Mild Traumatic Brain Injury (MTBI) in the Australian Defence Force: Results from the 2010 ADF Mental Health Prevalence and Wellbeing Dataset

Monthly Report

The Health and Wellbeing Survey Phase 2 – Contract Extension (Purchase Order Number: 4500784633)

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Executive Summary

- 28.3% of ADF personnel have experienced at least one mTBI in their lifetime.
- 12.6% of the ADF reported being exposed to a blast or explosion IED, and 14.0% reported being exposed to an RPG.
- Motor vehicle accidents were the most prevalent cause of mTBI.
- Motor vehicle accidents and falls carry a greater risk of mTBI than blast exposure.
- ADF members with a lifetime mTBI were more likely to be:
  - male
  - in the army
  - older in age
  - junior in rank (other ranks and non-commissioned officers); and
  - less likely to have been on operational deployment.
- mTBI is associated with a significantly increased risk of all domains of psychological disorder.
- Post-concussion symptoms are highly nonspecific and have a substantial overlap with psychological symptoms including PTSD.
- From a public health perspective, the prevention of motor accident trauma in the ADF needs to be addressed in any policy about mTBI.
- The prevalence of falls as a cause of mTBI suggests the risks associated with training and should not be underestimated from an occupational health and safety perspective.
- Given the evidence of increasing risk of permanent sequelae associated with repeated mTBI, solely focusing on the deployment exposures will miss the fact that many ADF members are likely to have had mTBI prior to deployment from non-combat related causes.

Background

The occurrence of mild traumatic brain injury (mTBI) has attracted much attention in the research literature, as well as public domains (such as the media), in recent years. This has emerged due to a suspected increase in mTBI, thought to be the result of increased use of explosive devices in combat in the last decade. There is a controversy amongst medical professionals and researchers as to the prevalence of long-term consequences of traumatic brain injury. In addition, significant uncertainty exists in the literature as to whether mTBI is a complete explanation for post-deployment symptoms experienced by soldiers returning from combat.

Definition of MTBI

Due to its particular relevance to the current conflicts in the Middle East, mTBI has been described as the “signature injury” of the Afghanistan and Iraq wars (Okie, 2005). In this context, mTBI is characterised by a “brief loss of consciousness or altered mental status, as a result of deployment-related head injuries, particularly those resulting from proximity to blast explosions” (Hoge et al., 2008, p.454). This definition is consistent with those widely cited in research (Carroll, Cassidy, Holm, Kraus, & Coronado, 2004) and is used as a basis for American military screening programs (Defense and Veterans Brain Injury Center, 2009).

Symptoms of MTBI

Symptoms that can occur following mTBI include problems with memory, balance, sleep and concentration, headache, tinnitus, sensitivity to light or other visual disturbance, fatigue and irritability (Bryant, 2008; Fear et al., 2009). A small proportion of individuals continue to have difficulties weeks or months later; estimates of those with persisting symptoms have been as high as 20% but comprehensive reviews report that 5% is likely a more accurate figure (Carroll et al., 2004; McCrea et al., 2009).

Prevalence of MTBI

Accurate prevalence estimates of MTBI are extremely difficult to ascertain given the non-specific nature of post-concussive symptoms (Fear, et al., 2009; Powell, 2008; Stein & McAllister, 2009). There is a large degree of overlap between symptoms of MTBI and symptoms of psychiatric disorders like depression and post-traumatic stress disorder (PTSD; American Psychiatric Association, 1994) which can be misattributed to mTBI.

Prevalence estimates of mTBI also vary between countries. In general, the United States has reported a higher prevalence of mTBI than the United Kingdom and Canada, particularly in studies employing MEAO-deployment screening data (Brenner et al., 2010; Pietrzak, Johnson, Goldstein, Malley, & Southwick, 2009; Polusny et al., 2011; Schneiderman, Braver, & Kang, 2008; Terrio et al., 2009). A 2008 review, for example, reported that 12% to 20% of returned US personnel deployed to Iraq and Afghanistan met criteria for a mTBI episode following deployment (Thompson, 2008). In contrast, 4.4% of British personnel returning from Afghanistan and Iraq and 6.4% of Canadian military personnel returning from Afghanistan reported deployment-related mTBI (Rona, Jones, Fear, Hull, et al., 2012; Zamorski, Darch, & Jung, 2009).

Why is the prevalence of mTBI difficult to establish?

Explanations that exist to account for the variation in reported rates of mTBI include measurement issues (to determine the degree of combat exposure (Rona, Jones, Fear, Hull, et al., 2012) and deployment length (Rona, Jones, Fear, Sundin, et al., 2012)) as well as cultural differences such as compensation practices and healthcare systems across countries (Hoge, Goldberg, & Castro, 2009; Rona, Jones, Fear, Hull, et al., 2012). Aside from these differences across countries, determination of the prevalence of deployment-mTBI is difficult in general owing to significant problems with the methods used to measure and diagnose mTBI (e.g., lack of reliable diagnostic tools (Hoge, et al., 2009) and reliance on retrospective self-report of events involving loss of consciousness, awareness and memory (Belanger, Uomoto, & Vanderploeg, 2009; Polusny, et al., 2011)).

Accurate diagnosis of mTBI is further complicated by the fact that symptoms associated with mTBI are highly non-specific and overlap greatly with many other conditions and syndromes, in particular, PTSD, depression and chronic pain. PTSD in particular shows significant overlap with deployment-related mTBI. There is overlap in both symptom profiles and also aetiology; with the potential for both disorders to arise from the same combat experience. Many research groups have explored the relationship between these two conditions with conflicting results. Hoge et al. (2008) found in their US infantry sample returning from Iraq that 32.6% of those reporting mTBI also met criteria for PTSD, while only 16.2% of those reporting other injuries and 9.1% of non-injured met criteria. Similarly, 13% of those reporting mTBI met criteria for depression compared with 6.6% of those with other injuries and 3.3% of those reporting no injury. In their cross-sectional survey of Iraq/Afghanistan veterans, Schneiderman et al. (2008) found a strong association between PTSD and post-concussive symptoms, even after removing the symptoms that overlapped between the measures used; sleep difficulties and irritability. Despite the lack of clarity in the literature on this subject, it is clear that psychiatric comorbidity must be considered when an individual presents with post-concussive symptoms.

Understanding mTBI in the context of deployment is important owing to the implications for healthcare provision, deployability status and compensation for affected veterans. As such, there is a distinct lack of epidemiological estimates of mTBI in military populations, including the Australian Defence Force, that needs to be addressed.

Purpose of this report

The purpose of this report is to examine the lifetime prevalence of self-reported head injury in a representative sample of the ADF. Mechanisms of injury, frequency of reported post-injury symptoms, differences between deployed and non-deployed groups, and relationships between injury and various psychiatric disorders will also be explored. Injury groups and some analyses have been modelled on a paper by Hoge and colleagues (2008).

Method

Data used in this report was collected in 2010 as part of the 2010 ADF Mental Health Prevalence and Wellbeing Study (MHPWS; McFarlane, Hodson, Van Hooff, & Davies, 2011). This study aimed to measure the prevalence of 12-month mental health disorder and psychological distress in a representative sample of currently serving ADF personnel. Trainees and reservists were not included in this study. Of the 50,049 currently serving ADF members invited to complete the survey, 24,481 responded between the 23rd of April 2010 and the 31st of January 2011.

Recruitment

Phase one of the MHPWS study involved completion of a self-report questionnaire examining the impact of a range of occupational factors on the mental health of ADF members. The self-report questionnaire included the mTBI screening questions, the Kessler Psychological distress scale (K10), the Post-Traumatic Stress Disorder Checklist (PCL), the Patient Health Questionnaire depression assessment (PHQ-9) and the Alcohol Use Identification Test (AUDIT). Anonymity was preserved through the allocation of a unique study number for each participant. A brief description of each of the measures/outcome variables relevant to this short report is provided below.

Measures

For each of the psychological health measures, the optimal screening and epidemiological cut-offs identified in the MHPWS report (MHPWS; McFarlane, Hodson, et al., 2011) were used to determine psychological caseness. These cut-offs were derived using Receiver Operating Characteristic (ROC) analysis in order to detect 30-day ICD-10 disorder and are described in detail in the main report. Additionally, the cut-off used by Hoge et al. (2008) for the PCL was also used to allow direct comparison with their results and is provided in Annex 1.

PCL

The PTSD Checklist (PCL; Weathers, Litz, Herman, Huska, & Keane, 1993) has been designed to incorporate all of the symptomatic criteria for PTSD as specified in the Diagnostic and Statistical Manual of Mental Disorders, fourth edition (DSM-IV; American Psychiatric Association, 1994). The 17 questions of the PCL are scored from 1 to 5 and are summed to give a total score from 17 to 85. Greater scores indicate greater distress. Cut-offs used were scores of at least 50 (based on Hoge et al.'s (2008) analyses), 29 (MHPWS screening cut-off) and 53 (MHPWS epidemiological cut-off) which are required to detect ICD-10 30 day PTSD.

K10

The Kessler 10 (K10) is a short 10-item screening questionnaire for psychological distress that was developed in the context of the US National Co-morbidity study (Kessler et al., 2002). The 10 questions of the K10 are scored from 1 to 5 and are summed to give a total score of between 10 and 50. Greater scores indicate greater distress. Cut-offs used in analyses were scores of at least 17 (MHPWS screening cut-off) and 26 (MHPWS epidemiological cut-off), which are the optimal cut-offs for determining a 30 day ICD-10 Anxiety Disorder.

