HHS Public Access

Author manuscript

Mil Med. Author manuscript; available in PMC 2018 March 01.

Published in final edited form as:

Mil Med. 2017 March ; 182(3): e1645–e1650. doi:10.7205/MILMED-D-16-00221.

Postconcussive Symptoms, PTSD, and Medical Disease Burden in Treatment-Seeking OEF/OIF/OND Veterans

Joah L. Williams, Ph.D.[1,2,3], **Meghan E. McDevitt-Murphy, Ph.D.**[2,3], **James G. Murphy, Ph.D.**[2,3], and **Ellen M. Crouse, Ph.D.**[3,4]

[1]Department of Psychology, University of Missouri – Kansas City, 5030 Cherry St., Rm. 310, Kansas City, MO, 64110

[2]Department of Psychology, University of Memphis, 202 Psychology Building, Memphis, TN, 38152

[3]Memphis Veterans Affairs Medical Center, 1030 Jefferson Ave., Memphis, TN, 38104

[4]Department of Psychiatry, University of Tennessee Health Science Center, 1030 Jefferson Ave., Memphis, TN, 38104

Structured Summary

Introduction—The most common psychological and cognitive sequelae associated with deployments to Afghanistan (OEF) and Iraq (OIF) are mild traumatic brain injury (mTBI) and posttraumatic stress disorder (PTSD). High rates of PTSD are often observed among Veterans with a history of mTBI, and persistent postconcussive symptoms commonly endorsed after mTBI are known to be associated with PTSD. Therefore, this study examined whether PTSD mediates relations between postconcussive symptoms and two indices of medical disease burden: 1) the number of disease categories positive for a diagnosis, or system disease burden, and 2) total number of physical diagnoses, or cumulative disease burden.

Materials and Methods—Participants were 91 OEF/OIF/OND Veterans seeking treatment at a Veterans Affairs Medical Center who screened positive for mTBI and later attended a follow-up Polytrauma clinic evaluation for neuropsychiatric assessment. Medical records were reviewed for a history of mTBI, postconcussive symptoms, and physician diagnoses, which were used to derive system and cumulative disease burden variables. Mediation was tested using bootstrapping procedures. Participants provided written informed consent and all study procedures were approved by both the VA and university institutional review boards.

Results—Postconcussive symptoms ($r = .53$) and PTSD symptoms ($r = .32$) were both associated with cumulative disease burden. Only postconcussive symptoms were associated with system disease burden ($r = .32$). Results of our follow-up mediation analysis suggest that PTSD did not mediate relations between postconcussive symptoms and cumulative disease burden (bootstrap coefficient = −.02, 95% CI [−.05–.01]).

Conclusion—These findings join an emerging body of literature suggesting that postconcussive symptoms have a direct impact on Veterans' health above and beyond the effects of PTSD.

Portions of this study were presented at the annual meeting of the International Society for Traumatic Stress Studies, November 2012.

Strengths of this study include the use of objective, clinician-diagnosed medical conditions as an indicator of health, while limitations include the use of self-report measures to assess postconcussive and PTSD symptoms. This study underscores the need for more original research on the impact of mTBI on the long-term health and readjustment of returning Veterans. Furthermore, this study highlights the need for additional research on the psychosocial and pathophysiological mechanisms underlying the link between mTBI and poor health.

Keywords

postconcussive symptoms; mTBI; PTSD; disease burden; veterans

Introduction

Recently deployed Veterans seeking Veterans Affairs (VA) healthcare often present with a variety of health conditions and complaints in the months and years after returning from deployment. Psychological and cognitive sequelae of combat deployments, most notably mild traumatic brain injury (mTBI), also commonly referred to as concussion[1], and posttraumatic stress disorder (PTSD), often play a critical role in the development and/or maintenance of these health complaints. Estimates suggest that between 15% and 19% of Veterans deployed as part of Operations Enduring Freedom in Afghanistan (OEF), Iraqi Freedom (OIF) and New Dawn (OND) sustained mTBI during deployment[2,3]. Prevalence may be even higher among treatment-seeking Veterans, given that efforts to screen OEF/OIF Veterans for mTBI within the Veterans Affairs (VA) health care system[4] indicate that approximately 21% of these Veterans experienced a probable mTBI during deployment and continue to experience persistent, postconcussive symptoms (e.g., headaches, dizziness, sensitivity to bright light) associated with the injury[5]. While generally thought to be residual symptoms of mild brain injury, postconcussive symptoms are often nonspecific and associated with a number of mental health problems, including PTSD[6,7].

