Original Contribution

Longitudinal Health Study of US 1991 Gulf War Veterans: Changes in Health Status at 10-Year Follow-up

Bo Li, Clare M. Mahan, Han K. Kang*, Seth A. Eisen, and Charles C. Engel

* Correspondence to Dr. Han K. Kang, Environmental Epidemiology Service (10P3A), Department of Veterans Affairs, 810 Vermont Avenue NW, Washington, DC 20420 (e-mail: han.kang@va.gov).

Initially submitted November 22, 2010; accepted for publication April 14, 2011.

The authors assessed changes in the health status of US 1991 Gulf War-era veterans from a 1995 baseline survey to a 2005 follow-up survey, using repeated measurement data from 5,469 deployed Gulf War veterans and 3,353 nondeployed Gulf War-era veterans who participated in both surveys. Prevalence differences in health status between the 2 surveys were estimated for adverse health indices and chronic diseases for each veteran group. Persistence risk ratios and incidence risk ratios were calculated after adjustment for demographic and military service characteristics through Mantel-Haenszel stratified analysis. At 10-year follow-up, deployed veterans were more likely to report persistent poor health, as measured by the health indices (functional impairment, limitation of activities, repeated clinic visits, recurrent hospitalizations, perception of health as fair or poor, chronic fatigue syndrome-like illness, and posttraumatic stress disorder), than nondeployed veterans. Additionally, deployed veterans were more likely to experience new onset of adverse health (as measured by the indices) and certain chronic diseases than were nondeployed veterans. During the 10-year period from 1995 to 2005, the health of deployed veterans worsened in comparison with nondeployed veterans because of a higher rate of new onset of various health outcomes and greater persistence of previously reported adverse health on the indices.

Gulf War; health status; incidence; longitudinal studies; risk; stress disorders, post-traumatic; veterans

Abbreviation: PTSD, posttraumatic stress disorder.

Over the years since the 1991 Gulf War, initial concerns regarding the health consequences of participation in the war have turned to requests for longitudinal evaluation of how the health of Gulf War veterans has changed over time. In 1995, we conducted a baseline health survey of 30,000 Gulf War-era veterans (15,000 deployed and 15,000 nondeployed) that permitted comparison of the prevalence of health outcomes between the 2 cohorts (1). We completed a follow-up survey of the same cohorts in 2005, approximately 10 years after the baseline survey (2). On the basis of 2005 follow-up survey data, we previously reported that deployed Gulf War veterans continued to experience a higher prevalence of functional impairment, limitation of activities, health-care utilization, poor perception of health, and various self-reported medical and mental conditions (2). The reported high prevalence of various health conditions in 2005 among the deployed veterans compared with the nondeployed veterans could have been explained by either a greater persistence of the existing conditions or a higher incidence of delayed onset of conditions which were not present in 1995.

In 2003, Hotopf et al. (3) published results from a study that assessed selected health outcomes in 2,370 United Kingdom veterans of the Gulf War, with 2 waves of data collected in 1997 and 2001. In the United Kingdom study, Gulf War veterans continued to experience considerably poorer health with regard to all of the outcomes studied than control groups of United Nations peacekeepers who served in Bosnia and nondeployed Gulf War-era veterans. Hotopf et al. reported that although the health gap between Gulf War veterans and comparison groups had narrowed slightly in 4 years, the Gulf War veterans were more likely to exhibit a higher incidence and greater persistence of various adverse health conditions (3).
While there exists a vast amount of literature on the health of US Gulf War veterans, to our knowledge, the current study is the only longitudinal investigation of a population-based sample of US Gulf War veterans. The purpose of this study was to assess whether or not deployed veterans were less likely to improve and more likely to experience new onset of certain selected health conditions in comparison with nondeployed veterans over a 10-year period, 1995–2005.