AUDIT

Alcohol consumption and problem drinking were examined using the Alcohol Use Disorders Identification Test (AUDIT; Saunders, Aasland, Babor, De la Fuente, & Grant, 1993); a brief self-report screening instrument developed by the World Health Organization. This instrument consists of 10 questions to examine the quantity and frequency of alcohol consumption (questions 1 to 3), possible symptoms of dependence (questions 4–6), and the reactions or problems related to alcohol (questions 7–10). The AUDIT is an instrument that is widely used in epidemiological and clinical practice for defining at risk patterns of drinking. Scores range between 0 and 40. Cut-offs used in analyses were scores of at least 8 (MHPWS screening cut-off) and 20 (MHPWS epidemiological cut-off) which were the cut-offs required to detect either 30 day ICD-10 Harmful Alcohol Use or 30 day ICD-10 Alcohol Dependence.

PHQ-9

Depression was assessed by the Patient Health Questionnaire depression scale (PHQ-9; Kroenke, Spitzer, & Williams, 2001). This measure comprises 9 items in which respondents rate how bothered they have been in the previous 2 weeks by 9 depression symptoms. Items are scored from 0 to 3 and are summed to give a total score range of 0 to 27. Cut-offs used in analyses in this report were 6 (MHPWS screening cut-off) and 18 (MHPWS epidemiological cut-off) which are required to detect 30 day ICD-10 Depressive Episodes.

Head injury and mTBI screening questions

Participants were asked a number of mTBI screening questions based on a measure developed by the Defense and Veterans Brain Injury Center (Defense and Veterans Brain Injury Center, 2009; Defense and Veterans Brain Injury Center Working Group on the Acute Management of Mild Traumatic Brain Injury in Military Operational Settings, 2006; Schwab et al., 2007). The first four of these questions (outlined below) were used in order to provide mTBI prevalence.

In question 1 each participant was asked whether during their lifetime they experienced any of the following events known to be associated with mTBI:

- blast or explosion IED (improvised explosive device)
- RPG (rocket propelled grenade), land mine, grenade etc
- vehicular accident/crash (any vehicle including aircraft)
- fragment/bullet wound above the shoulders
- fall

Question 2 asked participants to indicate the number of times they had experienced loss of consciousness (LOC) or were “knocked out” immediately following any of the events listed in question 1. Those who reported that they had experienced loss of consciousness or had been “knocked out” at least once immediately following one of the above injury events were classed as having a “head injury with LOC”.

In questions 3 and 4, participants were asked to indicate the number of times they experienced either “being dazed, confused or seeing stars” or “not remembering the event” immediately following any of the events listed in Question 1. Those who reported either of these symptoms at least once immediately following one of the above injury events were classed as having a “head injury with altered mental status.”

Based on these questions, three groups were then defined:

Group 1: mTBI group
Participants reporting an injury listed in Question 1 with *immediate symptoms* of either loss of consciousness or altered mental state were classified as meeting criteria for mTBI.

Group 2: Other injury group
Participants reporting an injury of listed in Question 1 with *no immediate symptoms* of either loss of consciousness or altered mental state were calssified as having expereinced an injury/event with no associated mTBI.

Group 3: No injury group
Participants who did not report experiencing any of the injury events listed in Question 1 were classified as having “no injury”.

These classifications are based on those described by Hoge et al. (2008). Consistent with Hoge et al. (2008), the “other injury” group served as a reference against which the mTBI group was compared.

Participants were also asked if any of the following problems (referred to as post-concussive symptoms) began or got worse immediately after the injury event: memory problems/lapses, balance problems/dizziness, sensitivity to bright light, irritability, headaches, and sleep problems. The presence of these symptoms in week prior to completion of the questionnaire was also recorded. The number of times the participant reported a concussion or head injury after the events listed in Question 1 were also noted for the mTBI group.

Statistical analyses

Statistical analyses were conducted in SAS version 9.2. In order to correct for differential non-response the results were weighted based on strata formed from sex, service, rank and MEC status. Within each stratum the weight was calculated as the population size divided by the number of respondents from the stratum. In each section of the questionnaire, responses were only used if the participant responded to all of the questions from that section. As a result, a separate weight was calculated for each section of the questionnaire.

A finite population correction was also applied to adjust the variance estimates for the reasonably large sampling fraction within each stratum. All analyses in this report were conducted using weighted estimates of totals and proportions.

Chi square analyses were used to compare the prevalence of mTBI versus other injury by sex, service, marital status, rank, education, MEC status, deployment status, injury event and post-concussive symptoms. Differences between the mTBI and the other injury group on the age and the proportion of ADF personnel scoring above the MHPWS screening and epidemiological cut-offs on the PCL, PHQ-9, K10 and AUDIT were analysed using weighted logistic regressions. All regressions involved the variables sex, Service, rank, MEC status, age, education and ADF deployment. The interaction between sex and Service was initially included, but was removed as found to be non-significant.

Results

Participants

Of 24,481 respondents, data from 4,691 (19.2%) were excluded due to missing data on any of the measures used for analyses. Responses from the remaining 23,320 were used; however, statistics using the weighted data are reported (total population of 50,049) and hence represent and estimate of the prevalence of head injury and mTBI in the entire Australian Defence Force (ADF).

Injuries

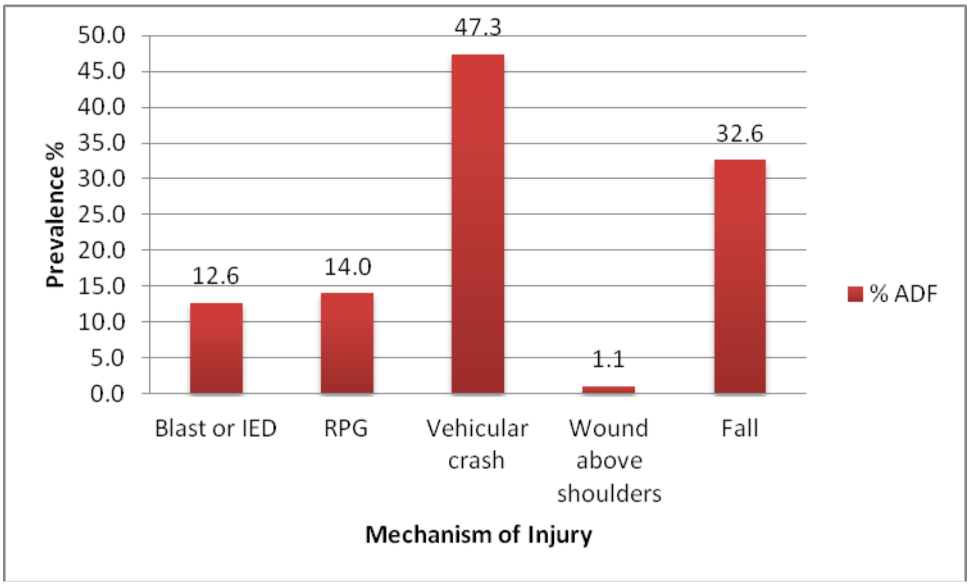
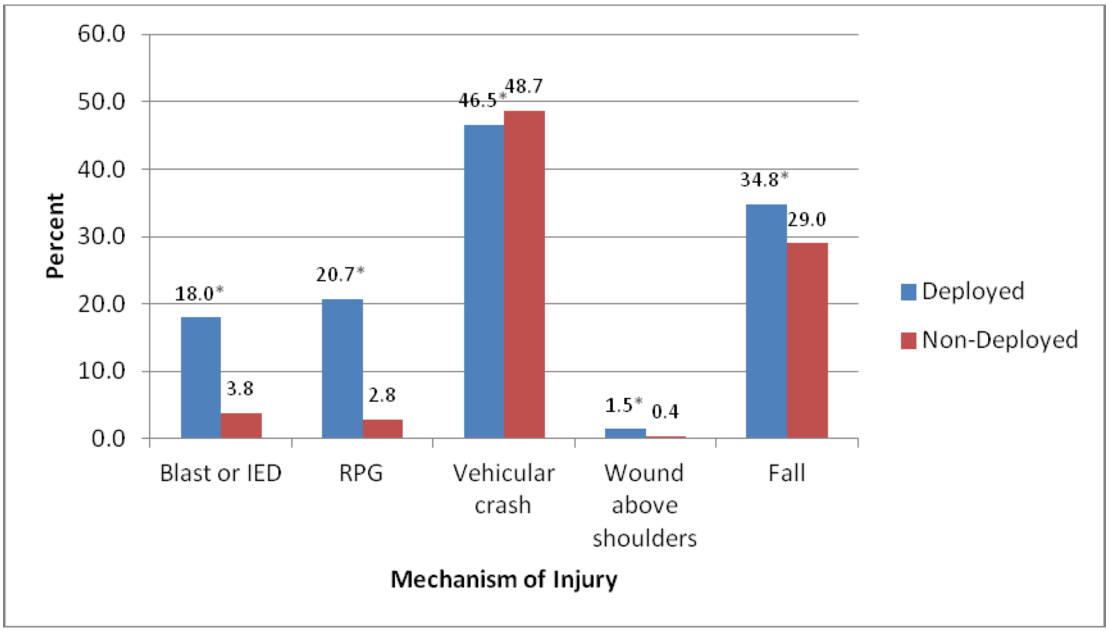


Figure 1: Lifetime prevalence of injury events in the ADF

As can be seen in Figure 1, the most common mechanism of injury in the ADF were vehicular crashes (47.3% N=23685). Over their lifetime, 32.6% (N=16321) of the ADF reported having a fall, 14% (N=7009) were exposed to an RPG, 12.6% (N=6321) experienced a blast or explosion IED and 1.1% of (N=534) reporting having experienced a fragment wound or bullet above the shoulders.

