

Environmental Exposure and Health of Operation Enduring Freedom/Operation Iraqi Freedom Veterans

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Objective: We characterized the prevalence of self-reported environmental exposures, concerns about exposures, and their relationships with somatic symptoms in Operation Enduring Freedom (Afghanistan) (OEF) and Operation Iraqi Freedom (Iraq) (OIF) veterans seeking treatment at a specialty Veterans Affairs (VA) clinic. Concerns about environmental exposures were expected to lead to more reporting of somatic symptom burden. **Methods:** We conducted a chart review of 469 OEF/OIF veterans seen at a VA tertiary care clinic. **Results:** OEF/OIF veterans reported a high level of environmental exposures and concerns about environmental exposures. Greater reported environmental exposures ($\beta = 0.13$) and environmental exposure concerns ($\beta = 0.39$) were associated with a greater somatic symptom burden. Exposure concerns accounted for some of the relationship of exposures on somatic symptom burden (confidence interval, 0.33–0.60). **Conclusions:** OEF/OIF veterans seeking treatment at a VA clinic reported a high prevalence of environmental exposures and exposure concerns. Both negatively impacted health outcomes.

The first Persian Gulf War highlighted the importance of understanding how potential environmental exposures sustained during deployment were related to health outcomes. For example, after the first Persian Gulf War, veterans reported increased widespread somatic symptoms such as pain, fatigue, and cognitive deficits and concerns about whether these symptoms were because of environmental exposures.^{1–6} Concern about exposure to environmental toxins led to a continued targeted research effort to examine the effects of environmental exposures on the health of Persian Gulf War veterans.^{1,2,5–9} Despite this effort, the relationship between exposures and health outcomes is still contested and symptoms continue to persist in some individuals.^{1,2,5–9}

In contrast to fairly extensive research on environmental exposures during the Persian Gulf War, there have been relatively few studies on environmental exposures among servicemen and women deployed to Afghanistan (Operation Enduring Freedom; OEF) and Iraq (Operation Iraqi Freedom; OIF). A few reports of specific environmental exposures have appeared, such as about burn pits,^{10–12} however, we know of only two publicly available reports on the prevalence of a broad set of environmental exposures during OEF/OIF.

The first was a small scale study (N = 56), which was completed by our center in 2006 and used a previous version of the exposure measure that is reported in the current study.¹³ At that time, the most commonly reported concerns were smoke from burning trash, multiple vaccinations, and depleted uranium.¹³ The second report, from the Department of Defense's Medical Surveillance Monthly Report,¹⁴ described the rates of exposure concerns reported on the Post-Deployment Health Reassessment completed after return from deployment by 118,715 service members between September 2005 and August 2006. At that time, the top five exposure concerns were sand, loud noises, smoke from burning trash, vehicle exhaust, and fuel.¹⁴ Despite the paucity of published research on exposure concerns among OEF/OIF military personnel, there have been numerous media reports on the effect of OEF/OIF environmental exposures^{15–19} and reports of increases in somatic symptoms among OEF/OIF military personnel.^{20,21} With more than 2 million OEF/OIF veterans returning from war it is important that we understand the impact of potential exposures and concerns about exposures after a combat deployment.

The goal of the current study was to determine the prevalence of self-reported environmental exposures and concerns about environmental exposures, and to examine the relationship of reported exposures and exposure concerns to somatic symptom burden. Environmental exposures and concerns about those exposures can impact somatic symptoms through two possible mechanisms. First, environmental exposures may impact physiologic function in the exposed individual, and thereby impact health. Second, perceived environmental exposures and concerns about exposures may lead to increases in somatic symptoms through psychological mechanisms.^{7,22} Thus, both physiologic and psychological factors could play a role in enhanced somatic symptom reports after exposure to environmental hazards.^{23,24}