MATERIALS AND METHODS

Study population

The 30,000-member panel of 15,000 deployed Gulf War veterans and 15,000 nondeployed Gulf War-era veterans was assembled in 1995 for the National Health Survey of Gulf War Era Veterans and Their Families (1). The panel of deployed personnel was constructed to ensure that each branch of service (Air Force, Army, Marine Corps, Navy), unit component (active, Reserve, Guard), and gender (male, female) was adequately represented from the entire population of approximately 690,000 Gulf War veterans identified by the Department of Defense. The nondeployed comparison panel was sampled from 1990–1991 military personnel to mirror the frequencies in the deployed cohort (1, 2). The Washington, DC, Veterans Affairs Medical Center institutional review board and the US Army Medical Research and Materiel Command (Fort Detrick, Maryland) approved the study protocol and the informed consent process.

Survey design

In the original study (1), we reported on 20,917 participants from the 30,000-member panel. In this article, we report results from repeated measurements on 8,822 veterans (5,469 deployed and 3,353 nondeployed) who completed the 1995 and 2005 surveys (see Web Figure 1, which is posted on the Journal’s website (http://aje.oxfordjournals.org/)). Selected survey responses were supplemented by reviews of 287 deployed veterans’ medical charts and 240 nondeployed veterans’ medical charts. For the baseline survey in 1995, 11,441 deployed veterans (76%) and 9,476 nondeployed veterans (63%) participated. For the 10-year follow-up survey in 2005, all 29,607 living members of the 30,000-member permanent panel were mailed a prenotification letter, followed by a modified version of the 1995 structured health questionnaire, including an informed consent form. In keeping with a modification of Dillman’s mail survey method, successive mailings of thank-you/reminder postcards and questionnaires were sent to nonrespondents to the earlier mailings. During the 20-month period devoted to data collection, 9,970 veterans responded (6,111 deployed and 3,859 nondeployed), resulting in an overall response rate of 34% (40% deployed and 27% nondeployed) of the 29,607 living panel members. The most common reasons for nonparticipation in the postal survey were that people did not remember receiving the survey (32% of nonrespondents); were not interested in participating in the survey (21%); intended to complete the survey (16%); did complete the survey and mail it back (7%); gave no particular reason for not completing the survey (7%); felt the survey did not apply to them (5%); were deployed or out of town (4%); and thought the survey was too long and involved (3%) (Web Table 1).

The group of 8,822 veterans who participated in both surveys was selected for all analyses of health changes described in this article. When this subset of veterans was stratified by deployment status, they were found to be representative of the permanent panel of 30,000 veterans in terms of demographic and military characteristics: gender, age, race, marital status, rank, branch, and unit component (Web Table 2).

Health outcomes

Structured questionnaire items were adopted from the 1994 National Health Interview Survey questionnaire (4) and used to evaluate health outcomes from self-reported adverse health indices and selected chronic diseases in both the initial and follow-up surveys. Those questionnaire items included for adverse health indices were primarily functional impairment, limitation of activities, perceived health of fair or poor, use of health-care services (including repeat clinic visits related to illness), and overnight hospitalizations. Information on 5 selected chronic diseases was also collected. In both waves, functional impairment was defined as an affirmative response to the question, “Thinking back over the past 2 weeks, did you stay in bed or at home all or part of any day because you did not feel well or as a result of illness or injury?” Limitation of activities was defined as a positive response to the question, “Are you limited in your employment or the kind of work you can do around the house because of any impairment or health problems?”

Clinic visits due to illness within the previous year excluded routine visits for vaccinations or physical examinations. The timing for hospitalizations was also within the past year. Another health index was perceived health of fair or poor. “Chronic fatigue syndrome-like” illness (past 12 months) was defined using a modified case definition available in the questionnaire instruments (2). The Posttraumatic Stress Disorder (PTSD) Checklist, which was included in both survey questionnaires, contains 17 items concerning PTSD symptoms experienced in the past month (5). A cutoff score of 50 points from the civilian version of the PTSD Checklist was used to classify PTSD caseness (6, 7). All health outcomes are described fully in earlier reports (1, 2).