If we look at these events according to whether the ADF member had ever been on operational deployment or not (Figure 2), deployed personnel were significantly more likely to experience all types of injury events than personnel who had never deployed with the exception of vehicular accidents, where deployed personnel were less likely to be exposed (46.5% deployed vs 48.7% non-deployed, OR=0.92 (95% CI 0.87-0.96), p=0.0051). For example, deployed personnel were over 5 times more likely to be exposed to a blast/IED (18% deployed vs 3.8% non-deployed, OR = 5.6 (95% CI 5.1-6.1), *p* <.0001); almost 9 times more likely to be exposed to an RPG/land mine/grenade etc (20.7% deployed vs 2.8% non-deployed, OR = 8.9 (95% CI 8.0-9.9), *p* <0001); 3.4 times more likely receive a fragment or bullet wound above the shoulders (1.5% deployed vs 0.4% non-deployed, OR=3.4 (95% CI 2.5-4.7), p<.0001) and 1.3 times more likely to experience a fall (34.8% deployed vs 29% non-deployed, OR=1.3 (95% CI 1.2-1.4), p<.0001), than non-deployed personnel. Details of whether any of the events happened during a deployment however were not specified.



Note = significantly different from non-deployed group, injury events are not mutually exclusive*

Figure 2. Percentages of ADF members who have experienced injury events by deployment status.

Lifetime Prevalence of mTBI

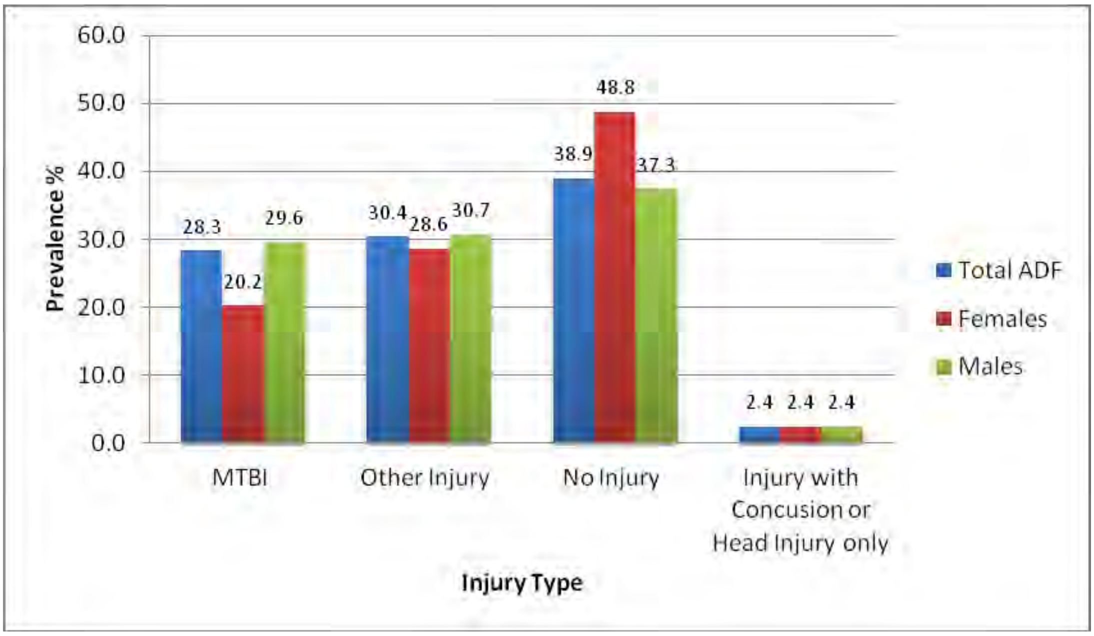


Figure 3: Lifetime prevalence of mTBI in the ADF by Sex

Based on the available data, one in three (N=14,170, 28.3%) members of the ADF met criteria for an mTBI in their lifetime. This is comprised of 16.38% who reported loss of consciousness and 11.93% reporting either being dazed or confused, or not remembering the event with no associated loss of consciousness.

A further 30.4% reported experiencing an injury event with no accompanying symptoms of mTBI (other injury). This was the reference group for all analyses.

Finally 38.9% of the ADF reported never having experienced an injury listed in Question 1 of the mTBI screening questions.

Males were significantly more likely than females to report an mTBI compared to other injuries ($p<.0001$). A small number of ADF members (2.4%) reported experiencing one of the 5 injury events with an associated concussion or head injury but no other symptoms of mTBI.

Demographic Characteristics of the mTBI and other injury group

The demographic characteristics of the study population are presented in Table 1. All p-values were obtained using weighted regression models.

Table 1. Demographic characteristics of the 3 study groups

Characteristic	Sub-groups	MTBI N (%)	Other Injury, N (%)	No Injury, N (%)	P Value for MTBI vs Other injury
N		**14170**	**15208**	**19464**	
Sex					<.0001
	F	1375 (9.7%)	1948 (12.8%)	3322 (17.1%)	
	M	12794 (90.3%)	13261 (87.2%)	16143 (82.9%)	
Service					<.0001
	Navy	3101 (21.9%)	3118 (20.5%)	5110 (26.3%)	
	Army	7883 (55.6%)	8175 (53.8%)	8677 (44.6%)	
	Air Force	3186 (22.5%)	3915 (25.7%)	5677 (29.2%)	
Age					0.0002
	Mean (SD)	35.6 (SD)	35.1 (9.4)	32.3 (8.8)	
Age Range					
	18-27	4075 (28.8%)	4307 (28.3%)	7679 (39.9%)	
	28-37	4319 (30.5%)	5088 (33.5%)	6448 (33.5%)	
	38-47	3950 (27.9%)	4233 (27.8%)	3884 (20.2%)	
	48-57	1700 (12.0%)	1512 (9.9%)	1177 (6.1%)	
	58+	127 (0.9%)	68 (0.4%)	46 (0.2%)	
Marital Status					0.2487
	Yes	10687 (75.4%)	11602 (76.3%)	14036 (72.1%)	
	No	3482 (24.6%)	3607 (23.7%)	5429 (27.9%)	
Education					<.0001
	Up to Year 12	5646 (39.9%)	6489 (42.8%)	8436 (43.9%)	
	Certificate or Diploma	5724 (40.5%)	5443 (35.9%)	6658 (34.7%)	
	Bachelor Degree	1199 (8.5%)	1501 (9.9%)	2241 (11.7%)	
	Post-Graduate	1574 (11.1%)	1741 (11.5%)	1862 (9.7%)	
Rank					0.0023
	Non-Commissioned Officer	3276 (23.1%)	7275 (47.8%)	7874 (40.5%)	
	Commissioned Officer	6619 (46.7%)	3900 (25.6%)	4570 (23.5%)	
	Other ranks	4275 (30.2%)	4033 (26.5%)	7020 (36.1%)	
Mec					<.0001
	Mec 1	8332 (58.8%)	9959 (65.5%)	13785 (70.8%)	
	Mec 2	3904 (27.5%)	3707 (24.4%)	3788 (19.5%)	
	Mec 3	1468 (10.4%)	1290 (8.5%)	1593 (8.2%)	
	Mec 4	466 (3.3%)	252 (1.7%)	297 (1.5%)	
ADF Deployment					<.0001
	Yes	8838 (62.4%)	10413 (68.5%)	11246 (57.8%)	
	No	5332 (37.6%)	4796 (31.5%)	8218 (42.2%)	
Mechanism of Injury+					
	Blast or explosion	2586 (18.3%)	3559 (23.4%)	0 (0.0%)	0.0291
	RPG	2612 (18.4%)	4194 (27.6%)	0 (0.0%)	<.0001

Characteristic	Sub-groups	MTBI N (%)	Other Injury, N (%)	No Injury, N (%)	P Value for MTBI vs Other injury
	Fragment or shrapnel	270 (1.9%)	239 (1.6%)	0 (0.0%)	0.0905
	Fall	9683 (68.3%)	5886 (38.7%)	0 (0.0%)	<.0001
	Vehicle Accident	11906 (84.0%)	10821 (71.2%)	0 (0.0%)	<.0001

Note. N = 50,049

Compared to ADF members in Group 2 (other injury), ADF members with mTBI were more likely to be male, in the army, older in age, more likely to be junior in rank (other ranks and non-commissioned officers), less likely to be MEC 1 and less likely to have been on operational deployment (Table 1).

For both groups (mTBI and other injury) vehicular accidents and falls were the most common mechanisms of injury. Additionally, compared with those with other injuries, a significantly greater proportion of those with mTBI have experienced vehicle accidents or falls. The opposite effect was found for RPGs/land mines/grenades; these were more prevalent in the other injury group.

Post-concussive symptoms

Weighted frequencies of those reporting immediate (Table 2) and current (Table 3) post-concussive symptoms are shown below. Weighted regression models were used to compare the mTBI group with those with other injuries.

As can be seen in Table 2, a significantly greater proportion of those in the mTBI group reported post-concussive symptoms immediately following the event compared with those with other injuries. This effect was consistent for every post-concussive symptom (memory problems, balance problems, sensitivity to bright light, irritability, headaches) except for sleep problems.

Table 2: Post concussive symptoms immediately following event in the 3 study groups.