We examined a psychological pathway through which environmental exposures could lead to increased somatic symptom reports. Consistent with Leventhal's Common-Sense Model of Self-Regulation^{25,26} we hypothesized that greater reports of environmental exposures and more concerns about these exposures could direct attention to somatic symptoms and thereby lead to greater reporting of somatic symptoms. Leventhal's Common-Sense Model of Self-Regulation proposes that individuals search for explanations for somatic symptoms. An individual with concerns about an environmental exposure will likely use knowledge of the exposure as one explanation of their symptoms.²⁷ This, in turn, could lead to greater attention to, and report of, somatic symptoms.^{7,26,28,29} If individuals are not concerned about the cause of their somatic symptoms, they are more likely to attribute their symptoms to a harmless cause and not attend to them (eg, headache attributed to stress).³⁰

To explore the possibility that concerns about potential environmental exposures in the theaters of war in Iraq and Afghanistan may be viewed as increasing reports of somatic symptoms, we first examined the prevalence of self-reported environmental exposures and concerns in a sample of OEF/OIF veterans seeking care for postdeployment health concerns at a Veterans Affairs tertiary care clinic. We predicted that these veterans would report high rates of environmental exposures and concern about these exposures. We further predicted that self-reported environmental exposures would

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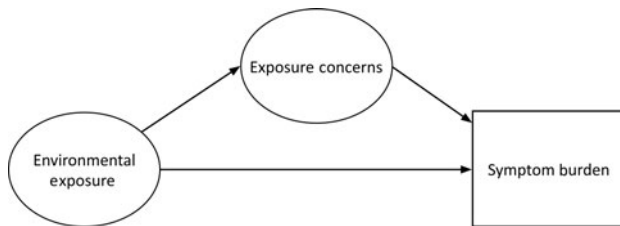


FIGURE 1. Predicted relationship between environmental exposures and symptom burden.

be associated with greater overall somatic symptom burden, and that this relationship would be partially accounted for by concern about the environmental exposures (Fig. 1).

METHODS

We conducted a chart review of OEF/OIF veterans seen at the Department of Veterans Affairs New Jersey War Related Illness and Injury Study Center (NJ WRIISC), a tertiary specialty care clinic. The WRIISC is a secondary referral source for veterans from all eras with deployment-related concerns or with unexplained physical symptoms. Since its inception in 2001, the NJ WRIISC has seen more than 800 OEF/OIF veterans. OEF/OIF veterans seen at the NJ WRIISC generally receive a 1-day clinical evaluation that includes a history and physical symptoms with a physician, psychological and neuropsychological assessments, a comprehensive exposure evaluation with an occupational medicine physician, and visits with both a social worker and an education specialist. All veterans seen at the NJ WRIISC complete a structured intake packet with questions regarding their health, symptoms, exposures, and exposure concerns. The current exposure measure was added to the intake packet in 2006, and 469 OEF/OIF veterans since then have completed this measure. Data from all veterans completing this measure were included in this analysis.

MEASURES

Demographic

Age, reported in years, and gender were obtained by self-report.

Exposures

The structured intake packet included a 16-item self-report exposure measure created by a WRIISC Occupational and Environmental Medicine physician (RFT). The measure asked participants whether they had been exposed to specific hazards during their deployment or military career (with response options of yes, no, and don't know). Potential exposures included air pollution, air pollution from a specific source, contaminated food/water, petrochemicals, chemicals that they worked with, depleted uranium, chemical alarms/gear/antidote tablets, chemical weapons, biological or radiologic warfare agents, vaccines, anthrax vaccine, preventive medicines, insect bites, insect repellent/insecticide/pesticide/flea collars, herbicides, bodies/death/combat injuries. Self-report is a common method for capturing such environmental exposures, especially in light of a dearth of objectively measured (and accessible) data about actual exposures in the combat theater. We calculated a sum of the total number of exposures endorsed (Cronbach $\alpha = 0.76$).

Exposure Concerns

Veterans who indicated that they were exposed to a hazard were then asked to indicate their level of concern for each hazard. Veterans indicated their level of concern on a five-point Likert scale (0, not at all; 1, somewhat; 2, moderately; 3, very; 4, extremely). Veterans who reported that they were not exposed to a hazard were

not asked about their level of concern. Thus, for this study, when a veteran indicated they were not exposed to a specific hazard we coded this as no concern about the specific exposure. We calculated a sum of the extent of concern endorsed for each item (Cronbach $\alpha = 0.94$).

