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The Association between Toxic Exposures and Chronic Multisymptom Illness in Veterans of the Wars of Iraq and Afghanistan

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Abstract

Objective—The purpose of this study was to determine if post-9/11 veterans deployed to the Iraq and Afghanistan conflicts experienced toxic exposures and whether they are related to symptoms of Chronic Multisymptom Illness (CMI).

Methods—Data from 224 post-9/11 veterans who self-reported exposure to hazards in theater were analyzed using hierarchical regression.

Results—Of the sample, 97.2% endorsed experiencing one or more potentially toxic exposure. In a regression model, toxic exposures and CMI symptoms were significantly associated above and beyond covariates. Follow-up analyses revealed that pesticide exposures, but not smoke inhalation was associated with CMI symptoms.

Conclusions—These findings suggest that toxic exposures were common among military personnel deployed to the most recent conflicts, and appear to be associated with CMI symptoms. Additional research on the impact of toxic exposures on returning Iraq and Afghanistan Veterans' health is needed.

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BACKGROUND

Since their return from military service in the 1990–1991 Gulf War, a substantial minority of veterans have been affected by a complex of persistent and disabling symptoms that are not explained by well-established medical or psychiatric diagnoses. Multiple studies describe a consistent profile of protracted symptoms that include chronic headache, widespread pain, mood disturbances, respiratory problems, persistent and unexplained fatigue, memory problems and other cognitive difficulties, gastrointestinal disturbances and skin rashes [1–3]. These symptoms affect 1990–1991 Gulf War veterans at significantly higher rates than non-deployed veteran comparison groups from the same era [3,4]. This same constellation of symptoms is found in veterans who deployed to the Gulf and were exposed to chemical hazards, but not in same-era veterans who served elsewhere [5]. This cluster of symptoms has been referred to as "Gulf War Syndrome," "Gulf War Veterans' illnesses," "Gulf War illness" (GWI), or simply "chronic multi-symptom illness" (CMI) [1,2].

CMI is now well documented [5–7]. Research consistently demonstrates that CMI is not induced by general stress and cannot be classified as a psychosomatic disorder [3, 4, 8,9]. Although a clear etiology has yet to be discovered, research into the potential causes of CMI have focused on exposure to DEET, flea collars with pesticide, pyridostigmine bromide, nerve agents, and chemical weapons [2,10,11].

Pesticide exposures have been linked to CMI symptoms across multiple samples of Gulf War veterans and a dose-response association exists between exposure and CMI symptoms [5,10, 12–16]. In addition to pesticide exposure, pyridostigmine bromide pills were frequently used by Gulf War service members as a prophylactic against nerve gas exposure [17] and are also associated with CMI symptoms. Research demonstrates a dose-response relationship between pyridostigmine bromide and CMI [10,16]. Further, animal models of the effects of sarin gas, a chemical weapon, indicate that exposure results in neuropsychological problems such as memory loss [18]. In veterans, exposure to sarin gas is associated with reduced gray matter, white matter, and hippocampus volume; however, there are mixed results with respect to neuropsychological functioning [19,20]. Interestingly, farmers exposed to high levels of pesticides experience a similar constellation of symptoms (e.g., cognitive and movement problems) as do veterans with CMI [21]. Thus, while a clear etiological link has not been firmly established, it is reasonable to speculate that the exposures that took place during the 1990–1991 Gulf War may have contributed to CMI.

What remains unclear is whether the latest generation of veterans who served in Iraq and Afghanistan in the wars that followed the terrorist attacks of September 11, 2001 also faced hazardous exposures, and whether those exposures resulted in CMI. This is an important question because there have been reports from veterans in recent conflicts of symptoms that share similarities with CMI experienced by Gulf War era veterans [22,23]. Specifically, "Post-deployment Multi-Symptom Disorder" is characterized by post-concussive symptoms, chronic pain, and posttraumatic stress disorder (PTSD) symptoms [22] and CMI is defined as fatigue, mood and cognitive abnormalities, and musculoskeletal pain [23,24]. This research has indicated that Veterans of Iraq and Afghanistan had higher rates of CMI than soldiers who did not deploy [23]. Further, nearly 50% of Veterans who served in Iraq and

Afghanistan meet criteria for CMI 1 year following deployment [24]. Yet, other studies have demonstrated that Veterans of the wars in Iraq and Afghanistan experience symptom elevations generally [25] and do not experienced higher levels of symptoms than those who deployed to the Gulf-War [23,25,26]. However, Veterans of the conflicts in Iraq and Afghanistan report higher levels of symptoms than individuals who were not deployed, as well as civilians [23]. Thus, further clarification is needed to examine the link between hazardous exposures and their long-term effects within this generation of veterans.