Characteristic	Sub-groups	MTBI N (%)	Other Injury, N (%)	No Injury, N (%)	P Value for MTBI vs Other injury
N		**14170**	**15208**	**19464**	
Post-Concussive Symptoms	Memory problem	1597 (11.3%)	401 (2.7%)	31 (5.4%)	<.0001
	Balance Problem	1186 (8.4%)	184 (1.2%)	24 (4.2%)	<.0001
	Sensitivity to bright light	1119 (7.9%)	223 (1.5%)	26 (4.9%)	<.0001
	Irritability	2019 (14.2%)	1058 (7.2%)	24 (4.4%)	0.056
	Headaches	2670 (18.8%)	689 (4.7%)	47 (8.3%)	<.0001
	Sleep Problems	2608 (18.4%)	1596 (10.8%)	46 (8.5%)	0.2287

Table 3: Current post concussive symptoms experienced in the past week in the 3 study groups.

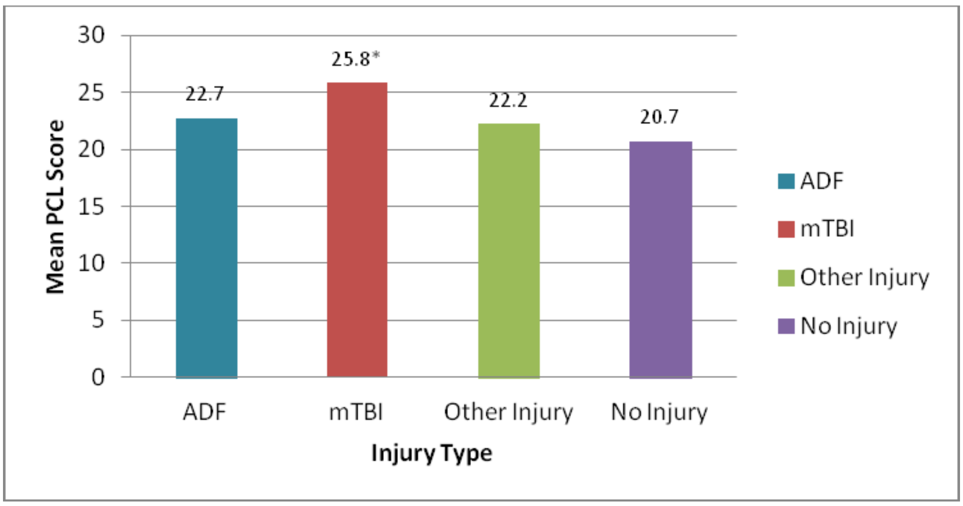
Characteristic	Sub-groups	MTBI N (%)	Other Injury, N (%)	No Injury, N (%)	P Value for MTBI vs Other injury
N		**14170**	**15208**	**19464**	
Post-Concussive Symptoms in past week	Memory problem	2278 (16.2%)	1317 (8.9%)	21 (5.9%)	<.0001
	Balance Problem	926 (6.6%)	487 (3.3%)	10 (2.7%)	0.0256
	Sensitivity to bright light	1184 (8.4%)	583 (3.9%)	8 (2.3%)	<.0001
	Irritability	3233 (22.9%)	2328 (15.7%)	25 (6.9%)	0.6319
	Headaches	3797 (27.0%)	2675 (18.0%)	40 (11.2%)	<.0001
	Sleep Problems	5416 (38.5%)	3908 (26.3%)	66 (19.0%)	<.0001

This pattern of increased symptoms in the mTBI group was also observed in the week prior to survey completion, implying a residual effect of a lifetime mTBI on current functioning in these personnel. For instance, a significantly greater proportion of the mTBI group report memory problems, balance problems, sensitivity to bright light, headaches and sleep problems than those who have been injured but do not have mTBI.

Psychological health measures

PTSD

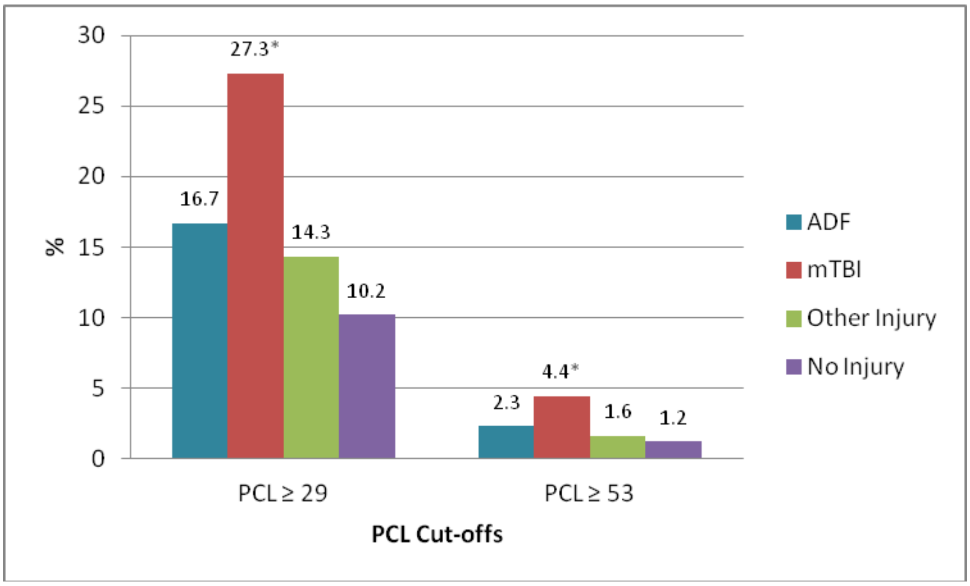
Mean PCL scores and the proportion of ADF members scoring above the screening and epidemiological cut-offs reported in the 2010 ADF Mental Health Prevalence and Wellbeing study are reported in Figures 4 and 5 and Table 4 below.



*Note: * Significantly different from Other injury group*

Figure 4: Mean PCL scores across the 3 study groups in comparison to the ADF (MHPWS).

As reported in Figure 4, ADF personnel in the mTBI group reported significantly higher mean PCL scores (Mean = 25.8, SD=11.2) than those in the other injury group (Mean = 22.2, SD = 8.5). Although not statistically verified, the mTBI group also appeared to have higher PCL scores than the entire ADF as reported in the 2010 MHPWS report.



*Note: * Significantly different from Other injury group*

Figure 5: Percentage of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for PTSD in comparison to the ADF (MHPWS).

Table 4: Proportion of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for PTSD.

PCL Cut-off	mTBI N(%)	Other Injury N(%)	No Injury N(%)	OR (95% CI) MTBI vs Other Injury,
N	**13431**	**14269**	**18228**	
PCL ≥ 29*	3669 (27.3%)	2047 (14.3%)	1862(10.2%)	2.1 (1.9, 2.3) p <.0001
PCL ≥ 53^	593 (4.4%)	226 (1.6%)	219(1.2%)	2.5 (2.0, 3.2) p <.0001

*Note: *MHPWS Screening cut-off, ^MHPWS Epidemiological cut-off,*

As reported in Figure 5 and Table 4, the mTBI group were twice as likely to meet screening criteria and 2.5 times more likely to score above the epidemiological cut-off for 30 day ICD-10 PTSD compared to those in the other injury group. ADF personnel who had never been injured were the least likely to score above both cut-offs. The proportion of the mTBI group scoring above the PCL cut-off (27.3%) and epidemiological cut-off (4.4%) also appeared higher than the proportions of the ADF reported in the MHPWS report (16.7% and 2.3% respectively).

For additional analyses based Hoge et al’s, (2008) cut-off of 50 please see Annex 1.

Depression

Mean PHQ-9 scores and the proportion of ADF members scoring above the screening and epidemiological cut-offs reported in the 2010 ADF Mental Health Prevalence and Wellbeing study are reported in Figures 6 and 7 and Table 5 below.

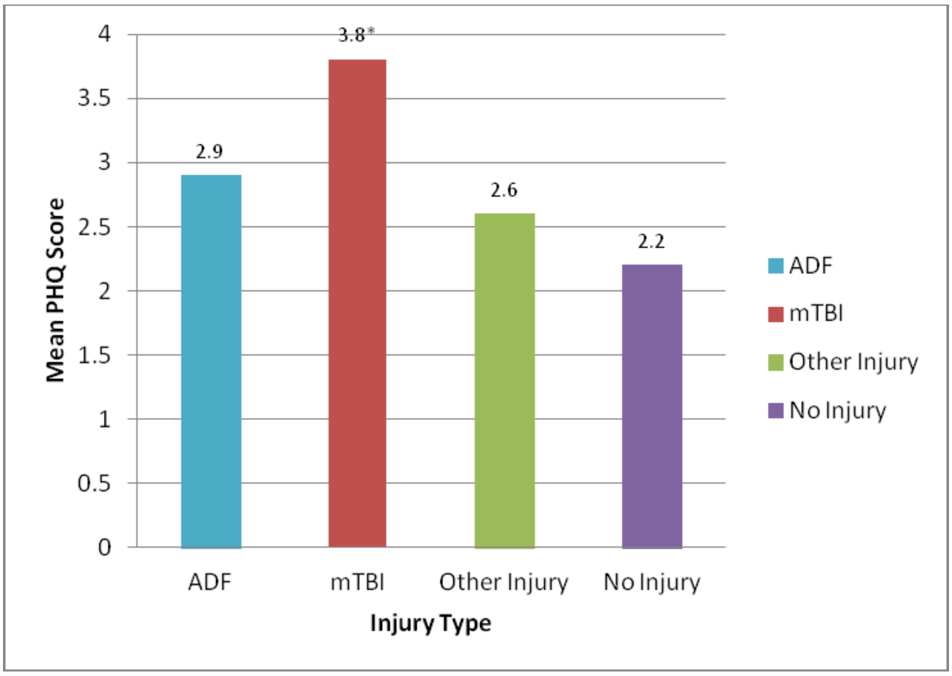
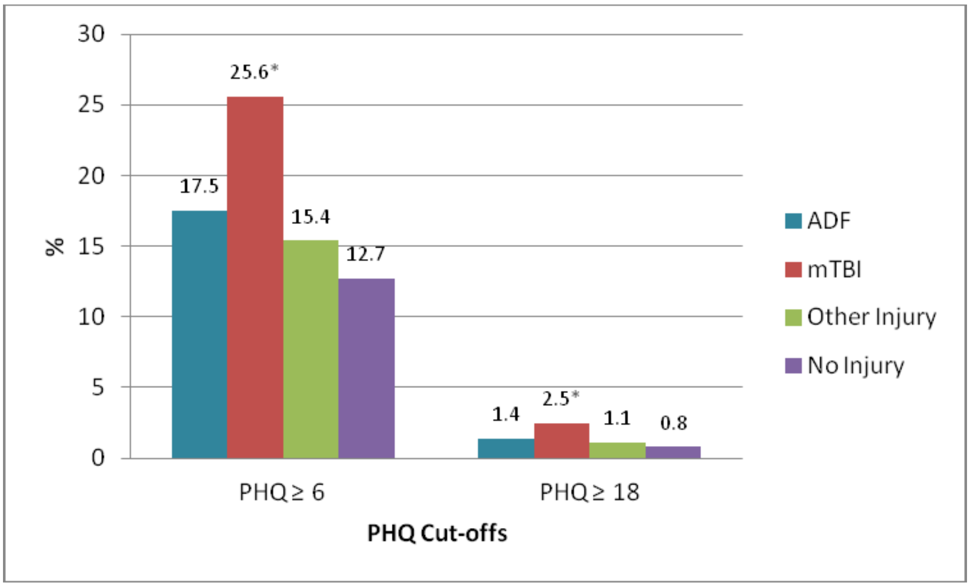


