

Psychological distress and line-of-duty head injuries in firefighters

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Background	Head injuries are common injury in the fire service; however, very little data exist on the risks this may pose to the development of post-traumatic stress disorder (PTSD) and depression in this high-risk population.
Aims	Our study aimed to compare levels of PTSD and depression symptoms in firefighters with a line-of-duty head injury, non-line-of-duty head injury and no head injury.
Methods	In this cross-sectional study, we assessed current PTSD and depression symptoms as well as retrospective head injuries.
Results	Seventy-six per cent of the total sample reported at least one head injury in their lifetime. Depression symptoms were significantly more severe among firefighters with a line-of-duty head injury compared to those with no head injury, but not compared to those who sustained a non-line-of-duty head injury. Depression symptoms did not differ between firefighters with a non-line-of-duty head injury and those with no head injury. PTSD symptoms were significantly more severe among firefighters with a line-of-duty head injury compared to both firefighters with no head injury and those with a non-line-of-duty head injury.
Conclusions	We found that firefighters who reported at least one line-of-duty head injury had significantly higher levels of PTSD and depression symptoms than firefighters who reported no head injuries. Our findings also suggest head injuries sustained outside of fire service could have less of an impact on the firefighter's PTSD symptom severity than head injuries that occur as a direct result of their job.
Key words	Depression; firefighter; head injury; post-traumatic stress disorder.

Introduction

There is a high prevalence of head injuries in the USA. More than 288 000 Americans were diagnosed with traumatic brain injuries (TBIs) at a hospital, and another 56 800 died of their TBI-related injuries in 2014 [1]. Over 1.1 million Americans serve as firefighters [2]. A recent study found that 75% of firefighters have sustained one or more lifetime head injuries, and a majority have sustained a mild TBI in their lifetime [3]. Repeated lifetime head

injuries have been found to be associated with mental health concerns [4]. This is concerning as firefighters are already at high risk for depression [5] and other mental health concerns, such as post-traumatic stress disorder (PTSD) [6]. These findings indicate that head injuries could pose a significant threat to the already compromised mental well-being of firefighters in the USA.

While minimal research is available on firefighter head injuries, there is a significant amount of literature regarding head injuries in populations, such as military veterans,

Key learning points

What is already known about this subject:

- Most firefighters have sustained at least one lifetime traumatic brain injury, with 15% sustaining one or more line-of-duty head injuries, and the more head injuries they sustain, the more severe their depression-related symptoms.
- Firefighters are at high risk for depression and other mental health problems, such as post-traumatic stress disorder and head injuries could pose a significant threat to the already compromised mental well-being of firefighters in the USA.
- Firefighters, who are similarly at risk for mental and physical health problems, were more likely to screen positive for post-traumatic stress disorder after one line-of-duty head injury and more likely to screen positive for depression when compared to firefighters without any head injuries.

What this study adds:

- This study is unique in finding that no significant difference in depression symptoms existed between firefighters with line-of-duty head injuries and those with non-line-of-duty head injuries.
- Firefighters who sustained line-of-duty head injuries had significantly more post-traumatic stress disorder symptoms than those who sustained a non-line-of-duty head injury. This finding suggests that head injuries sustained outside of fire service may have less of an impact on the firefighters than head injuries that occur because of their job.
- Our findings were contrary to other studies that have found that non-life-threatening injuries can lead to depression symptoms. However, no other study has compared depression symptoms after a non-life-threatening head injury in populations that regularly experience trauma, such as firefighters.

What impact this may have on practice or policy:

- Firefighters are at an increased risk of experiencing physical or psychological damage as a direct result of their jobs, it is important for practitioners to understand how receiving a head injury while in a life-threatening situation on duty may impact firefighter's mental health in the future.
- A better understanding of how the context of a head injury may impact a firefighter's psychological well-being will equip practitioners to better assess and support occupational functioning among firefighters.

who are similarly at risk for psychological problems and physical injuries [7]. A survey of Veterans ($n = 1388$) revealed that 17% met criteria for a TBI during military service [8]. Veterans reporting a line-of-duty head injury have endorsed significantly higher levels of PTSD and depression than Veterans with no head injuries [9]. Veterans were 4.5 times more likely to screen positive for PTSD after one line-of-duty head injury and 2.5 times more likely to screen positive for depression when compared to Veterans without any head injuries [10].