Veterans of the recent wars in Iraq and Afghanistan report experiencing toxic exposures, although they generally report fewer exposures than veterans of the first Gulf War [27,28]. The VA recognizes that veterans were exposed to these hazards in theater, including: burn pits, depleted uranium, chemical warfare agents, and exposure to work related chemicals, among others [29]. However, further research is needed to better understand these exposures. The small amount of research that exists indicates that nearly all veterans who served in Iraq and Afghanistan were exposed to at least one environmental hazard, the most common being exposure to pesticides and air pollution, which includes sand storms and burn pits [30–32]. In one study of veterans who served in support of the wars in Iraq and Afghanistan [31], hazardous exposures were associated with total somatic symptoms (i.e., headaches, nausea, dizziness) above and beyond age and gender; however, these analyses did not take into account combat exposure, PTSD symptoms or a history of traumatic brain injury, which would be expected to predict somatic and mental health symptoms [33]. In another study [32] of recently returned soldiers, toxic exposures were associated with total physical symptoms above and beyond deployment experiences in theatre, although they did not specifically control for combat experiences. Further, hazardous exposures were correlated at the bivariate level with posttraumatic stress symptoms, depressive symptoms, general physical health symptoms, mental health functioning, physical health functioning and cognitive functioning in one prior study of veterans of the recent wars in Iraq and Afghanistan [34]. The association between toxic exposures and PTSD symptoms, however, failed to be replicated in another study [35].

Objectives and Hypothesis

Many veterans who served in the Iraq and Afghanistan war theatres have had hazardous exposures; however, the health effects of these exposures have received relatively little attention. Accordingly, the objectives of the present study were to: (1) examine self-reported toxic exposure in a sample of veterans who served in support of the wars in Iraq and Afghanistan; (2) examine CMI symptoms reported by veterans; and (3) examine the associations among toxic exposures and CMI symptoms. It was hypothesized that toxic exposures would be associated with CMI symptoms in veterans who served in support of the conflicts in Iraq and Afghanistan, even after accounting for combat exposure, non-overlapping PTSD symptoms, and smoking status.

METHODS

Participants

Veterans who served in the campaigns in Iraq and Afghanistan ($n = 345$) who were enrolled within the Central Texas Veterans Health Care System (CTVHCS) were recruited to participate in a longitudinal study that assessed experiences in the warzone and post-deployment functioning. Prior to the start of the study, the CTVHCS Institutional Review Board approved all study procedures. Recruitment of participants was conducted through multiple channels including: (a) recruitment letters randomly selected and mailed to Veterans enrolled in the CTVHCS; (b) advertisements at Veteran's service organizations and other recruitment sites; and (c) in-service presentations to VA staff in areas such as mental health and primary care.

Participants were eligible for the study if they met the following criteria: (a) a Veteran who served in support of the wars in Iraq or Afghanistan after September 11, 2001; (b) able to provide informed consent; (c) deemed stable on medication or in psychotherapy if enrolled in treatment; (d) able to complete all assessment procedures; and (e) not moving out of the area within 4 months. Participants were excluded if they had a diagnosis of bipolar or psychotic disorder or suicidal/homicidal ideation with intent or plan warranting crisis intervention. Telephone screens were conducted to determine initial eligibility criteria, as above. Final eligibility was determined by assessing bipolar disorder and schizophrenia during the clinical interview using the Mini International Neuropsychiatric Interview (MINI; 36).

Of the total enrolled sample, 21 were deemed ineligible due to a diagnosis of bipolar disorder or schizophrenia, 13 were ineligible due to inability or unwillingness to complete the assessment, one participant was ineligible because of not serving as part of the wars in Iraq and Afghanistan, and one participant was ineligible due to planning to move out of the area. As the present study was primarily interested in the unique experiences of hazards sustained by Iraq and Afghanistan Veterans, those who also served in Vietnam and the first Gulf War were excluded (n = 59). Additionally, 10 individuals were missing data regarding their service in Vietnam and the Gulf War, and 16 were missing information regarding Gulf War Illness symptoms. The resulting final sample included 224 participants available for analysis.