Figure 6: Mean PHQ scores across the 3 study groups in comparison to the ADF (MHPWS).

As reported in Figure 6, ADF personnel in the mTBI group reported significantly higher mean PHQ-9 scores (Mean = 3.8, SD=4.7) than those in the other injury group (Mean = 2.6, SD = 3.8). Although not statistically verified, the mTBI group also appeared to have higher PHQ scores than the entire ADF as report in the 2010 MHPWS report.



*Note: * Significantly different from Other injury group*

Figure 7: Percentage of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for PTSD in comparison to the ADF (MHPWS).

Table 5: Proportion of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for Depression

PHQ Cut-off	mTBI N(%)	Other Injury N(%)	No Injury N(%)	OR (95% CI) MTBI vs Other Injury,
N	13492	14261	18282	
PHQ ≥ 6*	3454 (25.6%)	2198 (15.4%)	2321 (12.7%)	1.8 (1.6, 2.0) p <.0001
PHQ ≥ 18^	342 (2.5%)	155 (1.1%)	147 (0.8%)	2.1 (1.5, 2.80) p <.0001

*Note: *MHPWS Screening cut-off, ^MHPWS Epidemiological cut-off,*

As reported in Figure 7 and Table 5, the mTBI group were 1.8 times more likely meet screening criteria and 2.1 times more likely to score above the epidemiological cut-off for 30 day ICD-10 Depressive episode compared to those in the other injury group. The mTBI group also appeared to be more likely to score above these cut-offs than the entire ADF community. ADF personnel who had never been injured were the least likely to score above both cut-offs compared to both injury groups and the ADF.

Anxiety

Mean K10 scores and the proportion of ADF members scoring above the screening and epidemiological cut-offs for 30 day ICD-10 Anxiety Disorder reported in the 2010 ADF Mental Health Prevalence and Wellbeing study are reported in Figures 8 and 9 and Table 6 below.

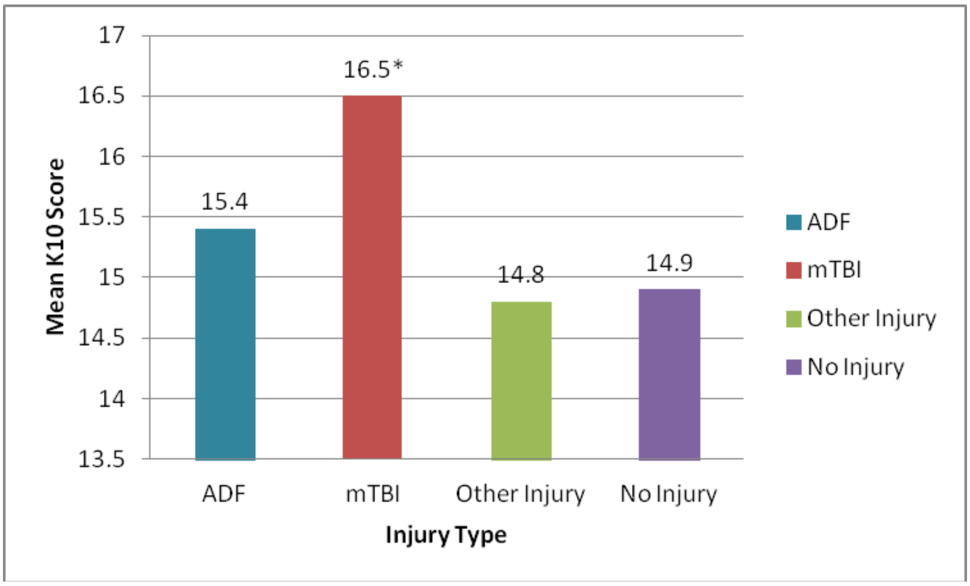
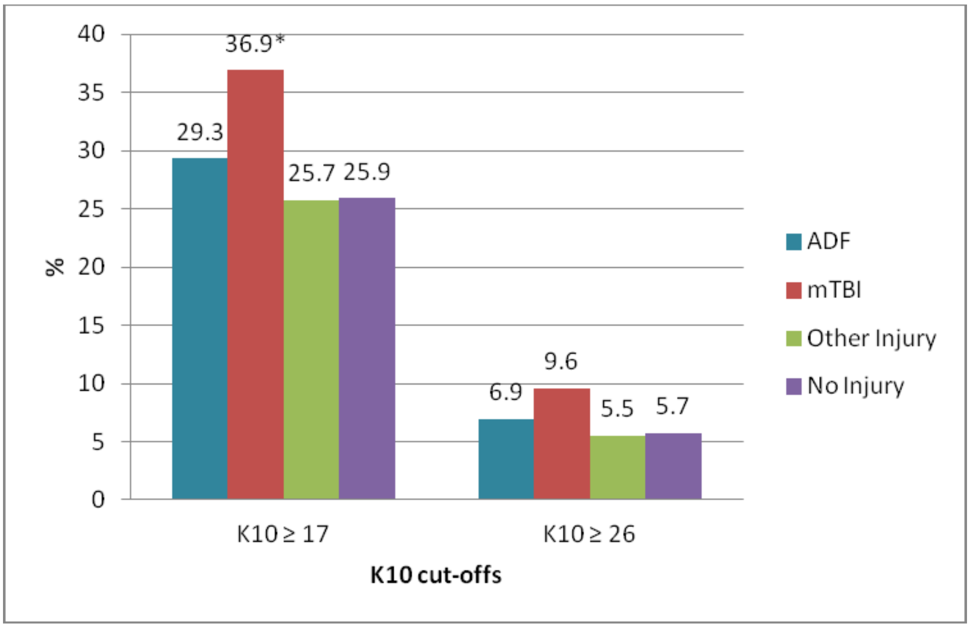


Figure 8: Mean K10 scores across the 3 study groups in comparison to the ADF (MHPWS).

As reported in Figure 8, ADF personnel in the mTBI group reported significantly higher mean K10 scores (Mean = 16.5, SD=6.3) than those in the other injury group (Mean = 14.8, SD = 5.4). Although not statistically verified, the mTBI group also appeared to have higher mean K10 scores than the entire ADF as reported in the 2010 MHPWS report. There was little difference between the other injury group and the no injury group.



*Note: * Significantly different from Other injury group*

Figure 9: Percentage of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for 30 day ICD-10 Anxiety in comparison to the ADF (MHPWS).

Table 6: Proportion of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for 30 day ICD-10 Anxiety

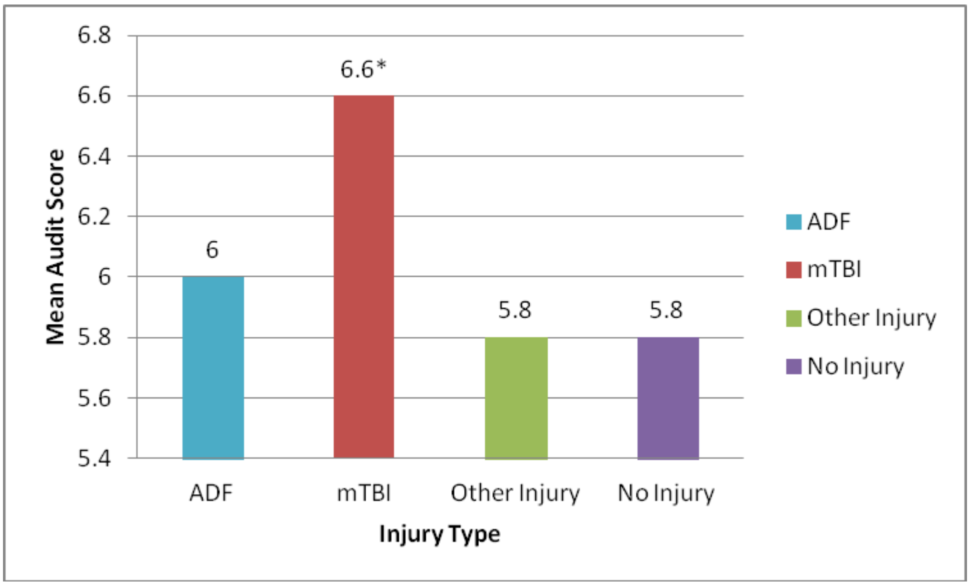
K10 Cut-off	mTBI N(%)	Other Injury N(%)	No Injury N(%)	OR (95% CI) MTBI vs Other Injury,
N	13881	14759	18759	
K10 ≥ 17*	5118 (36.9%)	3787 (25.7%)	4862 (25.9%)	1.6 (1.5, 1.8) p <.0001
K10 ≥26^	1339 (9.6%)	813 (5.5%)	1078 (5.7%)	1.7 (1.5, 2.0), p <.0001

*Note: *MHPWS Screening cut-off, ^MHPWS Epidemiological cut-off,*

As reported in Figure 9 and Tables 6, the mTBI group were 1.6 times more likely meet screening criteria and 1.7 times more likely to score above the epidemiological cut-off for 30 day ICD-10 Anxiety compared to those in the other injury group. ADF personnel who had never been injured were the least likely to score above the epidemiological cut-off. The ADF appeared to more closely resemble the other injury and no injury group than the mTBI group.