Symptom Burden

The Patient Health Questionnaire-15 (PHQ-15) asks patients about 15 somatic symptoms and how bothered the patient is by each symptom. The scale focuses on nonspecific somatic symptoms that are diffuse and can be associated with different medical diagnoses (eg, headache, trouble sleeping, chest pain). The PHQ-15 has shown excellent internal reliability and validity.³¹ Multiple studies have validated the use of this symptom checklist as a measure of somatic symptom severity.^{31–33} This questionnaire has been widely used in both civilian and veteran populations^{32,34} in both descriptive and clinical intervention trials.^{34–36} We calculated symptom burden from the PHQ-15 using a recommended scoring of 0 (not bothered), 1 (bothered a little), and 2 (bothered a lot) for each of the 15 symptoms (score range, 0 to 30).

ANALYSES

Variables were assessed for normality. The sum of the concern about exposures measure was skewed, and a square root transformation was used to normalize this variable for use in the regression analysis. All other variables could be considered to be normally distributed. We reported the exposure prevalence as the percentage of OEF/OIF veterans who indicated “Yes,” they had been exposed to each specific hazard. We reported the prevalence of the concern about exposure as the percentage of OEF/OIF veterans exposed to the hazard who indicated that they had “somewhat” or greater concern for a given hazard. We assessed the relationship of each reported exposure to symptom burden using independent *t* tests (Table 1) and the relationship of concern about each exposure to symptom burden using Pearson's correlation coefficient *r* (Table 2).

TABLE 1. Level of Symptom Burden for Those Exposed to an Environmental Hazard Versus Those Not Exposed to a Hazard

| Exposure | Mean Symptom Burden for Those Exposed | Mean Symptom Burden for Those Not Exposed |
|---------------------------------------|---------------------------------------|---|
| Herbicide | 15.55 | 10.90* |
| Biological warfare | 15.04 | 10.76* |
| Chemical weapons | 14.24 | 10.82* |
| Depleted Uranium | 13.16 | 10.44* |
| Chemical gear/tablets | 13.32 | 10.22* |
| Contaminated food/water | 12.87 | 9.97* |
| Insect repellent | 12.20 | 8.67* |
| Preventive medicine | 12.01 | 9.40* |
| Bodies/combat injury | 11.92 | 9.24* |
| Insect bites | 11.75 | 8.75* |
| Petrochemicals | 11.75 | 7.76* |
| Chemicals used on the job | 11.71 | 9.98* |
| Air pollution—specific (eg, burn pit) | 11.46 | 8.63* |
| Air pollution—general (eg, sandstorm) | 11.29 | 7.90* |
| Vaccines | 11.18 | 9.89 |
| Anthrax vaccine | 11.18 | 9.87 |

**P* ≤ 0.05; symptom burden scale range = 0–30.

TABLE 2. Correlation of Concerns About Exposure to Symptom Burden

| Concern about Exposure | Correlation With Symptom Burden |
|---|---------------------------------|
| Sum of concern | 0.49* |
| Concern about exposure to bodies/combat injury | 0.45* |
| Concern about exposure to petrochemicals | 0.42* |
| Concern about exposure to insect repellent | 0.40* |
| Concern about exposure to preventive medicine | 0.38* |
| Concern about exposure to insect bites | 0.37* |
| Sum of exposure | 0.34* |
| Concern about exposure to vaccines | 0.33* |
| Concern about exposure to air pollution-specific (eg, burn pit) | 0.32* |
| Concern about exposure to contaminated food/water | 0.32* |
| Concern about exposure to anthrax vaccine | 0.32* |
| Concern about exposure to air pollution-general (eg, sandstorm) | 0.31* |
| Concern about exposure to chemicals used on the job | 0.29* |
| Concern about exposure to chemical gear/tablets | 0.26* |
| Concern about exposure to depleted uranium | 0.22* |
| Concern about exposure to bio warfare | 0.17* |
| Concern about exposure to chemical weapons | 0.15* |
| Concern about exposure to herbicide | 0.14* |