The mean age of the 224 eligible participants was 36.55 years (SD = 9.09 years). Participants were primarily male (66.1%), although women were over-sampled. Of the sample 19.7% identified as Hispanic. In terms of race, 33.5% identified as Black, 58.8% as White, 5.9% as American Indian or Alaska Native, 2.7% as Asian, 1.8% as Hawaiian/Pacific Islander, and 5.9% as "Other" (categories were not mutually exclusive). The average education level in the sample was 14.02 years (SD = 2.05 years). The largest proportion of the sample served in the Army (85.7%), whereas 6.3% served in the Marine Corps, 4.0% served in the Navy, and 5.8% served in the Air Force, 30.4% served in the Reserves, and 24.1% served in the National Guard (categories were not mutually exclusive). Additionally, 16.1% served in OEF and 92.4% served in OIF/OND (categories not mutually exclusive).On

average, veterans participated approximately 4.8 years (SD = 2.33) following their last deployment.

Measures

Inclusion/exclusion criteria—The Mini International Neuropsychiatric Interview (MINI; 36) is a clinician-administered diagnostic assessment for Axis I disorders. The bipolar and psychotic disorders sections of the MINI were used to exclude for these disorders.

Demographic Information—A demographic questionnaire collected information including: age, gender, race and ethnicity, relationship status, education, employment, income, and military service characteristics.

Nuclear, Biological, and Chemical Exposures—Deployment Risk and Resilience Inventory – Exposure to Nuclear, Biological, and Chemical (NBC) Agents Scale [34]. The DRRI is a validated self-report assessment instrument which consists of 14 scales that assess risk and resilience factors related to deployment. The measure demonstrates excellent internal consistency, and good validity. The NBC scale of the DRRI assesses exposures to nuclear, biological, and chemical agents during deployment. This measure was used to assess nuclear, biological, and chemical exposures in theater. The 20-item self-report scale first asks veterans if they were exposed to a particular agent such as nerve gas, depleted uranium, pesticides, smoke or fumes, or vaccinations to prepare for deployment. The scale also asks veterans if they received vaccines prior to deployment; however, this item was removed from the analyses as it was not possible to determine the purpose of the vaccination or vaccines that were received (i.e., flu, etc.). The scale also contains two items that inquire about proximity to exploding artillery. As this was a common experience and not necessarily a toxic exposure, these two items were also removed from the analyses. One question also inquired about NAPPs, or pyridostigimine bromide (PB) pills. PB pills were commonly used in the first Gulf War, yet 11.2% of respondents (n = 25) indicated that they took PB pills even though they did not deploy to the Gulf War. As PB pills were not prominently used in the conflicts in Iraq and Afghanistan, this item was also removed from the analyses. Next, the veteran rates whether they had no exposure (rated as "0"), whether they do not know if they were exposed (rated as "1"), or if they know they were exposed to the agent (rated as "2"). "Don't know" answers were recoded as no exposure, and only definite exposures were rated. Finally, toxic exposures were grouped into similar exposure groups such as pesticide exposure (e.g., environmental pesticides, pesticides in uniforms, pesticides in flea collars, government-issued DEET, non-government issued insect repellents), smoke exposure (e.g., smoke or other air pollution, fumes or exhaust from heaters or generators, burning trash or feces) and gas exposure (e.g., nerve gas agents, mustard gas/blistering agents). Internal consistency for this scale was .80.

Chronic Multisymptom Illness: There are two case definitions for CMI/Gulf War Illness recommended by the Institute of Medicine, the CDC/Fukada definition and the Kansas case definition [1,4]. The CDC definition was used as it is more encompassing and is able to be assessed via self-report. The case definition is based on 3 symptom domains: 1) fatigue, 2)