Alcohol

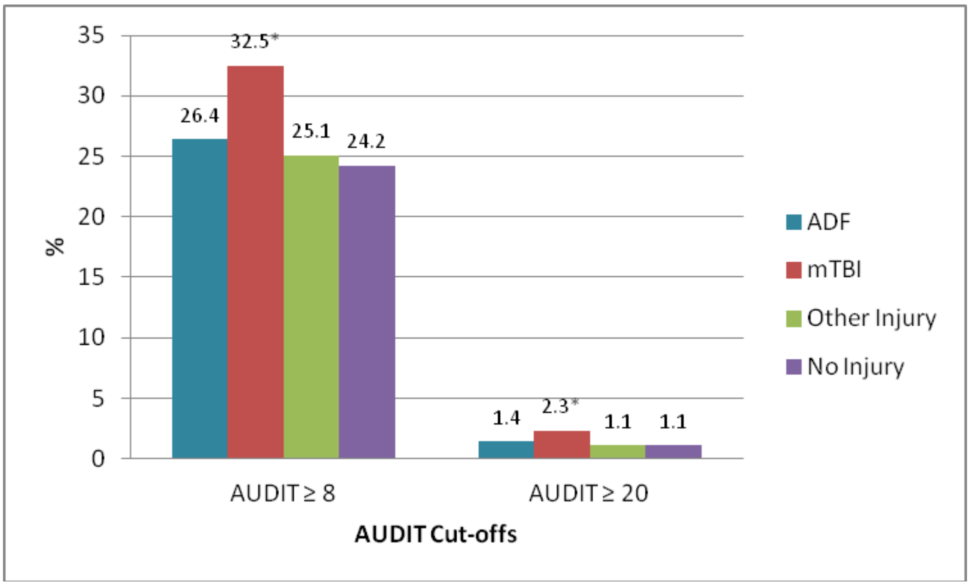
Mean AUDIT scores and the proportion of ADF members scoring above the screening and epidemiological cut-offs for 30 day ICD-10 Alcohol Disorder reported in the 2010 ADF Mental Health Prevalence and Wellbeing study are reported in Figures 10 and 11 and Table 7 below.



*Note: * Significantly different from Other injury group*

Figure 10: Mean Audit scores across the 3 study groups in comparison to the ADF (MHPWS).

As reported in Figure 10, ADF personnel in the mTBI group reported significantly higher mean AUDIT scores (Mean = 6.6, SD=4.8) than those in the other injury group (Mean = 5.8, SD = 4.2). Although not statistically verified, the mTBI group also appeared to have higher AUDIT scores than the entire ADF as reported in the 2010 MHPWS report.



*Note: * Significantly different from Other injury group*

Figure 11: Percentage of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for an ICD-10 Alcohol Disorder (Harmful use or Alcohol Dependence) in comparison to the ADF (MHPWS).

Table 7: Proportion of ADF personnel in 3 study groups meeting the MHPWS screening and epidemiological criteria for Any ICD-10 Alcohol Disorder

AUDIT Cut-off	**mTBI N(%)**	**Other Injury N(%)**	**No Injury N(%)**	**OR (95% CI) MTBI vs Other Injury,**

N	13662	14454	18446	
AUDIT ≥ 8*	4436 (32.5%)	3629 (25.1%)	4466 (24.2%)	1.4 (1.3, 1.6) p <.0001
AUDIT ≥ 20^	321 (2.3%)	165 (1.1%)	206 (1.1%)	1.9 (1.4, 2.6) p <.0001

*Note: *MHPWS Screening cut-off, ^MHPWS Epidemiological cut-off,*

As reported in Figure 11 and Table 7, the mTBI group were 1.4 times more likely meet screening criteria and 1.9 times more likely to score above the epidemiological cut-off for 30 day ICD-10 Alcohol Disorder compared to those in the other injury group. ADF personnel who had never been injured were the least likely to score above the screening cut-off.

Discussion

This report shows that almost 1 in 3 (28.3%) ADF personnel have experienced at least one mTBI in their lifetime. This is higher than the MEAO deployment specific rates of 4.4% - 20% reported in the US, Canadian and UK military samples. In line with this finding, the most common causes of mTBI in this study were *not* events specific to deployment. In fact the most common mechanisms of injury of both mTBI and other injuries were vehicular accidents (which were more prevalent in the non-deployed group) and falls. The previous studies of military populations referred to above have not identified the significance of vehicle accidents as the most common cause of mTBI in military populations as they have focused on the deployment environment. The findings presented in this report are not surprising, given the elevated risk of motor vehicle accidents in younger males and the prevalence of accidents in the Australian community. From a public health perspective, the prevention of motor accident trauma in the ADF needs to be addressed in any policy about mTBI.

Only 12.6% of the ADF reported being exposed to a blast or explosion IED, and 14.0% reported being exposed to an RPG, both of which *were* significantly associated with deployment. Interestingly, a greater proportion of those reporting other injuries (not mTBI) experienced an RPG/land mine/grenade compared to those with an mTBI. This suggests that personnel are less likely to incur an mTBI from an event of this type and that although deployment may increase the chances of exposure to a blast explosion, IED or RPG, it does not necessarily increase your risk for mTBI via these mechanisms compared to other forms of traumatic injury such as falls.

Importantly, vehicle accidents and falls appear to carry a greater risk of resulting in mTBI. The prevalence and these consequences of falls were not anticipated and the precise nature, mechanism and causes thereof were not examined. Consequently, these issues require investigation from an occupational health and safety perspective.

The findings of this report highlight the need to examine lifetime rates of mTBI in Defence personnel in the context of deployment related mTBI. Solely focusing on the deployment exposures has the potential to overlook the fact that many ADF members are likely to have had an mTBI prior to deployment from causes unrelated to combat. These finding are consistent with the ADF Mental Health Prevalence Study that identified the high rates of traumatic exposures, accidents and assaults in non-deployment settings. Hence the risks associated with training and service in Australia should not be underestimated from an occupational health and safety perspective.

Compared to ADF members without mTBI, ADF members with a lifetime mTBI were more likely to be male, in the army, older in age, more likely to be junior in rank (other ranks and non-commissioned officers), less likely to be MEC 1 and less likely to have been on operational deployment. The fact that those with lifetime mTBI are less likely to have been deployed supports the finding of increased risk of mTBI following non-deployment related activities. The association with age suggests a cumulative risk of mTBI across a life-time of accidents, that is, the older a person is, the greater the cumulative probability of being injured. The activities associated with the training of lower ranks in the army may also explain the greater prevalence of mTBI in this group. These demographic characteristics define a high-risk group within the ADF which may benefit from any targeted mTBI health screening and the exposures that are assessed should go beyond the deployment environment for reasons already discussed. Prevention strategies need to focus on both the training and combat environment as well as motor vehicle accidents.

As expected by mere definition of the injury grouping, ADF personnel with an mTBI reported significantly more post-concussive symptoms in the immediate aftermath of the injury compared with those with other injuries. This effect was consistent for memory problems, balance problems, sensitivity to bright light, irritability and headaches but not sleep problems. On first examination, these findings are highly suggestive of the causal relationship between these symptoms of post-concussion syndrome and the previous head trauma. Particularly noteworthy was the finding that this pattern of increased somatic complaints prevailed at the time the survey was conducted, potentially weeks, months or even a number of years following the injury. This suggests a link between lifetime mTBI and long-term somatic dysfunction, albeit the duration of time between injury and survey was not defined in this study. This causal association, however, requires considerable caution in interpretation for the following reasons.

Firstly, it is noteworthy that somatic symptoms are also present in the no-injury group. For example, 19% report sleep difficulties as against 38.5% in the mTBI group. The other injury group also reported a number of symptoms with 8.9% having memory problems in contrast to 16.2% of the mTBI group. Sleep difficulties were present in 26.3% of those with other injuries. Hence the symptoms that are typically associated with post-concussion syndrome are highly non-specific and have multiple possible aetiologies. Table 3 highlights the non-specific nature of these phenomena and the significant limitations in making any causal attributions. One potential confound is the prevalence of psychiatric disorders in the mTBI, other-injury, and no-injury groups.