A wider range of rates of probable PTSD have been reported, with 12% to 39% of OEF/OIF/OND Veterans either enrolled in or actively seeking VA health care screening positive for PTSD[8–10]. However, these injuries are not mutually exclusive – between 26% and 44% of OIF Veterans screening positive for mTBI also screen positive for PTSD[2,11]. This overlap conceptually makes sense given that mTBIs usually occur under potentially traumatic, life-threatening conditions, and mTBI and postconcussive symptoms may leave individuals at increased risk for developing PTSD by taxing cognitive resources necessary to successfully accommodate trauma memories[12]. The high rates of mTBI and PTSD carry significant implications for the long-term readjustment of this Veteran cohort, especially in light of a growing body of literature linking both mTBI and PTSD with greater medical morbidity and worse health functioning[2,13,14].

Among OIF Veterans, Hoge et al.[2] found associations between mTBI and multiple physical symptoms including chest pain, dizziness, and shortness of breath but reported that these associations diminished after accounting for PTSD and depressive symptoms. To explore whether the association between mTBI and health problems might be at least partially explained by PTSD symptoms, Pietrzak, Johnson, Goldstein, Malley, and Southwick[13]

examined whether PTSD symptoms mediated the relation between screening positive for mTBI on the VA TBI Clinical Reminder[5] and self-reported health in a sample of treatment-seeking OEF/OIF Veterans and found evidence consistent with mediation. Most recently, Vasterling et al.[15], in a sample of OIF Veterans assessed as part of the Neurocognition Deployment Health Study, found evidence that a history of deployment-related mTBI was associated with worse self-reported health functioning even after adjusting for PTSD symptoms. Taken together, these studies suggest that PTSD symptoms may at least partially explain the association between a history of mTBI and health outcomes, although mixed findings and methods across studies limit conclusions that can be drawn about the mediational role of PTSD in this association.

Several factors may contribute to mixed findings, including methodological inconsistencies across studies (e.g., different mTBI assessment strategies) and sample characteristics (e.g., time since deployment). Another shortcoming of this literature is that mTBI is often treated dichotomously (i.e., screening positive versus negative for mTBI). This issue is an important one to address given that individuals may greatly differ in terms of how many postconcussive symptoms they continue to report long after sustaining an mTBI and raises the question of whether PTSD mediates the relation between postconcussive symptoms and health outcomes. Thus, this study aimed to examine a) the associations between postconcussive symptoms, PTSD symptoms, and two indices of medical disease burden (system disease burden and cumulative disease burden[14]), and b) whether associations between postconcussive symptoms and health outcomes is better explained (or mediated) by PTSD symptoms – a well-known risk factor for poor health outcomes that is also strongly associated with persistent, postconcussive symptoms.

Method

Participants

Participants were 91 OEF/OIF/OND Veterans with a mean age of 32.71 years (*SD* = 7.94). The majority of the sample was male (*n* = 86, 94.5%) and identified as either Caucasian (*n* = 54, 59.3%) or African American (*n* = 32, 35.2%). Data for the current study were obtained from measures completed as part of the screening phase of a larger alcohol intervention study[16] and a comprehensive medical record review of Veterans who completed the screening phase of the larger trial. Eligible Veterans recruited for the screening phase of the larger alcohol trial were those who a) were deployed to a combat zone in support of OEF/OIF/OND and b) attended a specialized primary care clinic for OEF/OIF/OND Veterans upon entry into the VA system. Only those Veterans screening positive for mTBI during this initial primary care appointment who later attended a follow-up Polytrauma clinic evaluation were included in the current study. All data collection procedures were approved by the University of Memphis and Veterans Affairs Medical Center (VAMC) institutional review boards.