**P* > 0.05.

A multivariate hierarchical regression analysis was conducted to determine the effect of the sum of exposures and the sum of concern about exposures on symptom burden. In the first step, age, gender, and sum of environmental exposures were entered. In the second step, sum of concern about exposure was entered. Concern about exposure was hypothesized to be a mediator of the relationship between the sum of exposures and symptom burden. A mediator variable is a variable that reveals a potential mechanism underlying the relationship between an independent (ie, predictor) and dependent (ie, outcome) variable. To determine whether concern about exposures mediated the relationship between total exposures and symptom burden, we used a bootstrapping technique with 5000 bootstraps and a 95% confidence interval.³⁷ Bootstrapping techniques are beneficial in determining mediation effects because they do not require the underlying sampling distribution to be normally distributed.^{37,38}

RESULTS

The average age of this sample of 469 OEF/OIF veterans was 32.4 years; 88% were male with 57% white, 36% Hispanic, 24% African American, and 19% other. The majority were either married (41%) or single (42%); all had at least a high school degree, and 51% had a college degree.

The OEF/OIF veterans in this sample reported a high level of environmental exposures and concern about these exposures (Table 3). The most prevalent exposures were air pollution (94%), vaccines (86%), and petrochemicals (81%). On average, OEF/OIF

veterans in this sample reported being exposed to 8.5 of the possible 16 hazards. For each hazard, at least 74% of those exposed reported somewhat or more concern about that hazard. Exposures and concern about exposures both were related to greater somatic symptom burden (Tables 1 and 2). The sum of concern about exposure was highly correlated with symptom burden ($r = 0.49$). In other words, 25% of the variance in symptom burden was accounted for by concerns about exposures.

A regression analysis was conducted to determine whether the sum of exposure and sum of concern about exposure were related to greater symptom burden after controlling for age and gender (Table 4). In the first step, the demographic variables and the sum of environmental exposures variable was entered. Older veterans, female veterans, and those with greater total environmental exposures reported significantly greater symptom burden. In the second step, concern about exposures was added. Greater overall concern about exposures was related to greater symptom burden. When the overall concern about exposure was entered in the regression model, the sum of environmental exposures went from significant to nonsignificant. This is considered an indication of mediation.³⁹ We also used a bootstrapping technique to determine whether the overall concern about exposure was a mediator. This technique demonstrated that there was an effect of total exposures on symptom burden through the proposed mediator of the overall concern about exposure (point estimate of 0.56; 95% confidence interval, 0.41–0.72).

DISCUSSION

OEF/OIF veterans seeking treatment at a tertiary care VA clinic reported high rates of exposure to environmental hazards and reported significant concern about these exposures. Both self-report of environmental exposures and concerns regarding those exposures were related to greater somatic symptom burden. Some of the relationship between self-reported environmental exposures and somatic symptoms was accounted for, or mediated by, concern about exposures. This suggests that one way that environmental exposures can impact somatic symptoms is through concern or worry.

Our finding that exposure concerns is related to greater physical symptom burden is consistent with some prior literature.^{22,40} McMahan and Meyer⁴⁰ examined perceptions and worry about exposure to overhead transmission lines. They found that worry about the transmission lines was significantly related to health problems for those individuals living near the transmission lines.⁴⁰ Gallacher and colleagues²² examined how perceived risk of exposure to an oil tanker spill related to somatic symptom reporting. They surveyed six towns near an oil spill, four of which had been exposed to the oil spill and two, which had not been exposed to the oil spill. They found that perceived risk was associated with general somatic symptoms, whereas exposure to the oil was specifically associated with toxicologically related symptom reports.²² As these studies show, exposure to a hazard impacts symptom reporting, at least in part, through psychological mechanisms. Although such mechanisms are probably relevant for all individuals exposed to a hazard, the relative contribution of the psychological mechanisms may vary depending on the exposure, the individual or the context.²⁴