Consistent with Hoge et al. (2008)'s findings, mTBI was associated with poorer psychological health outcomes compared with those with other injuries in relation to both mean scores and the proportion scoring above the screening and epidemiological cut-offs on the PCL, AUDIT, K10 and PHQ. ADF personnel who reported a lifetime mTBI were significantly more likely to meet criteria for Depression, Anxiety, Alcohol Abuse or Dependence and PTSD, with these differences being most pronounced in relation to PTSD. The mTBI group were twice as likely to meet screening criteria and 2.5 times more likely to score above the epidemiological cut-off for 30 day ICD-10 PTSD compared to those in the other injury group. For example, using the epidemiological cut-offs for case definition, 4.8% of the mTBI group had PTSD in contrast to 1.6% of the other-injury and 1.2% of the no-injury group. Although not statistically verified, it also appeared that the other injury group and no injury group more closely resembled the entire ADF on all psychological measures than the mTBI group. For all measures of PTSD, Anxiety, Depression and Alcohol Disorder, the mTBI group appeared to show increased patterns of psychological distress compared to the ADF as reported in the 2010 MHPWS report, although this was not subject to specific statistical comparison.

These finding raise the possibility that the symptoms of post-concussion syndrome may be mediated by the presence of a comorbid psychological disorder such as PTSD, which may largely account for these symptoms including those not presently defined in the diagnostic criteria (Schneiderman, et al., 2008). Other possible confounders include depression and chronic pain. Whatever the cause, these findings suggest an increase in the development of post-concussive symptoms over time that requires great care in interpretation. Future research using this sample should examine the prevalence of current post-concussive symptoms while controlling for the mediating effects of other types of psychopathology. These issues are discussed extensively in the report prepared for the Department of Veterans Affairs (McFarlane, Saccone, Clark, & Rosenfeld, 2011).

Secondly, an important limitation of this study relates to the self-report questionnaire selected to measure the nature and consequence of head injury, mTBI and its consequences. The instrument used was developed by the US Centre for Defence and Veterans' Brain Injury Center and has been used extensively in research of military populations worldwide. There are potential deficiencies in the questionnaire, however, due to its original intended use within the deployment setting. Firstly, the instrument does not ask about mTBI arising as a consequence of interpersonal violence. This is an important omission, given that assaults can be common among young males, independent of deployment. In the ADF environment, physical activity training is a common cause of physical injuries (B. H. Jones et al., 1993). A particular focus of concern relating to mTBI in the recent scientific literature is body contact sports (Koh, Cassidy, & Watkinson, 2003) such as rugby and AFL (McCrory, Ariens, & Berkovic, 2000). Given that many ADF members actively participate in these sports, any future questionnaire utilised should ask specifically about this domain of risk. Finally, the risks associated with certain training activities such as exposure to grenades in entry training exercises is a further matter that should be documented.

The language and definitions used by ADF members in relation to mTBI also requires further investigation. As can be seen in Table 3, there is a small group of ADF members (2.4%) who report experiencing one of the five injury events with an associated "concussion or head injury" but report no other symptoms of mTBI (i.e., no associated loss of consciousness, no feelings of being dazed or confused and no loss of memory). This implies a possible misunderstanding of the term concussion and/or head injury in this group, whereby the meaning of these terms does not concur with the typically accepted medical definitions. This is an important issue for the language used in medical consultations and history taking. For the purposes of the analyses in this report, this group was specifically excluded because of the lack of clarity of the nature of the alleged injuries. In summary, there is a need for the further development of self-report measures to be used in a military context to examine the causes of and phenomena associated with mTBI.

Thirdly, this report did not examine the relationship between the number of mTBI exposures and as a risk factor for post-concussive or psychological symptoms. Given the increasing recognition in the sporting literature about the relationship between repeated mild traumatic brain injury and subsequent cognitive impairment (e.g., Guskiewicz et al., 2005), this is an issue that requires further examination in this dataset.

Fourthly, this report is solely based on retrospective self-report information. Neurobiological measures of cognitive function and brain volume also are important to examine in relation to the consequences of traumatic brain injury and would be beneficial in substantiating these findings. However, it should not be assumed that changes in neurobiological measures are necessarily a mechanical cause of blast or head trauma in motor vehicle accidents. For example, Hedges and Woon (2010) found that total brain volume is significantly smaller in adults with PTSD compared with trauma-exposed controls. Furthermore, Karl et al. (2006) identified that in PTSD, the decreased brain volumes are found in many of the regions typically associated with mTBI. Therefore, any study utilising neurocognitive information in relation to mTBI should keep these caveats in mind.

Lastly, there is now extensive literature about abnormalities in working memory networks in PTSD (Moores et al., 2008). Hence, the sensitivity and specificity of any measures need to take account of the significant overlap that has been identified in this study between post-concussive symptomatology, presumed to be of physical aetiology, and psychiatric symptoms. These relationships are of particular importance in individuals who have had multiple trauma exposures. In particular, it is critical that the relationship between mTBI and PTSD is considered a complex interaction. These issues and a number of others touched on in this report have been extensively reviewed in the literature reviewed prepared for the Department of Veterans' Affairs (McFarlane, Saccone, et al., 2011).

The context of these findings

One of the current difficulties in the literature is the strikingly different emphases that have emerged from the studies conducted in the US and the UK. Most studies examining deployment-related mTBI and associated post-deployment functioning in Afghanistan and Iraq veterans have been conducted by American researchers (Brenner, et al., 2010; Hoge, et al., 2008; Pietrzak, et al., 2009; Polusny, et al., 2011; Schneiderman, et al., 2008; Terrio, et al., 2009). There has been a major focus on the neural and cellular consequences of mTBI in the US literature (e.g., Davenport, Lim, Armstrong, & Sponheim, 2012). Often this literature fails to explore the related neuropathology of PTSD which may interact with, and explain some of these abnormalities. The high profile of mTBI in the US has also influenced healthcare provision and compensation policies for American military personnel (Hoge, et al., 2009). The findings in Annex 1 which allow a comparison of the ADF with the report of Hoge et al. (2008) demonstrate the very high rates of PTSD in the US veterans with and without mTBI and the need for caution in directly applying US recommendations to the Australian setting without careful consideration.

Researchers from the UK have published investigations on head injury in military personnel from Iraq (Fear, et al., 2009) and have also recently published data relevant to military personnel in both Iraq and Afghanistan (Rona, Jones, Fear, Hull, et al., 2012). These studies have highlighted the nonspecific nature of post-concussive symptoms and the fact that other exposures readily explain their occurrence. This emphasis is similar to the Canadian (Zamorski, et al., 2009) and Dutch (Engelhard, Huijding, van den Hout, & de Jong, 2007) research that has published data related to military personnel in Iraq and Afghanistan. The findings of this report are consistent with this position.

The difference between the US and UK positions is perhaps best characterised by the conclusion stated in the review of the UK group about the history of shell shock and mTBI (E. Jones, Fear, & Wessely, 2007). They concluded that: "*disorders that cross any divide between physical and psychological require a nuanced view of their interpretation and treatment. These findings suggest that the hard-won lessons of shell shock continue to have relevance today*." This review highlights the importance of caution in this domain as there may be a propensity for concussive injury to be over simplified as the cause of post-deployment symptoms. This report needs to be considered in the light of these conclusions.

Summary

This report is the first to determine the lifetime prevalence of mTBI in a currently serving representative military sample. Although limited in capacity for investigation of the relationship between mTBI and psychological dysfunction it provides important baseline prevalence data to inform future analyses.

An important finding was that head injury in the ADF is most commonly caused by motor vehicle accidents. The surprising finding was that the rates of mTBI were higher in non-deployed individuals and can be accounted for by this risk of motor vehicle accidents in the Australian environment. Individuals who have been deployed have significantly higher rates of experiencing IED blasts and RPGs, as well as exposure to falls. Hence, the issue of mTBI is one that requires broad investigation and focus in the ADF environment because it is a significant risk in both deployed and non-deployed personnel.

Post-concussive symptoms are associated with mTBI. Careful analysis, however, demonstrates that post-traumatic, depressive, and anxiety disorders strongly contribute to these symptoms. Hence, clinicians should not simply attribute post-concussive symptomatology to the experience of an mTBI in the absence of a thorough psychiatric history and assessment. Hence, any assessment process in the ADF context needs to assess both mTBI post-concussive symptomatology and psychiatric symptomatology concurrently. Solely focusing on the relationship between post-concussive symptomatology, cognitive dysfunction, and mTBI is likely to lead to significant misattribution. In essence, this is a complex area that requires careful consideration and the development of consensus based guidelines with contributions from a broad range of domain specific experts.

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Annex 1: Proportion of ADF personnel in various injury groups meeting Hoge et al. (2008)'s criteria for PTSD

	Injury with LOC N(%)	Injury with Altered Mental Status N (%)	Other injury N (%)	mTBI N (%)	No Injury	Odds Ratio LOC vs Other injury, 95%CI for Odds Ratio and p value	Odds Ratio Altered Mental status vs Other injury , 95%CI for Odds Ratio and p value	ODDS Ratio MTBI vs Other injury, 95%CI for Odds Ratio and p value
Current Study PCL ≥ 50	5.6%	4.9%	2.1%	5.3%	1.7%	2.29 (1.80, 2.92), p <0.0001	2.22 (1.71, 2.88), p < 0.0001	2.26 (1.82, 2.8163), p <.0001
Hoge et al (2008) PCL ≥ 50	43.9%	27.3%	16.2%	32.63%	9.1%	P<.001	P<.001	

In order to directly compare the results from the current study with those reported in Hoge et al. (2008), further analyses using a cut-off of 50 on the PCL were conducted. Results are presented in Annex 1 for the two components of the mTBI group (Injury with LOC and Injury with AMS) separately.