Measures

VA TBI Clinical Reminder—The VA TBI Clinical Reminder is a 4-part screen for mTBI administered to all OEF/OIF Veterans seeking VA health care[4]. The screener consists of an

initial prompt question asking whether the Veteran received a TBI diagnosis during an OEF or OIF deployment, and an affirmative response on this initial question yields a positive screen. Veterans with a negative response on the prompt question complete a series of additional questions organized into 4 sections assessing exposure to mTBI-related events, symptoms in the immediate aftermath of the event, symptoms following the event, and current symptoms. A positive screen requires an affirmative response to at least one item in each section, and Veterans with a positive screen are subsequently referred to a Polytrauma clinic for further clinical evaluation.

Neurobehavioral Symptom Inventory (NSI)—The NSI[17] is a 22-item self-report measure of postconcussive symptoms. On each item, respondents rate how much they have been bothered by a particular symptom in the past 2 weeks. Symptoms are rated on a 5-point scale ranging from 0 to 4, where a score of 4 is associated with greater symptom severity. The NSI is widely thought to assess three clusters of postconcussive symptoms, including cognitive, affective, and somatic symptoms[18]. The NSI has shown excellent internal consistency in clinical samples of patients with mild brain trauma[19] and in the present sample (α = .95).

Posttraumatic Stress Disorder Checklist – Military Version (PCL-M)—The PCL-M[20] is a 17-item self-report measure corresponding to the *DSM-IV-TR*[21] symptom criteria for PTSD. For each item, respondents indicate how much they have been bothered by a particular symptom during the past month using a 5-point scale ranging from 1 (*Not at All*) to 5 (*Extremely*). Items can be summed to derive an overall symptom severity score, with higher scores suggestive of more severe symptoms. Total scores on the PCL-M can range from 17 to 85. The PCL-M has shown excellent psychometric properties in samples of OEF/OIF Veterans[13,22] and in the current sample (α = .96).

Disease Burden—Disease burden was assessed using medical diagnoses collected from participants' VAMC medical records. Medical diagnoses were coded using the *International Classification of Diseases* (*ICD-9-CM*[23]) coding system. All medical conditions diagnosed by a VA clinician within one year following completion of the self-report screening packet and documented in the "Problem List" section of the Veteran's electronic medical record were used to derive measures of system and cumulative disease burden. Accordingly, all conditions were diagnosed following combat deployments. Consistent with Possemato, Wade, Andersen, and Ouimette's[14] definitions of system and cumulative disease burden, system disease burden was defined as the number of *ICD-9-CM* major medical categories positive for a diagnosis, and cumulative disease burden was defined as the total number of *ICD-9-CM* diagnostic codes (not including mental health codes) listed in a Veteran's records. Conditions categorized in the *ICD-9-CM* as originating in the perinatal period, congenital anomalies, or complications of pregnancy or childhood were not computed as part of either disease burden variable since these conditions would have originated pre-deployment and would not be associated consistently with any trauma-related conditions (e.g., PTSD) or injuries.

