (7.7%)



Results: Summary 2

- In the first 180 days **following** mTBI diagnosis, the prevalence of diagnosed conditions increased significantly, especially visual disturbances (327.2%), cognitive conditions (313.9%), vestibular conditions (192.6%), those related to headache (152.2%) and hearing (72.9%).
- Sleep-related conditions remained moderately positively correlated with a group of co-occurring conditions, led by cognitive conditions ($r=0.50$), anxiety disorders ($r=0.42$), PTSD ($r=0.43$) and headaches and related conditions ($r=0.37$).



Results 6: Comorbidity Incidence and Period Prevalence by Period

Condition or Condition Group	-180 to -1 days	0-30 days	0-90 days	0-180 days	-180 to 180 days
	N (%) ^a	N (%)	N (%)	N (%)	N (%)
	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incident Rate Ratio (Post/Pre)/ Period Prevalence
Alcohol and Substance Abuse Disorders	2,128 (5.1)	673 (1.6)	1,050 (2.5)	1,388 (3.3)*^	0.65 ^{#1}
		1,820 (4.3)	2,316 (5.5)	2,713 (6.5)	3,516 (8.4)
Anxiety Disorders	4,741 (11.3)	2,666 (6.3)	4,089 (9.7)	5,047 (12.0)*^	1.06 ^{#2}
		4,858 (11.6)	6,816 (16.2)	8,009 (19.1)	9,788 (23.3)
Cervicogenic Disorders	4,560 (10.9)	3,157 (7.5)	4,421 (10.5)	5,306 (12.6)*^	1.16 ^{#2}
		5,009 (11.9)	6,693 (15.9)	7,755 (18.5)	9,866 (23.5)
Cognitive Conditions	2,173 (5.2)	6,315 (15.0)	8,220 (19.6)	8,996 (21.4)*^	4.14 ^{#3}
		7,445 (17.7)	9,508 (22.6)	10,346 (24.6)	11,169 (26.6)
Depression & Related Conditions	2,620 (6.2)	1,018 (2.4)	1,729 (4.1)	2,395 (5.7)*^	0.91 ^{#2}
		2,131 (5.1)	3,092 (7.4)	3,874 (9.2)	5,015 (11.9)
Headache & Related Conditions	8,168 (19.4)	9,643 (22.9)	11,484 (27.3)	12,435 (29.6)*^	1.52 ^{#3}
		14,374 (34.2)	16,816 (40.0)	18,010 (42.9)	20,603 (49.0)
Hearing Related Conditions	2,349 (5.6)	2,372 (5.6)	3,371 (8.0)	4,061 (9.7)*^	1.73 ^{#3}
		3,166 (7.5)	4,378 (10.4)	5,161 (12.3)	6,410 (15.3)
Nausea/Vomiting	3,254 (7.7)	1,172 (2.8)	1,984 (4.7)	2,865 (6.8)*^	0.88 ^{#1}
		1,473 (3.5)	2,521 (6.0)	3,596 (8.6)	6,119 (14.6)

*p-value<0.001 McNemar Test for paired data ^p-value<0.005 Z-test of correlated proportions; Cohen's (g) Effect Size Estimate: ^{#1}Low: 0.05 < 0.15; ^{#2}Medium: 0.15 < 0.25; ^{#3}Large: ≥ 0.25.



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Results 7: Comorbidity Incidence and Period Prevalence by Period

Condition or Condition Group	-180 to -1 days	0-30 days	0-90 days	0-180 days	-180 to 180 days
	N (%) [†]	N (%)	N (%)	N (%)	N (%)
	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incident Rate Ratio (Post/Pre)/ Period Prevalence
Neuroendocrine Disorders	12 (0.0)	4 (0.0)	6 (0.0)	9 (0.0)*	0.75 ^{#1}
		9 (0.0)	14 (0.0)	17 (0.0)	21 (0.0)
Other Neurologic Conditions	1,424 (3.4)	597 (1.4)	1,121 (2.7)	1,613 (3.8)*^	1.13 ^{#2}
		784 (1.9)	1,395 (3.3)	1,944 (4.6)	3,037 (7.2)
Other Psychiatric Conditions	1,413 (3.4)	1,016 (2.4)	1,821 (4.3)	2,415 (5.7)*^	1.71 ^{#2}
		1,389 (3.3)	2,294 (5.5)	2,949 (7.0)	3,828 (9.1)
PTSD	7,484 (17.8)	2,526 (6.0)	4,033 (9.6)	5,156 (12.3)*^	0.69 ^{#3}
		7,404 (17.6)	9,559 (22.7)	10,944 (26.0)	12,640 (30.1)
Psychosocial Conditions	3,299 (7.9)	1,093 (2.6)	2,014 (4.8)	2,842 (6.8)*^	0.86 ^{#1}
		2,202 (5.2)	3,460 (8.2)	4,444 (10.6)	6,141 (14.6)

*p-value<0.001 McNemar Test for paired data ^p-value<0.005 Z-test of correlated proportions; Cohen's (g) Effect Size Estimate: ^{#1}Low: 0.05 < 0.15; ^{#2}Medium: 0.15 < 0.25; ^{#3}Large: ≥ 0.25.