mood and cognition (e.g., depressed or anxious mood, irritability, difficulty with memory or concentration, difficulty finding words or sleep problems), 3) musculoskeletal pain. To meet the criteria, veterans must experience 2 of the 3 domains of symptoms. As the current study did not assess participants for CMI, 9 items taken from several instruments were used as a proxy measure of CMI caseness by assessing a constellation of symptoms associated with CMI. To assess the fatigue domain, the fatigue item from the Beck Depression Inventory [BDI; 37] was used. Similarly, difficulty concentrating, depressed mood, and irritability symptoms from the BDI and anxiety (any anxiety symptom endorsed) from the Depression, Anxiety, and Stress Scale (DASS; 38) were used to assess the cognitive and mood symptoms. However, these symptoms were assessed only in the past two weeks. Somatic pain was assessed with a chronic pain screening questionnaire that was specifically created for this study. Only chronic pain that had lasted for 6 months or more was considered to meet criteria. Joint stiffness and joint pain were not able to be assessed from this questionnaire. Further, the symptom of difficulty with finding words was not able to be assessed. Thus, 6 of the 9 symptoms of CMI were assessed. Because items were taken from different scales, all items were dichotomized. If a participant endorsed a symptom at a severe level on the BDI or DASS (e.g., a response of 2 or 3 on a 0–3 scale), the symptom was coded as "yes." Additionally, to assess whether a participant met for a symptom cluster the mood/cognition symptoms were dichotomized if a participant met for any symptom in that category. As the other two categories only consisted of one symptom assessed, this recoding was not necessary, If the participant met criteria for 2 of the 3 symptom categories they were considered to meet criteria for CMI.

Combat Exposure—Combat exposure was measured via the Full Combat Experiences Scale (FCES; 39). To control for the possibility that CMI symptoms could be related to combat exposure, this measure was included as a covariate in the model. The FCES is an 18-item self-report measure that assesses combat events that are relevant to service in the wars in Iraq and Afghanistan. Items are rated on a 5-point scale from 0 (never) to 4 (10 times or more), with higher scores indicating more combat exposure. The internal consistency for the measure was .92.

PTSD symptoms—PTSD symptoms were assessed via the Clinician Administered PTSD Scale (CAPS; 40). The CAPS is a semi-structured diagnostic interview that assesses the intensity and frequency of 17 symptoms of PTSD as defined by the Diagnostic and Statistical Manual, Fourth Edition (DSM-IV; 41). In this study, the interview focused on the worst traumatic event experienced during their service in support of the wars in Iraq and Afghanistan. In the infrequent instance that the participant could not identify an event, PTSD symptoms were assessed based on stress experienced during deployment. PTSD symptoms were assessed for the past 30 days (current).

Some CMI symptoms overlap with PTSD symptoms, including: difficulty concentrating, sleep problems, and irritability. Accordingly, these 3 overlapping symptoms were removed from the total score so that the PTSD symptom score consisted of the other 14 symptoms that did not overlap with CMI. Internal consistency of the CAPS current non-overlapping symptoms in the current study was .87.

Smoking Status—The Fagerstrom Test for Nicotine Dependence (FTND) was used to assess smoking status. The FTND consists of six questions regarding smoking amount and frequency in order to determine dependence on smoking. The FTND has demonstrated satisfactory internal consistency (α = .61), as well as convergent validity with biochemical indices of heaviness of smoking [42]. Smoking status was used as a covariate in the analyses.

Data Analytic Plan

Descriptive statistics were generated to examine rates of toxic exposure and CMI symptoms among Iraq and Afghanistan Veterans. Hierarchical regression was used to explore the association between self-reported toxic exposures and CMI symptoms. Age, gender, years of education, combat exposure, and non-overlapping PTSD symptoms were included as covariates in the model. The demographic variables were entered in the first step, combat exposure in the second, non-overlapping PTSD symptoms in the third, smoking status in the fourth step, and toxic exposure in the final step. This hierarchical approach enabled us to examine the unique effects of combat, PTSD, smoking status, and toxic exposure on CMI symptoms. Odds ratios were also computed. Follow-up analyses were conducted to determine the specific clusters of toxic exposures that impacted CMI symptoms.

RESULTS

Overall, 97.2% of Iraq and Afghanistan veterans endorsed experiencing at least 1 out of 16 potentially toxic exposures (Table 1), and the vast majority experienced multiple exposures ($M = 7.16$, $SD = 3.03$, range: 0 to 14). The most common exposures were related to smoke or fume inhalation, with 84.2% ($n = 187$) indicating inhaling smoke or other air pollution, 84.2% ($n = 187$) endorsing being exposed to burning trash or feces, and 80.3% ($n = 179$) reporting inhalation of fumes or exhaust from heaters or generators. Some toxic exposures were moderately correlated (see Table 2). In addition, 71.4% of veterans endorsed at least 1 symptom of CMI (Table 3), and 1.8% reported currently experiencing all 6 of the CMI symptoms that were measured ($M = 1.63$, $SD = 1.57$, range: 0 to 6). Symptoms were also broken down into clusters as per the CDC case definition (see Table 3). Of the total sample 10.3%% (n = 23) met criteria for at least 3 clusters. Overall 37.1% (n = 83) met criteria for CMI (e.g., two of the three diagnostic categories). As expected, toxic exposures were positively correlated with CMI symptoms ($r = .30$, $p < .001$). Follow-up analyses were conducted to determine if there was an association between specific types of toxic exposures and CMI symptoms.