Procedure

Veterans were recruited through a VAMC OEF/OIF/OND combat clinic that serves as a gateway for Veterans seeking VA health care. Participants gave informed consent and completed a brief questionnaire packet which included the PCL and an alcohol screening measure used to identify eligible participants for the aforementioned alcohol intervention study. For all participants, medical record reviews were conducted to obtain additional information regarding health status, including mTBI screening results and medical diagnoses. Records for all Veterans screening positive for mTBI on the VA TBI Clinical Reminder were also reviewed for any follow-up mTBI evaluations in a Polytrauma clinic. Of 573 Veterans whose records were reviewed, 95 Veterans screened positive for mTBI and completed follow-up mTBI evaluations in a VA Polytrauma clinic. Two more Veterans who did not initially screen positive for mTBI were eventually referred for and completed Polytrauma evaluations, resulting in a total of 97 Veterans completing Polytrauma evaluations. Information coded for the current study was unavailable in the Polytrauma evaluations of 2 Veterans, and 4 Veterans' Polytrauma results were not included in the current study because their evaluations occurred more than 3 months prior to or 3 months after completing the screening measures. Consequently, their scores on measures of postconcussive symptoms may not reflect their symptoms at the time of completing the screening packet for the larger study. Therefore, of the 97 Veterans identified for the purposes of this study, six were excluded from further analysis. To assess the accuracy of information collected from participants' medical records, 3 trained coders collected a subset of the chart data (records from 60 Veterans, or 10.5% of the full sample). Coders evidenced excellent interrater agreement with less than 1% overall error rate. All medical records data were de-identified, and participants provided informed consent prior to completing the screening packet during their initial contact with the research team.

Data Analysis

Relations between postconcussive symptoms, PTSD symptoms, and health indices were explored using Pearson's correlation statistics. Structural relations between postconcussive symptoms, PTSD symptoms, and health indices were assessed using a series of mediational models where PTSD symptoms were modeled as potential mediators between postconcussive symptoms and disease burden. Mediation was tested using bootstrapping procedures[24], which model the indirect effects of independent variables on dependent variables after controlling for the effects of any potential mediators. An advantage of bootstrapping is that indirect effects are estimated using random samples from a dataset, such that all data points are equally likely to be selected with each random sample. Consequently, large numbers of random samples may be drawn from the same dataset, and these random samples can then be used to model the distribution of a specified population parameter[25]. Here, estimates of the indirect effects of each mediator were based on 1,000 samples. The indirect effect is not statistically significant if the confidence interval for the estimated indirect effect contains zero.

Results

Descriptive Statistics

Data collected with the Polytrauma evaluations suggest that the majority of Veterans (n = 82, 90.1%) screening positive for mTBI sustained at most mild injuries, using the definition of mTBI as an injury involving less than 30 minutes loss of consciousness and no more than 24 hours of posttraumatic amnesia[1,26]. The mean NSI total score was 36.46 (SD = 17.86), and the mean PCL-M score was 54.09 (SD = 16.45). In terms of health outcome variables, frequencies of diagnostic conditions within each *ICD-9-CM* major medical category are presented in Table 1. The most commonly diagnosed conditions among Veterans evaluated in the Polytrauma clinic sample were mental disorders, nervous system and sense organ disorders, musculoskeletal disorders, and idiopathic complaints. Veterans completing Polytrauma evaluations received on average 5.14 (SD = 2.65) clinician-diagnosed medical conditions (the measure of cumulative disease burden) over the course of one year after initiating VA services. These diagnoses spanned, on average, 3.14 (SD = 1.40) categories of medical conditions (the measure of system disease burden).

Associations Between Postconcussive Symptoms, PTSD Symptoms, and Health Outcomes

Prior to testing mediational models, relations between variables were explored using Pearson correlation statistics. Relations were also explored between demographic variables and the primary variables of interest (i.e., NSI and PCL-M total scores and health outcome variables), given that demographic variables including gender, age, and marital status are often associated with measures of mental and physical health[14]. Results are presented in Table 2. A large, statistically significant correlation emerged between NSI scores and PCL-M scores, and NSI scores were also associated with both measures of disease burden. Surprisingly, PCL-M scores were associated with cumulative disease burden but not system disease burden. Thus, the basic conditions for a mediational model with system disease burden as the dependent variable were not satisfied. Demographic factors were unrelated to NSI and PCL-M scores and health outcome variables and, therefore, were not included in subsequent analyses.