Statistical analyses

We compared the estimated prevalences of adverse health outcomes for 7 health indices and 5 selected chronic diseases using survey data obtained from 8,822 veterans who participated in the 2 health surveys (1995 and 2005). Each veteran’s responses to health questions at baseline (1995) and at the 2005 follow-up formed a matched pair of measurements for analysis of change. The change within each veteran on each health index and chronic disease, observed at 2 points in time, served as the unit of interest; hence the term “matched pair.”

Population prevalences of symptoms and conditions were obtained using weighted estimates of individual gender/service-branch/unit component values provided during 1995.
according to the stratified sampling design (1). When estimating prevalence from this multistage survey design, we chose to ignore statistical weights for sampling stratification variables but to conduct model-based analysis by including these variables as predictors in the regression model (8). At the first level of analysis, the prevalences of adverse health outcomes and chronic diseases for deployed and nondeployed Gulf War-era veterans were estimated within the same veteran group for 1995 and again for 2005. Prevalence differences between the 2 survey waves were estimated, as well as 95% confidence intervals. The McNemar test (9, 10) for significance of change within matched pairs over time (excess rate of 2005 over 1995) was applied within each veteran group (deployed, nondeployed) because the study design compared nominal measurements on the same sample at 2 points in time.

After dichotomous classification of 1995 survey responses to questions on specific health outcomes as negative or positive, the term “incidence case” was applied to persons who gave a negative response in 1995 followed by a positive response in 2005. More generally, this represents the number of veterans whose health status changed from 0 (in 1995) to 1 (in 2005) for a specific health outcome. “Incidence risk” was defined as the ratio of the number of new occurrences for a particular health outcome observed in a defined cohort in 2005 to the total number of persons in the defined cohort with negative responses for the same health outcome at baseline (1995). The incidence risk for deployed persons divided by the incidence risk for nondeployed persons is expressed as the crude risk ratio. The term “persistence case” represented persons who gave a positive response in 1995 followed by a repeat positive response in 2005. This is the number of repeat occurrences for a particular health outcome observed in a defined cohort at follow-up in 2005 divided by the number of prevalent cases observed in the defined cohort for the same health condition at baseline (1995). At the multivariate level of analysis, adjusted risk ratios were used to evaluate the incidence and persistence of each health outcome at 10-year follow-up through the Mantel-Haenszel method (11), with adjustment for the following covariates: age, gender, race, rank, service branch, body mass index (weight (kg)/height (m)²), and current cigarette smoking (table footnotes specify cutpoints). Both smoking and obesity (as measured by body mass index) were considered risk factors for several health conditions under study (hypertension, diabetes, arthritis, and coronary heart disease). The prevalences of smoking differed significantly between deployed and nondeployed veterans. The different service branches apply different criteria of weight-fitness for enlistment and retention in the military (12). Therefore, these 2 variables were included in multivariate analyses along with demographic and military variables.

The frequencies of many of the health outcomes were too low to adjust for each covariate. When an analysis includes uncommon health outcomes and many covariates, a compensating statistical method can be used that involves generating a propensity score by regressing the deployment variable on the observed covariates. The scores are rank-ordered and divided into quintiles (13). We applied propensity score methods to reduce 8 covariates to a quintile, thus creating a stratification variable for Mantel-Haenszel adjusted risk ratios. Statistical significance was assessed using 95% confidence intervals. SAS statistical software was used to conduct all analyses (14).

RESULTS

Characteristics of persons who participated in both surveys are presented in Table 1. The sociodemographic and military service characteristics of deployed Gulf War veteran participants and nondeployed Gulf War-era participants were broadly similar. Compared with nondeployed participants, the deployed veterans were younger in 1991 (mean age = 31.8 years vs. 34.2 years), more likely to be African-American (15% vs. 11%) and single (38% vs. 32% in 1991 and 12% vs. 9% in 2005), and more likely to have served in enlisted ranks (83% vs. 75%).