Another study of Veterans ($n = 287$) examined their head injury history and PTSD symptoms before and after deployment. TBIs sustained from deployment nearly doubled the likelihood that the Veteran would display PTSD post-employment [11]. In response to this study, Hoge and Castro [12] acknowledged that head injuries that occur in non-life-threatening situations, such as sports, do not predispose an individual to PTSD.

Based on these previous findings pertaining to Veterans, the current study aimed to compare levels of PTSD and depression symptoms in firefighters with line-of-duty head injuries, non-line-of-duty head injuries and no head injuries. We hypothesized that firefighters with line-of-duty head injuries would have significantly higher levels of PTSD and depression symptoms than

firefighters who sustained non-line-of-duty head injuries and firefighters with no history of head injuries. We also hypothesized that firefighters with non-line-of-duty head injuries would have significantly higher levels of PTSD and depression symptoms than firefighters with no history of head injuries.

Methods

This study expands on a previously published paper that revealed frequency of TBI among firefighters [masked publication]. In the present study, we expound upon previous findings by comparing levels of PTSD and depression symptoms among firefighters with varying head injury histories. Professional firefighters from a southwestern US urban fire department were contacted via an e-mailed survey link. In addition, the survey was sent to 80 firefighters from previous mental health-focused studies conducted at fire departments nationwide who had indicated they were interested in participating in future studies. All respondents were eligible to win one of three \$100 gift cards. Study procedures were approved by [masked IRB name], and all participants provided informed consent.

The Ohio State University Traumatic Brain Injury Identification Method (OSU TBI-ID) is a self-report questionnaire that reviews history of head and neck injuries over a lifetime [13]. An online version of the OSU TBI-ID was used in the current study to determine the number of lifetime head injuries and the source of the injury. The online version of the OSU TBI-ID has also been tested and deemed feasible [14]. Concordance studies reviewed medical documentation and patient recall determined a recall rate of 68% [15], with inter-rater reliability ($r > 0.80$) [13] and acceptable test-retest ($r > 0.60$) [16].

The Warrior Administered Retrospective Causality Assessment Tool (WARCAT) is a 20-item self-report measure used to assess first responder-related injuries [17]. Specifically, data concerning amount of blast exposure, altered mental state and somatic/neuropsychiatric symptoms post-deployment and/or post-injury were gathered. In the current study, the measure was modified to encompass firefighter-related activities and to determine if the firefighter sustained a head injury during fire service-related activity. The survey was also conducted online, instead of the original pen-and-paper design. Psychometric properties indicate 96% specificity and 60% sensitivity [18].

The Beck Depression Inventory-Primary Care (BDI-PC) is used to measure depressive symptoms present in the previous 2 weeks. Depressive symptoms are based on Diagnostic and Statistical Manual for Mental Disorders, 4th Edition, Text Revision (DSM-IV-TR) criteria for major depressive disorder [19]. For this study, the BDI-PC was adapted for online use. Responses were provided on a four-point scale ranging from 0 to 3, with a possible total of 21. A positive screen for depression was determined if the total score exceeded 4. The BDI-PC has high specificity, internal consistency, reliability and sensitivity [20]. In this study, the BDI-PC showed strong internal consistency ($\alpha = 0.83$).

The PTSD Checklist-Civilian (PCL-C) is a 17-item self-report measure. Using DSM-IV criteria, it is used to measure PTSD symptoms over the past month [21]. For this study, the PCL-C was adapted for online use. Responses were provided on a Likert scale ranging from 1 (not at all) to 5 (extremely). A score of 50 was used as a clinical cut-off score to indicate a positive screening of PTSD [21]. The PCL-C has high rates of test-retest reliability (r ranging from 0.68 to 0.92; $P < 0.001$); discriminant validity ($r = 0.82$); convergent validity ($r > 0.75$); and [22] internal consistency ($\alpha = 0.93$) [23]. In this study, the PCL-C showed strong internal consistency ($\alpha = 0.94$).