Mediation Analyses Using Bootstrap Resampling Methods

A series of regression analyses with bootstrap estimates of indirect effects were conducted to test whether PCL-M scores mediated relations between NSI scores and health outcomes. Results are presented in Table 3. A statistically significant, direct effect was found between NSI scores and cumulative disease burden, although PCL-M scores did not appear to mediate this association.

Discussion

Treating Veterans of Operations Enduring and Iraqi Freedom poses special challenges for health care providers in that these Veterans are at increased risk for a variety of co-occurring physical and mental health problems, including persistent postconcussive symptoms and PTSD. Understanding how these problems uniquely impact health and health functioning

may be beneficial to clinicians in terms of treatment planning for Veterans presenting with complex clinical profiles. Nevertheless, understanding the unique impact of postconcussive symptoms and PTSD on Veterans' health remains an incredibly complex task requiring much more work to be done.

Among the 91 Veterans completing Polytrauma evaluations who were the focus of this study, mean NSI scores were generally more severe than NSI scores reported in other samples of OEF/OIF Veterans with a history of deployment-related mTBI[27]. PCL-M scores were also quite elevated – the mean PCL-M score of 54 among these Veterans is above the commonly used PCL-M cut-score of 50 used to identify individuals screening positive for PTSD[28]. As expected, NSI scores were strongly associated with PCL-M scores, an association that has been documented in similar samples of OEF/OIF Veterans[28]. The association between NSI scores and each health outcome, including both cumulative and system disease burden, was also expected, but a more puzzling finding is that PCL-M scores were only associated with cumulative disease burden. Several factors may explain this pattern of results. For instance, Possemato and colleagues[14] suggested that Veterans with PTSD may be more likely to accumulate diseases within medical categories that are already positive for at least one medical condition, at least during the years immediately following deployment. Furthermore, since the cumulative and system disease burden variables used in this study were aggregates of clinician-diagnosed conditions accumulated over the course of the year following entry into the VA system, the way in which these variables were constructed may obscure any time-dependent associations between PCL-M scores and system disease burden.

A mediational model was tested to explore whether PCL-M scores mediated relations between NSI scores and cumulative disease burden, and, contrary to our hypothesis, PCL-M scores did not mediate relations between NSI scores and cumulative disease burden. So, these results fail to support the theory that postconcussive symptoms indirectly contribute to disease burden by increasing risk for PTSD and PTSD-related health problems. Rather, these results suggest that persistent, postconcussive symptoms are uniquely associated with the overall accumulation of clinician-diagnosed medical conditions. This pattern of results is somewhat consistent with previous research indicating that a history of mTBI is uniquely associated with health even after accounting for the adverse health impact of PTSD[13,14].

One practical implication of these findings is that Veterans with unresolved somatic and sensory postconcussive symptoms may be more likely to report these symptoms to health care providers upon initiating treatment in the VA system, resulting in greater overall accumulation of documented somatic complaints of unknown origin. Indeed, idiopathic complaints (including dizziness, disturbance of skin sensation, and disturbed sleep) were the most commonly documented problems in this sample. It should be noted, though, that, while Veterans with ongoing postconcussive symptoms may present to primary care settings reporting a variety of health complaints, these complaints are likely to occur in the context of psychosocial problems like PTSD. Indeed, it is widely accepted at this point that PTSD and other psychiatric conditions are strongly associated with postconcussive symptoms and health problems[6,7]. Even so, there is emerging evidence that, at least in some Veterans, neuropsychiatric symptoms and associated idiopathic complaints may stem from actual

brain damage sustained in the context of mTBI. Recently, Shively et al.[29], for example, conducted a post-mortem case series exploring physical brain damage in brain specimens from male Veterans with a history of chronic and acute blast-related TBIs and found a distinct pattern of brain damage to neuroanatomical structures implicated in a number of postconcussive symptoms (e.g., headaches, sleep problems) and associated somatic complaints. These findings, along with the findings from our own study, underscore the need for more research on the pathophysiology of postconcussive symptoms.