As demonstrated in Table 2, within each deployment group, the prevalence of most adverse health outcomes according to the health indices was significantly higher in 2005 than in 1995. In the deployed group, exceptions were having a clinic visit during the past 12 months and perceiving one’s health as fair or poor. Exceptions in the nondeployed group were having a clinic visit, hospitalization, perceived health of fair or poor, and being a PTSD case. The 1995 survey participants reported their medical conditions and symptoms with a high level of concordance with medical record documentation: 93% for clinic visits and 94% for hospitalization (1, 15). Furthermore, little difference in concordance rates was observed by deployment status. We conducted a similar validation study to evaluate the proportion of agreement between self-reported and charted medical reasons for a clinic visit or hospitalization in the 2005 survey. Among persons who gave written consent for this review, satisfactory agreement rates of approximately 93% were observed for both cohorts (2).

In Table 3, chronic diseases are listed in descending order of prevalence for the 1995 deployed group. Deployed veterans reported significant increases in prevalence over time for hypertension, diabetes, arthritis, and coronary heart disease. Nondeployed veterans also reported significant increases in prevalence over time for these chronic diseases.

Two types of adjusted risk ratios (persistence and incidence) and their 95% confidence intervals are presented in Table 4. Deployed veterans were less likely to recover from any prior functional impairment, limitation of activities, or PTSD that they had in 1995 and more likely to report new onset of these adverse health outcomes in 2005 compared with nondeployed veterans. A relatively higher proportion of deployed veterans had received medical care either as inpatients or as outpatients over a 10-year period because of existing health conditions or a new health problem they had experienced. Perceived health of fair or poor was more likely to persist among deployed veterans, and relatively more deployed veterans reported that their health status had worsened over the 10-year follow-up period.

For arthritis, coronary heart disease, and diabetes, similar proportions of veterans who had reported these diseases in 1995 reported the same diseases in 2005, irrespective of
deployment status, while hypertension and asthma were less persistent among the deployed after adjustment for sociodemographic characteristics, body mass index, and smoking status (Table 5). Deployed veterans reported more new onset of the chronic diseases surveyed (arthritis, hypertension, asthma, and coronary heart disease). The adjusted incidence risk ratios remained significantly increased for arthritis, hypertension, and coronary heart disease after controlling for relevant covariates. Significantly increased adjusted incidence risk ratios ranged from 1.15 (95% confidence interval: 1.02, 1.29) for hypertension to 1.61 (95% confidence interval: 1.17, 2.23) for coronary heart disease.

**DISCUSSION**

In this longitudinal study, we collected health information using mailed questionnaires and telephone interviews administered in 1995 and 2005 to deployed and nondeployed veterans who were in military service during the 1991 Gulf War era. For most of the adverse health indices, deployed veterans were less likely to improve and more likely to experience new onset of these outcomes than nondeployed veterans. The magnitude of the relative increases in prevalence of poor health outcomes over time among deployed veterans compared with nondeployed veterans is attributable to a combination of higher incidence of newly reported health outcomes and greater persistence of previously reported adverse health outcomes. One encouraging finding is that for most chronic diseases, Gulf War veterans were no more likely to report persistence than were nondeployed veterans. Similar proportions of deployed and nondeployed veterans who had arthritis, coronary heart disease, or diabetes reported that these conditions persisted during the 10-year follow-up interval, while deployed veterans with hypertension or asthma reported a better prognosis. With respect to arthritis, hypertension, or coronary heart disease, significantly higher proportions of deployed Gulf War veterans reported new onset of these conditions by 2005 than did nondeployed veterans. The pattern suggests that among deployed veterans, many health outcomes identified in 1995 persisted to 2005, in addition to new onset of many of these outcomes, and health status worsened.

The extent to which any of the health problems experienced by Gulf War veterans were due to the effects of military service in the Gulf War is difficult to determine. Numerous physical and psychological stressors are associated with deployment to a war zone. The effects on some veterans would have been minor and transient, while some would have developed physical and psychological health problems among multiple organ systems, including the central nervous system, cardiovascular system, endocrine system, and immune system. Chronic stress is associated with heart disease, diabetes, and chronic pain (16, 17).