Hierarchical Regression

Hierarchical regression was used to explore whether toxic exposures experienced in theatre were associated with CMI symptoms in OEF/OIF/OND veterans. Age, gender and years of education were entered into the first step of the model. After this step, the overall model was significant, $F(3, 220) = 2.86$, $p = .04$, and years of education were a significant predictor in the model, $\beta = -.19$, $p < .001$, (see Table 4). Combat exposure was entered into the second step of the model. The overall model was not significant, $F(4, 219) = 2.21$, $p = .07$., $R^2 = .00$,. Non-overlapping PTSD symptoms were entered into the third step of the model. This

step was significant, $F(5, 218) = 22.50$, $p < .001$, $R^2 = .30$, as non-overlapping PTSD symptoms were associated with CMI symptoms $\beta = .57$, $p < .001$. Then, smoking status was added into the model. The model was significant, $F(6, 217) = 35.60$, $p < .001$, $R^2 = .00$, and but smoking status was not a significant predictor in the model. Toxic exposure was entered into the final step of the model. This step of the model was also significant $F(7, 216) = 17.21$, $p < .001$, and results indicated that toxic exposures were a significant predictor of CMI symptoms, $\beta = .14$, $p = .02$, $R^2 = .02$, 95% CI [.12, 1.35] over and above the effects of demographic variables, combat exposure, non-overlapping PTSD symptoms and smoking status. Overall, the final model explained 34% of the variance in CMI symptoms in OEF/OIF/OND Veterans.

Follow-up analyses were conducted to determine if specific types of toxic exposures were associated with CMI symptoms. Toxic exposures were grouped where possible into two categories: pesticide exposure which consisted of the following items: "environmental pesticides," "pesticides in uniforms," "pesticides in flea collars," and "government issued DEET-containing insect repellants;" smoke inhalation, which consisted of these items: "smoke/air pollution," "fumes/exhaust from heaters or generators," "burning trash or feces." Due to multicollinearity between the two groups of exposures, two separate regression models were run. Both models had the same steps as the first mode, but instead of overall toxic exposures in the last step, clusters of exposures were added in the last step. Thus, all steps of the model were the same as the previous model with the exception of the last step. For the pesticides model, the final step of the model was significant, $F(7, 216) = 17.43$, $p < .001$, 95% CI [.08, .63] and results indicated that pesticide exposures were a significant predictor of CMI symptoms, $\beta = .14$, $p = .01$, $R^2 = .02$, over and above the effects of demographic variables, combat exposure, non-overlapping PTSD symptoms and smoking status. In the second model, with smoke inhalation as a predictor of CMI symptoms, the final model was significant $F(7, 216) = 16.51$, $p < .001$, but smoke inhalation was not a significant predictor in the model, $\beta = .08$, $p = .13$, 95% CI [−.09, .65],[1]

CONCLUSIONS

This is one the first studies to investigate the association between toxic exposures in theater and later development of CMI in veterans who served in support of the conflicts in Iraq and Afghanistan. Self-reported toxic exposures experienced during these conflicts, and pesticides in particular, were indeed associated with symptoms similar to those experienced by Gulf War veterans who suffer from CMI. Results of the current study revealed that symptoms of CMI were associated with pesticide exposure in particular. Pesticides are associated with neurotoxicity resulting in mild cognitive dysfunction, mood disorder symptoms, and the development of movement disorders [5]. Importantly, this association was significant even after controlling for key confounding variables known to be associated with post-deployment somatic symptoms, including the effects of combat exposure, unique PTSD symptoms, and smoking status. Thus, our findings suggest that a significant

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[1]As 11% of Veterans responded that they took NAPP pills, and it is unclear if these types of pills were administered in the Iraq and Afghanistan conflicts, we removed this group and reran the analyses. Results were the same without this group added (final step: $F(7, 191) = 16.50$, $p < .001$, $\beta = .14$, $p = .03$, 95% CI [.08, 1.42], $R^2 = .02$.

proportion of veterans of the recent conflicts were exposed to toxic hazards during deployment. As with veterans of the 1990–1991 Gulf War, these exposures may have lasting effects, and for a significant minority (37.1%), a syndrome that is similar in presentation to CMI.