While this study contributes to the evolving literature on relations between postconcussive symptoms, PTSD, and health, it is not without limitations. First, postconcussive and PTSD symptoms were assessed via self-report, which may bias overall symptom reporting and select for people with a less stoic response to PTSD and mTBI symptoms. Second, it is not possible to fully determine whether postconcussive symptoms assessed on the NSI are indeed residual symptoms associated with a historical brain injury. Similarly, it is not possible to determine whether clinician-diagnosed health complaints assessed as part of the current study reflect medical conditions with onset that predated deployment. Third, the data used for the current study preclude a full exploration of potential mechanisms underlying these results, and future studies are needed to address these important limitations. Fourth, we were not able to obtain data for the current study concerning any physical injuries sustained during OEF/OIF deployments that may contribute to overall disease burden. Fifth, it is also possible that the electronic medical record Problem List used to collect diagnostic information did not, in some cases, provide accurate information about Veterans' medical conditions in that clinicians may embed diagnostic information in clinical encounter notes but not add the same diagnoses to the Problem List. Lastly, a limitation of using self-report data derived from VA medical records is that such information may be subject to the potential influence of secondary gain. Nevertheless, this study points toward the need for more research on the impact of mTBIs on the long-term health and readjustment of our returning service members.

Acknowledgments

This research was supported by the National Institutes of Health/National Institute on Alcohol Abuse and Alcoholism (K23 AA016120) and by the Memphis VAMC Office of Research and Development. This study was the basis of a doctoral dissertation for Joah L. Williams.

References

1. Hoge CW, Goldberg HM, Castro CA. Care of war veterans with mild traumatic brain injury: Flawed perspectives. N Engl J Med. 2009; 360:1588–1591. [PubMed: 19369664]
2. Hoge CW, McGurk D, Thomas JL, Cox AL, Engel CC, Castro CA. Mild traumatic brain injury in U.S. soldiers returning from Iraq. N Engl J Med. 2008; 358:453–463. [PubMed: 18234750]
3. Tanielian, T., Jaycox, LH. Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery. Santa Monica: RAND Corporation; 2008. Available at http://www.rand.org/pubs/monographs/MG720.html [accessed May 23, 2016]
4. Department of Veterans Affairs: Screening and evaluation of possible traumatic brain injury in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) veterans (VHA Directive 2007-013). Washington, DC: Veterans Health Administration, Department of Defense; 2007. Available at http://www.va.gov/optometry/docs/VHA_Directive_2007-013_Screening_Possible_TBI.pdf [accessed May 20, 2016]