Previous studies have found higher prevalences of PTSD and other common mental disorders among deployed Gulf War veterans versus nondeployed Gulf War-era veterans (1, 2, 18–22). PTSD can result in functional impairment and poor quality of life, as well as other comorbid medical conditions. In a study by Zatzick et al. (23), more than 90% of Vietnam veterans with PTSD reported having one or more of 30 chronic nonpsychiatric medical conditions within the preceding 12 months. However, little is known about the natural
Table 2. Observed Prevalences and Prevalence Differences for Adverse Health Outcomes Among US 1991 Gulf War-Era Veterans as Measured by Adverse Health Indices, by Deployment Status, 1995–2005

<table>
<thead>
<tr>
<th>Adverse Health Index</th>
<th>Deployed (n = 5,469)</th>
<th>Nondeployed (n = 3,353)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevalence in 1995, %</td>
<td>Prevalence in 2005, %</td>
</tr>
<tr>
<td>Functional impairment</td>
<td>27.2</td>
<td>31.0</td>
</tr>
<tr>
<td>Limitation of activities</td>
<td>18.0</td>
<td>28.8</td>
</tr>
<tr>
<td>Clinic visit</td>
<td>53.8</td>
<td>56.1</td>
</tr>
<tr>
<td>Hospitalization</td>
<td>8.3</td>
<td>10.0</td>
</tr>
<tr>
<td>Perceived health of fair or poor</td>
<td>23.7</td>
<td>24.1</td>
</tr>
<tr>
<td>Chronic fatigue syndrome-like illness (past year)</td>
<td>4.9</td>
<td>9.4</td>
</tr>
<tr>
<td>PTSD Checklist (past 4 weeks)</td>
<td>12.1</td>
<td>14.4</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; PD, prevalence difference; PTSD, posttraumatic stress disorder.

* P < 0.05.


history and incidence over time of psychological conditions among Gulf War veterans. A study of Australian Gulf War veterans demonstrated that onset of anxiety disorders, including PTSD, peaked in the first 2 years after return from deployment, but new cases continued to develop for the next 12 years (24). The investigators did not determine the proportion of veterans with these disorders who recovered during the study period. Our study showed that over the 10-year period 1995–2005, 44.5% of deployed veterans who had PTSD recovered, but 8.8% of deployed veterans who did not experience PTSD in 1995 developed the condition. The prevalence of PTSD among deployed veterans was 14.4% (nondeployed, 4.0%) in 2005, 14 years after the war. The baseline 1995 study showed that the risk of PTSD increased with the severity of stress, ranging from 3.3% in nondeployed reserve personnel who were not activated to 22.6% among deployed Gulf War veterans who 1) had worn chemical protective gear or heard chemical alarms, 2) had been involved in direct combat duty, and 3) witnessed deaths (18). In a population-based study of 3,016 Vietnam veterans, 15.2% of male Vietnam veterans had current combat-related PTSD 15–20 years after the war (25). The prevalence was 4 times as high in Vietnam veterans who were exposed to high levels of war-zone stress than in veterans with low or moderate war-zone stress (35.8% vs. 8.5%).

While clinical studies generally have not indicated an increased risk of chronic diseases among Gulf War veterans in comparison with nondeployed veterans (26–29), recent studies have suggested a possible biological basis for the excesses in chronic pain, fatigue, and neurocognitive symptoms among Gulf War veterans (30–32). An animal experiment demonstrated that exposure to repeated stress in combination with daily pyridostigmine treatment for two 5-day periods separated by a 2-day rest significantly disrupted the blood-brain barrier and thereby increased the neurotoxicity induced by chemicals in many cerebral areas (32). In a neurobehavior and neuroimaging study of deployed Gulf War veterans with suspected exposure to the organophosphate chemical warfare agents sarin and cyclosarin, it was found that these veterans had reduced total gray matter and hippocampal volumes in comparison with their unexposed peers (P < 0.01). There were significant positive correlations between total long-term neurobehavioral and functional symptoms.