IBM SPSS for Windows (version 25) was used to conduct the data analyses. First, the firefighters were divided into three groups: (i) firefighters who had never experienced a head injury ($n = 14$), (ii) those who sustained

at least one non-line-of-duty head injury, but no line-of-duty head injuries ($n = 31$) and (iii) those who had at least one line-of-duty head injury ($n = 15$). Second, each group distribution was checked for skewness. Skewness ranged by group; however, an acceptable amount of skewness was determined (0.21–0.63). Finally, a one-way analysis of variance (ANOVA) was run between the groups to determine if there was a significant difference in PTSD and depression symptoms between each head injury group.

Results

Of the 1112 firefighters contacted, 64 agreed to participate in the anonymous survey, which gathered information on head injuries acquired through athletics, military and fire service. Eligibility requirements included that the firefighters speak English and have access to a computer. While 64 firefighters originally completed the survey, four individuals reported ongoing litigations related to injuries and thus were excluded ($n = 60$). On the OSU, 12 injuries were unreadable or non-applicable (e.g. sprained wrist) and were not included. Since multiple injuries can be reported on the OSU, this did not reduce the sample size. Participants were mostly white (80%) males (90%) between the ages of 27 and 67 ($M = 41.64$; $SD = 9.36$). Prior to entering fire service, 95% of the respondents played sports, and 15% were in the military. At the time of completing the survey, 65% of the respondents were firefighters, 8% were captains and 8% were driver engineers (Table 1).

Seventy-six per cent ($n = 46$) of the total sample reported that they had sustained at least one head injury in their lifetime. Out of these respondents, 69% (31) sustained their head injury off duty (athletics, car accidents, etc.), and 33% (15) reported that they suffered a head injury in the line-of-duty. While 15% of the sample reported serving in the military, none reported sustaining a head injury during their time in the armed forces.

The level of skewness in the PCL-C and the BDI-PC was calculated and determined to be reasonable. Therefore, a one-way ANOVA was run between the groups. There was a statistically significant difference in both PTSD symptoms ($F(2,45) = 6.03$, $\eta^2 = 0.21$, $P < 0.01$) and depression symptoms ($F(2,45) = 3.97$, $\eta^2 = 0.15$, $P < 0.05$) between head injury groups (Table 2). Two items in the PCL-C ask about ‘trouble falling or staying asleep’ as well as ‘having difficulty concentrating’, both of which are common symptoms of head injuries [24,25]. These items were removed from the PCL-C to determine if the PTSD symptoms were still significantly different between head injury groups ($F(2,45) = 3.81$, $\eta^2 = 0.15$, $P < 0.05$). Once it was determined there was no spurious relationship with head injury symptoms; the remaining analyses were run with the complete PCL-C.

Table 1. Characteristics of firefighter study population

Injury categories	Total sample (<i>N</i> = 60)	Line-of-duty head injury (<i>n</i> = 15)	Non-line-of-duty head injury (<i>n</i> = 31)	No head injury (<i>n</i> = 14)
	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)	<i>n</i> (%)
Sex				
Male	54 (90)	14 (93)	29 (94)	11 (79)
Female	6 (10)	1 (7)	2 (7)	3 (21)
Race				
African American	1 (2)	0 (0)	1 (3)	0 (0)
Caucasian	48 (80)	11 (73)	26 (84)	11 (79)
Asian	1 (2)	0 (0)	1 (3)	0 (0)
Hispanic	5 (8)	1 (7)	3 (10)	1 (7)
More than one, other	5 (8)	3 (20)	0 (0)	2 (14)
Education				
High school diploma/GED	2 (3)	0 (0)	2 (6)	0 (0)
Associate's degree	6 (10)	0 (0)	4 (13)	2 (14)
Some college, no degree	24 (40)	7 (47)	12 (40)	5 (36)
College degree	20 (33)	6 (40)	9 (29)	5 (36)
Some graduate school	4 (7)	1 (7)	2 (6)	1 (7)
Graduate degree	4 (7)	1 (7)	2 (6)	1 (7)
Fire service rank				
Firefighter	39 (65)	9 (60)	20 (65)	11 (79)
Driver engineer	5 (8)	2 (13)	3 (10)	0 (0)
Lieutenant	3 (5)	1 (7)	2 (7)	0 (0)
Captain	5 (8)	1 (7)	2 (7)	2 (14)
Battalion Chief	2 (3)	0 (0)	1 (3)	1 (7)
Fire Marshall	1 (2)	1 (7)	0 (0)	0 (0)
Retired	3 (5)	1 (7)	2 (7)	0 (0)
Other	2 (3)	0 (0)	1 (3)	0 (0)