Interestingly, the smoke inhalation cluster of toxic exposures was not associated with CMI symptoms. Veterans of the conflicts in Iraq and Afghanistan were frequently exposed to burn pits and exhaust fumes [43]. Further, combat exposure was not associated with CMI symptoms, while non-overlapping PTSD symptoms did demonstrate an association. In prior studies of CMI in Gulf War Veterans combat exposure was not related to CMI symptoms [16]. Yet, non-overlapping PTSD symptoms were associated with CMI symptoms. This finding is consistent with prior literature noting an association between PTSD symptoms and increases in overall health symptoms [44].

Additional research is clearly needed to unravel the effects of chemical exposure on long-term physical and emotional functioning in veterans returning from the current conflicts. This study is one of the first to suggest that service members from a different war theatre who have toxic exposures also experience symptoms similar to those of CMI. Although our measures are only proxy measures of CMI, our assessment study demonstrates that toxic hazard exposure is associated with later CMI symptoms. Clearly, replication of these findings is needed.

Understanding the long-term impact of hazardous exposures has important policy implications, not only for the ongoing conflicts but for future campaigns. The Department of Defense (DoD) might consider examining the degree to which personnel are exposed to toxic exposures during the course of routine duties (i.e., pesticide exposure) and determine whether there are alternative, less hazardous, options or new technologies that can be employed. For example, there are alternatives to pesticides that may be less harmful to the body.

Limitations and Future Directions

Several limitations should be taken into consideration. First, all veterans who participated in this study were deployed in service of the conflicts in Iraq and/or Afghanistan following September 11th, 2001. Therefore, there was not a control group to make comparisons regarding symptoms. Additionally, because proxy measures of CMI symptoms were created using items from assessments designed to diagnose symptoms common to other problems (e.g. depression), the entire spectrum of symptoms known to constitute CMI was not assessed. For example, we did not assess problems finding words or joint pain. This could be a strength, however, as there was no potential response bias from participants when using a single instrument. Further, some measures of CMI symptoms assessed those symptoms within the past few weeks, which is a shorter time period than typically required in the Kansas definition. Severity of symptoms was not assessed. Future research using measures specifically designed to assess CMI symptoms in Iraq and Afghanistan veterans is needed.

While toxic exposures were determined by self-report, as was the case when researchers identified the symptom clusters that comprised CMI [2], we were not able to validate these

self-reports against military records of exposure. Specifically, we were not able to confirm whether participants were actually stationed near known munitions depletion sites or if they were exposed to sarin gas. Additional research that includes a thorough record review is warranted. Additionally, this cohort was not supposed to be administered pyridostigmine bromide, yet a significant minority endorsed that they did receive it. Thus, a discrepancy exists between the military record and the veterans' report. However, removing these veterans from the analyses did not produce any changes in the results.

Finally, due to the limited sample size, this study could not examine whether the association between toxic exposures and symptoms was limited to veterans who only served in the Persian Gulf Region or whether this association was also observed in those who served in Afghanistan. Such a comparison would be important in order to address whether this potential health hazard is limited to those serving in the Persian Gulf Regions or if broader precautions are warranted for all service members who are likely to be exposed to toxic hazards.

Conclusion

The present study provides the first direct evidence that veterans of the current conflicts are exposed to significant toxic hazards. These toxic exposures are associated with CMI symptoms even after controlling for key confounders. Our intent of this initial study was to generate additional research into this important area that has potentially far-reaching implications for health and recovery following warzone deployments. Large-scale epidemiological work aimed at identifying the prevalence of CMI symptoms in Iraq and Afghanistan veterans, as well as associated long-term health and functional outcomes of these symptoms, are needed. Additional fine-grained analysis of specific toxic exposures to which veterans may have been exposed and the potential association between these exposures and CMI symptoms is also of critical importance for prevention initiatives.