This study was limited by its sample and scope. We caution that our cross-sectional findings cannot distinguish between the possibility that not only may greater concerns mediate greater symptom burden, but also increased symptom burden may result in the search for potential explanations, and thus, increased exposure concerns. We cannot disambiguate these two possibilities without longitudinal data that can determine the contribution of each of these two causal explanations. We were also not able to collect or have access to data of objective measures of environmental exposures. Thus, all “exposures” are self-reported potential exposures, with the exceptions of certain exposures that all Service members presumably had, for example, vaccinations. Objective exposure data should be collected

TABLE 3. Prevalence of Self-Reported Exposure to an Environmental Hazard and Prevalence of Concern (at a Level of "Somewhat" or Greater Than) Among Those who Were Exposed

| Exposure | Prevalence, % | Concern About Exposure | Prevalence, % |
|---------------------------------------|---------------|-------------------------|---------------|
| Air pollution—general (eg, sandstorm) | 94 | Air pollution—general | 90 |
| Air pollution—specific (eg, burn pit) | 87 | Air pollution—specific | 93 |
| Vaccines | 86 | Vaccines | 78 |
| Anthrax vaccine | 86 | Anthrax vaccine | 86 |
| Petrochemicals | 81 | Petrochemicals | 84 |
| Insect bites | 75 | Insect bites | 74 |
| Bodies/combat injury | 69 | Bodies/combat injury | 75 |
| Insect repellent | 67 | Insect repellent | 73 |
| Chemicals used on job | 62 | Chemicals used on job | 74 |
| Preventive medicine | 55 | Preventive medicine | 74 |
| Contaminated food/water | 37 | Contaminated food/water | 93 |
| Chemical gear/tablets | 26 | Chemical gear/tablets | 85 |
| Depleted uranium | 21 | Depleted uranium | 94 |
| Chemical weapons | 7 | Chemical weapons | 93 |
| Biological warfare | 6 | Biological warfare | 92 |
| Herbicide | 2 | Herbicide | 90 |

TABLE 4. Regression Analysis Predicting Somatic Symptom Burden

| | Unstandardized Coefficients | | Coefficients | | |
|----------------|-----------------------------|------|--------------|-------|-------|
| | B | SE | β | t | P |
| Step 1 | | | | | |
| Age | 0.10 | 0.03 | 0.15 | 3.30 | <0.01 |
| Gender | -2.60 | 0.86 | -0.14 | -3.05 | <0.01 |
| Exposure total | 0.73 | 0.10 | 0.34 | 7.74 | <0.01 |
| Step 2 | | | | | |
| Age | 0.05 | 0.03 | 0.07 | 1.65 | 0.10 |
| Gender | -2.42 | 0.81 | -0.13 | -3.00 | <0.01 |
| Exposure total | 0.21 | 0.11 | 0.10 | 1.84 | 0.07 |
| Concern total | 1.47 | 0.19 | 0.41 | 7.78 | <0.01 |

SE, standard error.

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and made available for future studies in those deployed to combat theaters, and when available, potential physiologic mediators of exposure effects also should be examined. The sample was limited to OEF/OIF veterans seeking treatment at a VA tertiary clinic that offers environmental exposure evaluations. As a result, the prevalence rates cannot be generalized to a nontreatment seeking population, or to a primary care veteran population. Finally, data were cross-sectional, and as noted earlier, we cannot determine the cause of somatic symptoms, only co-occurring factors.

This study is one of the first to examine rates of environmental exposures and concerns about these exposures in a sample of treatment seeking OEF/OIF veterans seen at a tertiary care VA clinic. Our study suggests that these concerns can be a significant problem in this population, and that exposure concerns are associated with greater symptom burden. Veterans with exposure concerns likely need more extensive education and support concerning what is currently known (and not known) about the potential health effects of their exposures of concern, and providers likely need additional education to respond to those concerns thoroughly.^{9,41,42}

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