GED, General Education Development.

A Tukey *post hoc* comparison indicated that depression symptoms were significantly more severe among firefighters with a line-of-duty head injury ($M = 4.38$, $SD = 2.84$) compared to those with no head injury ($M = 1.43$, $SD = 1.83$, $P < 0.05$), but not compared to those who sustained a non-line-of-duty head injury ($M = 3.33$, $SD = 3.23$, $P = 0.54$). Depression symptoms did not differ between firefighters with a non-line-of-duty head injury ($M = 3.33$, $SD = 3.23$) and those with no head injury ($M = 1.43$, $SD = 1.83$, $P = 0.13$; [Table 2](#)).

A Tukey *post hoc* comparison indicated that mean PTSD symptoms were significantly more severe among firefighters with a line-of-duty head injury ($M = 41.69$, $SD = 13.81$) compared to both firefighters with no head injury ($M = 26.23$, $SD = 9.76$, $P < 0.01$) and those with a non-line-of-duty head injury ($M = 29.95$, $SD = 12.12$, $P < 0.05$; [Table 2](#)).

Discussion

Respondents were demographically similar to a national firefighter sample. In 2018, ~95% of career firefighters

were male, and ~80% were white, and 50% were between the ages of 30 and 49 [26]. However, the sample size for this study is small, and findings may not be generalizable.

Three-quarters of the firefighters in this sample reported having sustained at least one head injury in their lifetime. Firefighters who had at least one line-of-duty head injury had significantly higher levels of depression symptoms than those who had never had a head injury. Findings are consistent with previous research that found Veterans with line-of-duty head injuries were more likely to screen positive for depression than their uninjured counterparts [10]. This study also found that firefighters with line-of-duty head injuries did not have significantly higher levels of depression symptoms than firefighters with non-line-of-duty head injuries. No previous studies have compared depression symptoms of non-line-of-duty head injuries and line-of-duty head injuries in Veterans, firefighters or other professions with high physical and psychological risk. Future studies with larger sample sizes should continue to examine the impact of head injury on depression symptom severity.

Consistent with previous findings among Veterans [9], firefighters who reported at least one line-of-duty

Table 2. Descriptive statistics for the Beck Depression Inventory and the PTSD Checklist–Civilian Questionnaires

	Line-of-duty head injury		Non-line-of-duty head injury		No head injury		Test statistic	P-value
	M	SD	M	SD	M	SD		
Depression	4.38	2.84	3.33	3.23	1.43	1.83	3.97	0.026
PTSD	41.69	13.81	29.95	12.12	26.63	9.76	6.03	0.005

head injury had significantly more severe PTSD symptoms than firefighters who reported no head injuries. Firefighters who had sustained line-of-duty head injuries also had significantly higher levels of PTSD symptoms than those who had sustained a non-line-of-duty head injury. These data are congruent with previous findings that Veterans with line-of-duty injuries had greater PTSD rates than Veterans with non-line-of-duty injuries [27]. Head injuries sustained outside of fire service could have less of an impact on the firefighter's PTSD symptom severity than head injuries that occur as a direct result of their job.