5. Carlson KF, Nelson D, Orazem RJ, Nugent S, Cifu DX, Sayer NA. Psychiatric diagnoses among Iraq and Afghanistan war veterans screened for deployment-related traumatic brain injury. J Trauma Stress. 2010; 23:17–24. [PubMed: 20127725]
6. King PR, Donnelly KT, Donnelly JP, et al. Psychometric study of the Neurobehavioral Symptom Inventory. J Rehabil Res Dev. 2012; 49:879–888. [PubMed: 23299259]
7. Seal KH, Bertenthal D, Samuelson K, Maguen S, Kumar S, Vasterling JJ. Association between mild traumatic brain injury and mental health problems and self-reported cognitive dysfunction in Iraq and Afghanistan Veterans. J Rehabil Res Dev. 2016; 53:185–198. [PubMed: 27148692]
8. Erbes C, Westermeyer J, Engdahl B, Johnsen E. Post-traumatic stress disorder and service utilization in a sample of service members from Iraq and Afghanistan. Mil Med. 2007; 172:359–363. [PubMed: 17484303]
9. Jakupcak M, Luterek J, Hunt S, Conybeare D, McFall M. Posttraumatic stress and its relationship to physical health functioning in a sample of Iraq and Afghanistan war veterans seeking postdeployment VA health care. J Nerv Ment Dis. 2008; 196:425–428. [PubMed: 18477887]
10. McDevitt-Murphy ME, Williams JL, Bracken KL, Fields JA, Monahan CJ, Murphy JG. PTSD symptoms, hazardous drinking, and health functioning among U.S. OEF and OIF veterans presenting to primary care. J Trauma Stress. 2010; 23:108–111. [PubMed: 20104586]
11. Brenner LA, Ivins BJ, Schwab K, et al. Traumatic brain injury, posttraumatic stress disorder, and postconcussive symptom reporting among troops returning from Iraq. J Head Trauma Rehabil. 2010; 25:307–312. [PubMed: 20042982]
12. Bryant RA. Disentangling mild traumatic brain injury and stress reactions. N Engl J Med. 2008; 358:525–527. [PubMed: 18234757]
13. Pietrzak RH, Johnson DC, Goldstein MB, Malley JC, Southwick SM. Posttraumatic stress disorder mediates the relationship between mild traumatic brain injury and health and psychosocial functioning in veterans of Operations Enduring Freedom and Operations Iraqi Freedom. J Nerv Ment Dis. 2009; 197:748–753. [PubMed: 19829203]
14. Possemato K, Wade M, Andersen J, Ouimette P. The impact of PTSD, depression, and substance use disorders on disease burden and health care utilization among OEF/OIF veterans. Psychol Trauma. 2010; 2:218–223.
15. Vasterling JJ, Brailey K, Proctor SP, Kane R, Heeren T, Franz M. Neuropsychological outcomes of mild traumatic brain injury, post-traumatic stress disorder and depression in Iraq-deployed US Army soldiers. Br J Psychiatry. 2012; 201:186–192. [PubMed: 22743844]
16. McDevitt-Murphy ME, Murphy JG, Williams JL, Monahan CM, Bracken-Minor KL, Fields JA. Randomized controlled trial of two brief alcohol interventions for OEF/OIF veterans. J Consult Clin Psychol. 2014; 82:562–568. [PubMed: 24773573]
17. Cicerone K, Kalmar K. Persistent postconcussive syndrome: Structure of subjective complaints after mild traumatic brain injury. J Head Trauma Rehabil. 1995; 10:1–17.
18. Caplan LJ, Ivins B, Poole JH, Vanderploeg RD, Jaffee MS, Schwab K. The structure of postconcussive symptoms in 3 US military samples. J Head Trauma Rehabil. 2010; 25:447–458.
19. Gizzi M, Zlotnick M, Cicerone K, Riley E. Vestibular disease and cognitive dysfunction: No evidence for a causal connection. J Head Trauma Rehabil. 2003; 18:398–407. [PubMed: 12973270]
20. Weathers, FW., Litz, BT., Herman, DS., Huska, JA., Keane, TM. The PTSD checklist (PCL). Boston: National Center for PTSD; 1993. Available at http://www.ptsd.va.gov/professional/assessment/adult-sr/ptsd-checklist.asp [accessed May 23, 2016]
21. American Psychiatric Association. Diagnostic and Statistical Manual of Mental Disorders. 4. Washington DC: American Psychiatric Association; 2000. text revision
22. Grieger TA, Kolkow TT, Spira JL, Morse JS. Posttraumatic stress disorder and depression in health care providers returning from deployment to Iraq and Afghanistan. Mil Med. 2007; 172:451–455. [PubMed: 17521088]
23. U.S. Department of Health and Human Services. Washington, DC: U.S. Department of Health and Human Services; 1991. International Classification of Diseases, 9th Revision, Clinical Modification (DHHS Publication No. 91-1260). Available at http://www.cdc.gov/nchs/icd/icd9cm.htm [accessed May 23, 2016]