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Table 1

Rates of Self-reported Toxic Exposures in Veterans of the Conflicts in Iraq and Afghanistan

Exposures	n(%)
Nerve gas agents	6(2.7%)
Mustard gas/blistering agents	5(2.2%)
Environmental pesticides	81(36.2%)
Pesticides in uniforms	113(50.5%)
Pesticides in flea collars	34(15.2%)
Government-issues DEET-containing insect repellents	113(50.5%)
Non-government-issued insect repellents	135(60.3%)
Smoke or other air pollution	187(83.5%)
Diesel or other petrochemical fuel on skin	156(70.0%)
Fumes or exhaust from heaters or generators	179(80.0%)
Depleted uranium in munitions	50(22.3%)
Burning trash or feces	187(83.5%)
Local food other than provided by the Armed Forces	153(68.3%)
Entered an enemy bunker or military facility	115(51.3%)
Climbed inside of an enemy tank that had been abandoned or burned out	32(14.3%)
Exposed to chemical or biological weapons	12(5.4%)

Table 2

Correlations Between Toxic Exposures

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Nerve gas agents	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
2. Mustard gas/blistering agents	.72***	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
3. Environmental pesticides	.16*	.08	–	–	–	–	–	–	–	–	–	–	–	–	–	–
4. Pesticides in uniforms	.00	.03	.50***	–	–	–	–	–	–	–	–	–	–	–	–	–
5. Pesticides in flea collars	.16*	.27***	.28***	.31***	–	–	–	–	–	–	–	–	–	–	–	–
6. Government-issued DEET-containing insect repellents	.05	.04	.32***	.46***	.20**	–	–	–	–	–	–	–	–	–	–	–
7. Non-government-issued insect repellents	.02	.00	.33***	.21**	.19**	.40***	–	–	–	–	–	–	–	–	–	–
8. Smoke/air pollution	.07	.07	.30***	.34***	.08	.25***	.24***	–	–	–	–	–	–	–	–	–
9. Diesel or other petrochemical fuel on skin	.11	.03	.17*	.17*	.23**	.23**	.23**	.30***	–	–	–	–	–	–	–	–
10. Fumes/exhaust from heaters or generators	.08	.00	.23***	.24***	.02	.26***	.18**	.41***	.37***	–	–	–	–	–	–	–
12. Depleted Uranium in Munitions	.04	.00	.06	.10	.22***	.22***	.16*	.14*	.21**	.13	–	–	–	–	–	–
13. Burning trash or feces	.07	.07	.25***	.27***	.15*	.28***	.21**	.30***	.23**	.44***	.14*	–	–	–	–	–
13. Local food other than that provided by Armed Forces	.05	.04	–.07	.11	.10	.14*	.16*	.13*	.20**	.20**	.09	.11	–	–	–	–
14. Entered enemy bunker or military facility	.09	.06	.18**	.21**	.14*	.20**	.24***	.13	.22**	.27***	.20**	.32***	.26***	–	–	–
15. Climbed inside an enemy tank that had been abandoned or burned out	.11	.04	.12	.02	.15*	.02	.07	.03	.16*	.14*	.24***	.14*	.20**	.11	–	–
16. Exposed to chemical or biological weapons	.21**	.10	.07	.00	.12	.03	.10	.05	.11	.12	.16*	.10	.11	.10	.26***	–.

Table 3

Number and Percentage of Participants who Endorsed Each CMI Symptom

Symptoms	n(%)
Fatigue	42(18.8%)
Sleep problems	83(37.1%)
Difficulty concentrating	62(27.7%)
Irritability	57(26.6%)
Anxiety or depression	53(23.8%)
Musculoskeletal Pain	108(48.2%)
Fatigue Cluster	42(18.8%)
Mood/Cognition Cluster	117(52.2%)
Musculoskeletal Cluster	108(48.2)
Met Criteria for CMI (met criteria for 2 of 3 clusters)	83(37.1%)

Table 4

Summary of the Continuous Regression Model Predicting Chronic Multisymptom Illness

	GWI-like Symptoms	
	R^2	β
Step 1	0.03	
Gender		−0.07
Age		0.01
Education Level		−0.19 [***]
Step 2	0.001	
Combat Exposure		0.12
Step 3	0.30 [***]	
Non-Overlapping Posttraumatic Stress Disorder Symptoms		0.57 [***]
Step 4	.00 [***]	
Smoking Status		.00
Step 5		
Nuclear, Biological, and Chemical Exposures	.02 [**]	.14 [**]
Total R^2	0.34	

Note:

[*] $p < 0.05$;

[**] $p < 0.01$;

[***] $p < 0.001$