Both depression and PTSD symptoms were more severe among firefighters with line-of-duty head injuries when compared with firefighters with no head injuries. It cannot be determined that head injuries are what caused mental health-related symptoms, rather that they co-occur. These findings are consistent with the significant body of research that indicates that head injuries are associated with PTSD [28] and depression [29]. Our study also found that neither depression nor PTSD symptoms were significantly different between the firefighters with non-line-of-duty head injuries and the firefighters with no head injuries. The PTSD symptoms similarity between these two groups is consistent with previous research that indicates that a head injury in a non-life-threatening situation does not predispose an individual to PTSD [12]. The depression symptoms having no significant difference, however, are contrary to other studies that found non-life-threatening injuries (such as sports injuries) can lead to depression symptoms [28]. However, no other study has compared depression symptoms after a non-life-threatening head injury in populations that regularly experience trauma, such as firefighters.

This study had several limiting factors, including our small sample size, which may have limited statistical power to detect differences between groups. Additionally, recruitment materials referenced head injury study, which may have caused firefighters with a positive head injury history to self-select into the study, ultimately skewing the data. The OSU also asks questions regarding lifetime history of head injuries, which could have collected non-line-of-duty head injuries that occurred before the firefighter joined fire service. Additionally, the PCL-C, which assessed DSM-IV rather than DSM-V

criteria, is now outdated. This study also did not measure other parameters that may affect depression and PTSD outside of head injuries, such as adverse life events.

Future research may benefit from larger sample sizes and the use of a timeline to determine when a firefighter experienced their head injury. Future studies should also assess the time elapsed between the firefighter's sustained injury and return to work. This would allow for a more in-depth examination of the effect that returning to a high-stress work environment after sustaining a line-of-duty head injury may have on a firefighter's psychological well-being. Similarly, future studies should collect information regarding adverse life events and depression symptoms experienced before a head injury. This information would strengthen future studies by allowing for a more in-depth examination of mental health before a head injury. A prospective survey sent to the firefighters that indicated head injuries would also strengthen future studies, as this would indicate if those with head injuries suffered long-term disadvantages. Due to the implications of the study findings, it is important that more research is conducted to further understand how line-of-duty head injuries may uniquely impact a firefighter's mental health.

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Competing interests

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References

- Peterson AB, Xu L, Daugherty J, Breiding MJ. Surveillance report of traumatic brain injury-related emergency department visits, hospitalizations, and deaths, United States. 2014.
- Evarts B, Molis JL. *United States Firefighter Injuries 2017*. Quincy, MA: National Fire Protection Association, 2018.