24. Preacher KJ, Hayes AF. Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. Behav Res Methods. 2008; 40:879–891. [PubMed: 18697684]
25. Mallinckrodt B, Abraham WT, Wei M, Russell DW. Advances in testing the statistical significance of mediation effects. J Couns Psychol. 2006; 53:372–378.
26. Alexander MP. Mild traumatic brain injury: Pathophysiology, natural history, and clinical management. Neurol. 1995; 45:1252–1260.
27. Belanger HG, Kretzmer T, Vanderploeg R, French LM. Symptom complaints following combat-related traumatic brain injury: Relationship to traumatic brain injury severity and posttraumatic stress disorder. J Int Neuropsychol Soc. 2010; 16:194–199. [PubMed: 19758488]
28. Ruggiero KJ, Del Ben K, Scotti JR, Rabalais AE. Psychometric properties of the PTSD Checklist–Civilian version. J Trauma Stress. 2003; 16:495–502. [PubMed: 14584634]
29. Shively SB, Horkayne-Szakaly I, Jones RV, Kelly JP, Armstrong RC, Perl DP. Characterisation of interface astroglial scarring in the human brain after blast exposure: a post-mortem case series. Lancet Neurol. 2016; 15:944–953. [PubMed: 27291520]

Table 1

Frequencies of ICD-9-CM Medical Conditions among 91 Veterans with Valid Polytrauma Evaluations

Conditions (*ICD-9-CM* Codes)	**Frequency (%)**
Infectious and Parasitic Diseases (001 – 139)	3 (0.5%)
Neoplasms (140 – 239)	1 (0.2%)
Endocrine, Nutritional, and Metabolic Diseases and Immunity Disorders (240 – 279)	17 (2.7%)
Diseases of the Blood and Blood-Forming Organs (280 – 289)	2 (0.3%)
Mental Disorders (290 – 319)	128 (20.1%)
Diseases of the Nervous System and Sense Organs (320 – 389)	77 (12.1%)
Diseases of the Circulatory System (390–459)	17 (2.7%)
Diseases of the Respiratory System (460 – 519)	16 (2.5%)
Diseases of the Digestive System (520 – 579)	28 (4.4%)
Diseases of the Genitourinary System (580 – 629)	5 (0.8%)
Complications of Pregnancy, Childbirth, and the Puerperium (630 – 677)	--
Diseases of the Skin and Subcutaneous Tissue (680 – 709)	9 (1.4%)
Diseases of the Musculoskeletal System and Connective Tissue (710 – 739)	140 (22.0%)
Congenital Anomalies (740 – 759)	40 (6.3%)
Certain Conditions Originating in the Perinatal Period (760 – 779)	1 (0.2%)
Symptoms, Signs, and Ill-Defined Conditions (780 – 799)	145 (22.8%)
Injury and Poisoning (800 – 999)	8 (1.3%)

Table 2

Bivariate Correlations between Postconcussive Symptom, PTSD, Health, and Demographic Variables

Variables	1	2	3	4	5	6	7
1. NSI	--	.74**	.53**	.32**	−.08	.13	.09
2. PCL-M		--	.32**	.07	−.10	.07	.02
3. CDB			--	.78**	.06	.04	.17
4. SDB				--	.15	.00	.15
5. Gender					--	−.02	−.04
6. Age						--	.06
7. MAR							--

Note. NSI = Neurobehavioral Symptom Inventory; PCL-M = PTSD Checklist; CDB = Cumulative Disease Burden; SDB = System Disease Burden; MAR = Marital Status. Phi coefficients are reported when examining the association between two categorical variables.

** $p < .01$.

Table 3

Regression Analyses with Bootstrap Estimates: PTSD Mediating Relations between Postconcussive Symptoms and Health Outcomes

	Regression Results			Bootstrap Estimates		
Path/Effect	***B***	***SE***	R^2	***B***	***SE***	***95% CI***
Cumulative Disease Burden (n = 89)			.30			
c (NSI → CDB)	.08**	.01				
a (NSI → PCL-M)	.68**	.07				
b (PCL-M → CDB)	−.03	.02				
c′	.10**	.02				
a × b				−.02	.01	−.05, .01

Note. NSI = Neurobehavioral Symptom Inventory; PCL-M = PTSD Checklist; CDB = Cumulative Disease Burden. $n = 89$ due to missing data on outcome measures.

** $p < .01$.