Using this cutoff, 5.6% of the ADF members with a lifetime head injury with LOC met criteria for PTSD, compared with 4.9% of those reporting injury with altered consciousness and 2.1% with other injuries.

Annex 2: Demographic characteristics of injury groups as reported in Hoge et al. (2008) to allow direct comparison with their results

Charateristic		Sub-groups	Injury with Loss of Consciousness with or without Altered mental status, N (%)	Injury with Altered Mental Status without Loss of Consciousness, N (%)	Other Injury, N (%)	No Injury, N (%)	P Value for AMS vs Other injury	P Value for LOC vs Other injury
N	50050		8197	5973	15208	19234		
Sex							0.0017	<.0001
	6808	F	738 (9.0%)	637 (10.7%)	1948 (12.8%)	3274 (17.0%)		
	43242	M	7459 (91.0%)	5336 (89.3%)	13261 (87.2%)	15960 (83.0%)		
Service							0.0003	<.0001
		Navy	1818 (22.2%)	1283 (21.5%)	3118 (20.5%)	5052 (26.3%)		
		Army	4552 (55.5%)	3330 (55.8%)	8175 (53.8%)	8548 (44.4%)		
		Air Force	1827 (22.3%)	1359 (22.8%)	3915 (25.7%)	5634 (29.3%)		
Age							0.4944	<.0001
		Mean (SD)	35.8 (10.0)	35.2 (9.7)	35.1 (9.4)	32.3 (8.8)		
Age Range								
		18-27	2333 (28.5%)	1742 (29.2%)	4307 (28.3%)	7679 (39.9%)		
		28-37	2465 (30.1%)	1854 (31.0%)	5088 (33.5%)	6448 (33.5%)		
		38-47	2276 (27.8%)	1674 (28.0%)	4233 (27.8%)	3884 (20.2%)		
		48-57	1037 (12.6%)	663 (11.1%)	1512 (9.9%)	1177 (6.1%)		
		58+	86 (1.1%)	41 (0.7%)	68 (0.4%)	46 (0.2%)		
Marital Status							0.1419	0.7101
		Yes	6214 (75.8%)	4474 (74.9%)	11602 (76.3%)	13896 (72.2%)		
		No	1983 (24.2%)	1499 (25.1%)	3607 (23.7%)	5338 (27.8%)		
Education							<.0001	0.0313
		Up to Year 12	3364 (41.1%)	2282 (38.3%)	6489 (42.8%)	8436 (43.9%)		
		Certificate or Diploma	3282 (40.1%)	2442 (41.0%)	5443 (35.9%)	6658 (34.7%)		
		Bachelor Degree	665 (8.1%)	535 (9.0%)	1501 (9.9%)	2241 (11.7%)		
		Post-Graduate	871 (10.6%)	703 (11.8%)	1741 (11.5%)	1862 (9.7%)		
Rank							0.3841	0.0005
		Non-Commissioned Officer	3848 (46.9%)	2771 (46.4%)	7275 (47.8%)	7820 (40.7%)		
		Commissioned Officer	1802 (22.0%)	1474 (24.7%)	3900 (25.6%)	4548 (23.6%)		
		Other ranks	2547 (31.1%)	1728 (29.9%)	4033 (26.5%)	6866 (35.7%)		
Mec							<.0001	<.0001
		Mec 1	4657 (56.8%)	3674 (61.5%)	9959 (65.5%)	13614 (70.8%)		
		Mec 2	2311 (28.2%)	1593 (26.7%)	3707 (24.4%)	3757 (19.5%)		
		Mec 3	933 (11.4%)	535 (9.0%)	1290 (8.5%)	1568 (8.2%)		
		Mec 4	296 (3.6%)	171 (2.9%)	252 (1.7%)	296 (1.5%)		
ADF Deployment							0.0102	<.0001
		Yes	4932 (60.2%)	3906 (65.4%)	10413 (68.5%)	11162 (58.0%)		
		No	3265 (39.8%)	2067 (34.6%)	4796 (31.5%)	8072 (42.0%)		

Mechanism of Injury								
	6320	Blast or explosion	1295 (15.8%)	1291 (21.6%)	3559 (23.4%)	0 (0.0%)	<.0001	0.2627
	7008	RPG	1371 (16.7%)	1242 (20.8%)	4194 (27.6%)	0 (0.0%)	<.0001	<.0001
	0	Fragment or sharpnel	178 (2.2%)	92 (1.5%)	239 (1.6%)	0 (0.0%)	0.0054	0.9249
		Fall	5888 (71.8%)	3795 (63.5%)	5886 (38.7%)	0 (0.0%)	<.0001	<.0001
		Vehical Accident	7022 (85.7%)	4884 (81.8%)	10821 (71.2%)	0 (0.0%)	<.0001	<.0001
Post-Concussive Symptoms								
		Memory problem	1052 (12.9%)	545 (9.2%)	401 (2.7%)	8 (2.1%)	<.0001	<.0001
		Balance Problem	814 (10.0%)	372 (6.3%)	184 (1.2%)	4 (1.2%)	<.0001	<.0001
		Sensitivity to bright light	744 (9.1%)	374 (6.3%)	223 (1.5%)	6 (1.7%)	<.0001	<.0001
		Irritability	1152 (14.1%)	867 (14.6%)	1058 (7.2%)	8 (2.4%)	0.9844	0.002
		Headaches	1742 (21.3%)	928 (15.7%)	689 (4.7%)	18 (4.9%)	<.0001	<.0001
		Sleep Problems	1448 (17.8%)	1160 (19.5%)	1596 (10.8%)	17 (4.7%)	0.1007	0.0009
Post-Concussive Symptoms past week								
		Memory problem	1294 (15.8%)	985 (16.6%)	1317 (8.9%)	21 (5.9%)	<.0001	<.0001
		Balance Problem	584 (7.2%)	343 (5.8%)	487 (3.3%)	10 (2.7%)	0.533	0.0033
		Sensitivity to bright light	713 (8.7%)	471 (7.9%)	583 (3.9%)	8 (2.3%)	0.0028	<.0001
		Irritability	1807 (22.1%)	1426 (24.0%)	2328 (15.7%)	25 (6.9%)	0.1043	0.5081
		Headaches	2286 (28.1%)	1510 (25.4%)	2675 (18.0%)	40 (11.2%)	0.0645	<.0001
		Sleep Problems	3134 (38.5%)	2283 (38.4%)	3908 (26.3%)	66 (19.0%)	<.0001	<.0001
Mental Health Problem								
		PCL Score Mean(SD)	25.8 (11.4)	25.7 (10.9)	22.2 (8.5)	20.7 (7.4)	<.0001	<.0001
		PhQ-9 Score Mean(SD)	3.9 (4.8)	3.8 (4.5)	2.6 (3.8)	2.2 (3.4)	<.0001	<.0001
		K10 Mean Score (SD)	16.6 (6.5)	16.4 (6.0)	14.8 (5.4)	14.9 (5.4)	<.0001	<.0001
		AUDIT Score Mean(SD)	6.7 (4.8)	6.5 (4.7)	5.8 (4.2)	5.8 (4.0)	<.0001	<.0001

* Sample Size: Total Population is 50 049. Total sample for MTBI is 23320
* Injury with Loss of Consciousness: answered Yes to any questions in Q7.2 (HWB) and Q2.68 (Census and Prospective) and answered greater than zero to Loss of Consciousness in Q7.3 (HWB) and Q2.69 (Census and Prospective)
* Injury with Altered Mental Status: answered Yes to any questions in Q7.2 (HWB) and Q2.68 (Census and Prospective) and answered greater than zero to either Being Dazed and Not Remembering and equal to zero or missing for Loss of Consciousness in Q7.3 (HWB) and Q2.69 (Census and Prospective
* Other Injury: answered Yes to any questions in Q7.2 (HWB) and Q2.68 (Census and Prospective) and answered zero to all questions in Q7.3 (HWB) and Q2.69 (Census and Prospective)
* No Injury: answered No to all questions in Q7.2 (HWB) and Q2.68 (Census and Prospective) and did not answer (Missing) to Q7.3 (HWB) and Q2.69 (Census and Prospective)
* Injury with Concusion or Head Injury only: Answered Yes to Q7.2 (HWB) and Q2.68 (Census and Prospective) and answered greater than zero to questions Concusson and/or Head Injury in Q7.3 (HWB) and Q2.69 (Census and Prospective)
* No Injury but has Symptoms: did not answered (Missing) to Q7.2 (HWB) and Q2.68 (Census and Prospective) but given information to Q7.3 (HWB) and Q2.69 (Census and Prospective)

* Statistical analyses were conducted in SAS version 9.2. In order to correct for differential non-response the results were weighted based on strata formed from sex, Service, rank and MEC status. Within each stratum the weight was calculated as the population size divided by the number of respondents from the stratum. In each section of the questionnaire, responses were only used if the participant responded to all of the questions from that section. As a result, a separate weight was calculated for each section of the questionnaire. A finite population correction fraction within each stratum was also applied to adjust the variance estimates for the reasonably large sampling. All analyses were conducted using weighted estimates of totals and proportions. Standard errors were estimated using linearisation.

* Comparisons of sex, service, marital status, rank, education, mec status, adf deployment, Mechanism of Injury and Post-Concussive Symptoms between the prevalence of LOC vs other injury and altered mental injury vs other injury were analysed using Weighted Regression Model (Different from the Hoge et al. (2008)'s paper).

* Comparisons of Age, PCL score, PhQ score and AUDIT score between LOC vs other injury and altered mental injury vs other injury were using weighted regression model.