Results 8: Comorbidity Incidence and Period Prevalence by Period

Condition or Condition Group	-180 to -1 days	0-30 days	0-90 days	0-180 days	-180 to 180 days
	N (%) ^a	N (%)	N (%)	N (%)	N (%)
	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incidence/ Period Prevalence	Incident Rate Ratio (Post/Pre)/ Period Prevalence
Seizure-Related Conditions	144 (0.3)	57 (0.1)	107 (0.3)	151 (0.4)*^	1.05 ^{#2}
		120 (0.3)	181 (0.4)	230 (0.5)	295 (0.7)
Sleep Related Conditions	9,131 (21.7)	4,877 (11.6)	6,815 (16.2)	8,039 (19.1)*^	0.88 ^{#3}
		10,750 (25.6)	13,690 (32.6)	15,259 (36.3)	17,170 (40.9)
Suicidal Ideation/Homicidal Ideation	944 (2.2)	406 (1.0)	687 (1.6)	966 (2.3)*^	1.02 ^{#1}
		572 (1.4)	904 (2.2)	1,209 (2.9)	1,910 (4.5)
Vestibular Related Conditions	1,972 (4.7)	3,440 (8.2)	4,985 (11.9)	5,768 (13.7)*^	2.92 ^{#3}
		4,205 (10.0)	5,888 (14.0)	6,730 (16.0)	7,740 (18.4)
Visual Disturbances	1,047 (2.5)	2,630 (6.3)	3,837 (9.1)	4,473 (10.6)*^	4.27 ^{#3}
		2,895 (6.9)	4,147 (9.9)	4,816 (11.5)	5,520 (13.1)

*p-value<0.001 McNemar Test for paired data ^p-value<0.005 Z-test of correlated proportions; Cohen's (g) Effect Size Estimate: ^{#1}Low: 0.05 < 0.15; ^{#2}Medium: 0.15 < 0.25; ^{#3}Large: ≥ 0.25.



Discussion & Conclusions

- Our period prevalence estimates of PTSD (30.1%) and depression and related conditions (11.9%) among those with mTBI is higher than the 5% prevalence among non-deployed SMs and 8% with combat deployment across the force, further suggesting that co-occurrence of these conditions is significantly higher among brain injured SMs.
- While some conditions were frequent prior to mTBI, especially sleep-related conditions, headaches, and PTSD, mTBI co-occurred with an increase in certain conditions following its diagnosis, especially cognitive conditions, vestibular related conditions, visual disturbances, hearing related conditions, and headache and related conditions.



Discussion & Conclusions

- Our study's findings of a high prevalence of sleep related conditions prior to mTBI and high incidence after its diagnosis, foretell a difficult road ahead.
- Results indicate mTBI doesn't exist in isolation among our Military's SMs and suggests a rather arduous recovery pathway for mTBI patients, especially those with accompanying conditions.
- Caring for mTBI patients requires a holistic approach, one that considers the complex nature of SMs conditions, prior and after mTBI.
- We found a complex correlation of conditions that suggest SMs with mTBI are undergoing a multifaceted experience, one that may require the development of a targeted multidimensional clinical practice recommendations and practice.



Limitations

- This study uses a total of 1 year of follow-up, 180 days pre-mTBI and 180 days post-mTBI, thus setting the time bounds of identifying conditions, therefore these estimates must be understood with this limitation in place.
- SMs with undiagnosed mTBIs or undiagnosed conditions may not appear in our data, thus leading to underestimation, especially given that repeat TBIs are omitted by current surveillance systems.
- The surveillance effect. SMs with newly diagnosed mTBI are diagnosed with comorbid conditions at a higher rate than prior to their mTBI diagnosis, even if conditions are not causal. While changes in diagnoses following mTBI reflect a clinical reality, it is possible that some conditions diagnosed post-mTBI were undocumented prior to its diagnosis.



Limitations

- Some of these pre-existing conditions, such as suicidal ideation, depression, PTSD, and alcohol and substance abuse disorders, are known to have stigma as a barrier to care utilization, likely influencing their diagnosis, and presence in our data.
- Provider coding pre and post-mTBI, as well as coding variance between ambulatory and inpatient military treatment facilities and similar settings in the civilian private system, may have also introduced uncertainty in the estimates provided.
- Conditions examined herein were considered clinically well-established in the literature and among experts, however other conditions, directly or indirectly associated with TBI, may have been present, but not captured by our query.



Future Efforts

- Evaluate the ability to use the findings of these efforts and others to develop “real time” dashboards to assist operational and medical leadership to improve decision making and clinical planning.



Questions



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