3. Torres VA, Strack JE, Dolan S *et al.* Identifying frequency of mild traumatic brain injury (mTBI) in firefighters. *Workplace Health Saf* 2020.
4. Bryan CJ, Clemans TA. Repetitive traumatic brain injury, psychological symptoms, and suicide risk in a clinical sample of deployed military personnel. *JAMA Psychiatry* 2013;**70**:686–691.
5. Tak S, Driscoll R, Bernard B, West C. Depressive symptoms among firefighters and related factors after the response to Hurricane Katrina. *J Urban Health* 2007;**84**:153–161.
6. Chen YS, Chen MC, Chou FH *et al.* The relationship between quality of life and posttraumatic stress disorder or major depression for firefighters in Kaohsiung, Taiwan. *Qual Life Res* 2007;**16**:1289–1297.
7. Fischer H. *US Military Casualty Statistics: Operation New Dawn, Operation Iraqi Freedom, and Operation Enduring Freedom.* Library of Congress. Washington, DC: Congressional Research Service, 2013.
8. Lindquist LK, Love HC, Elbogen EB. Traumatic brain injury in Iraq and Afghanistan veterans: new results from a national random sample study. *J Neuropsychiatry Clin Neurosci* 2017;**29**:254–259.
9. Morissette SB, Woodward M, Kimbrel NA *et al.* Deployment-related TBI, persistent postconcussive symptoms, PTSD, and depression in OEF/OIF veterans. *Rehabil Psychol* 2011;**56**:340–350.
10. Maguen S, Madden E, Lau KM, Seal K. The impact of head injury mechanism on mental health symptoms in veterans: do number and type of exposures matter? *J Trauma Stress* 2012;**25**:3–9.
11. Yurgil KA, Barkauskas DA, Vasterling JJ *et al.*; Marine Resiliency Study Team. Association between traumatic brain injury and risk of posttraumatic stress disorder in active-duty marines. *JAMA Psychiatry* 2014;**71**:149–157.
12. Hoge CW, Castro CA. Treatment of generalized war-related health concerns: placing TBI and PTSD in context. *J Am Med Assoc* 2014;**312**:1685–1686.
13. Corrigan JD, Bogner J. Initial reliability and validity of the Ohio State University TBI identification method. *J Head Trauma Rehabil* 2007;**22**:318–329.
14. Lequerica AH, Lucca C, Chiaravalloti ND, Ward I, Corrigan JD. Feasibility and preliminary validation of an online version of the Ohio State University traumatic brain injury identification method. *Arch Phys Med Rehabil* 2018;**99**:1811–1817.
15. McKinlay A, Corrigan JD, Bogner JA, Horwood LJ. Obtaining a history of childhood traumatic brain injury using the Ohio State University TBI identification method to elicit adult recall. *J Head Trauma Rehabil* 2017;**32**:E24–E28.
16. Bogner J, Corrigan JD. Reliability and predictive validity of the Ohio State University TBI identification method with prisoners. *J Head Trauma Rehabil* 2009;**24**:279–291.
17. Terrio H, Brenner LA, Ivins BJ *et al.* Traumatic brain injury screening: preliminary findings in a US Army Brigade Combat Team. *J Head Trauma Rehabil* 2009;**24**:14–23.
18. Terrio HP, Nelson LA, Betthausen LM, Harwood JE, Brenner LA. Postdeployment traumatic brain injury screening questions: sensitivity, specificity, and predictive values in returning soldiers. *Rehabil Psychol* 2011;**56**:26–31.
19. Beck AT, Guth D, Steer RA, Ball R. Screening for major depression disorders in medical inpatients with the Beck Depression Inventory for Primary Care. *Behav Res Ther* 1997;**35**:785–791.
20. Green A, Felmingham K, Baguley IJ, Sleva-Younan S, Simpson S. The clinical utility of the Beck Depression Inventory after traumatic brain injury. *Brain Inj* 2001;**15**:1021–1028.
21. Weathers FW, Litz BT, Herman DS, Huska JA, Keane TM. The PTSD Checklist (PCL): reliability, validity, and diagnostic utility. In: Annual Convention of the International Society for Traumatic Stress Studies, San Antonio, TX, 24 October 1993 (Vol. 462).
22. Ruggiero KJ, Del Ben K, Scotti JR, Rabalais AE. Psychometric properties of the PTSD Checklist-Civilian version. *J Trauma Stress* 2003;**16**:495–502.
23. Meyer EC, Zimering R, Daly E, Knight J, Kamholz BW, Gulliver SB. Predictors of posttraumatic stress disorder and other psychological symptoms in trauma-exposed firefighters. *Psychol Serv* 2012;**9**:1–15.
24. Makley MJ, English JB, Drubach DA, Kreuz AJ, Celnik PA, Tarwater PM. Prevalence of sleep disturbance in closed head injury patients in a rehabilitation unit. *Neurorehabil Neural Repair* 2008;**22**:341–347.
25. Ettenhofer ML, Abeles N. The significance of mild traumatic brain injury to cognition and self-reported symptoms in long-term recovery from injury. *J Clin Exp Neuropsychol* 2009;**31**:363–372.
26. Evarts B, Stein GP. *US Fire Department Profile 2017.* Quincy, MA: National Fire Protection Association, 2019.
27. Macgregor AJ, Tang JJ, Dougherty AL, Galarneau MR. Deployment-related injury and posttraumatic stress disorder in US military personnel. *Injury* 2013;**44**:1458–1464.
28. Roitman P, Gilad M, Ankri YL, Shalev AY. Head injury and loss of consciousness raise the likelihood of developing and maintaining PTSD symptoms. *J Trauma Stress* 2013;**26**:727–734.
29. Guskiewicz KM, Marshall SW, Bailes J *et al.* Recurrent concussion and risk of depression in retired professional football players. *Med Sci Sports Exerc* 2007;**39**:903–909.