<table>
<thead>
<tr>
<th>Chronic Diseasea</th>
<th>Deployed (n = 5,469)</th>
<th>Nondeployed (n = 3,353)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prevalence in 1995, %</td>
<td>Prevalence in 2005, %</td>
</tr>
<tr>
<td>Arthritis</td>
<td>25.7</td>
<td>28.9</td>
</tr>
<tr>
<td>Hypertension</td>
<td>12.9</td>
<td>19.4</td>
</tr>
<tr>
<td>Asthma</td>
<td>5.2</td>
<td>4.9</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>1.7</td>
<td>3.0</td>
</tr>
<tr>
<td>Diabetes</td>
<td>1.3</td>
<td>4.6</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; PD, prevalence difference.

* P < 0.05.

a Chronic diseases are listed in order of 1995 prevalence among deployed personnel.

b Excess prevalence in 2005 versus 1995. The PD underestimates the excess prevalence of chronic diseases in 2005 over 1995 because the time period queried about in the 2005 survey was 4 weeks, as opposed to 12 months in the 1995 survey.
white matter volume and measures of executive function and visuospatial abilities in veterans with suspected nerve agent exposure, suggesting that low-level exposure to nerve agents can have deleterious effects on brain structure and function more than a decade later (31). In another study of veterans with “Gulf War illness” and nondeployed veterans, veterans with symptoms of Gulf War illness (fatigue, mood or cognitive complaints, and chronic joint/muscle pain) demonstrated impaired immune function, as shown by decreased natural killer cell cytotoxicity and altered gene expression associated with natural killer cell function (30).

One major strength of the survey was the inclusion of nondeployed Gulf War-era veterans for comparison rather than a civilian control group. This may have reduced the “healthy soldier bias” that is hypothesized to occur because the military tends to select and retain healthy people (33, 34). Another strength was the verification of self-reported use of health-care services within the previous 12 months by obtaining and reviewing medical records. Among persons who gave written consent for this review, satisfactory agreement rates of approximately 93% were observed for both the deployed and nondeployed veteran groups (2).

A potential weakness of the study was the low response rate of 34% in the 2005 follow-up survey (2). This may have introduced selection bias, meaning that veterans who chose to respond to the 2005 survey could have differed in terms of health outcomes from veterans who did not respond to the survey. A systematic review of many published studies with varying response rates indicated that there was remarkably little heterogeneity for psychiatric outcomes, suggesting that the difference in effect size could not be explained solely by nonparticipation (20). An intensive follow-up of British troops who did not initially participate in one study showed that the possible nonresponse bias was not an explanation for the considerably poorer health observed among the British Gulf War veterans compared with nondeployed control veterans (22). In our baseline survey in 1995, we compared self-rated general health between a group of veterans who responded to the first mailing and a group of veterans who responded to a later mailing. We did not find a significant

### Table 5. Persistence and Incidence of Chronic Diseases Among US 1991 Gulf War-Era Veterans, by Deployment Status, 1995–2005

<table>
<thead>
<tr>
<th>Chronic Disease</th>
<th>Persistence Risk</th>
<th>Incidence Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Deployed, %</td>
<td>Nondeployed, %</td>
</tr>
<tr>
<td>Arthritis</td>
<td>58.1</td>
<td>60.2</td>
</tr>
<tr>
<td>Hypertension</td>
<td>53.2</td>
<td>67.1</td>
</tr>
<tr>
<td>Asthma</td>
<td>40.7</td>
<td>53.5</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>39.3</td>
<td>39.2</td>
</tr>
<tr>
<td>Diabetes</td>
<td>71.6</td>
<td>81.8</td>
</tr>
</tbody>
</table>

Abbreviations: aRR, adjusted risk ratio; CI, confidence interval.
* P < 0.05.
a Chronic diseases are listed in order of 1995 prevalence among deployed personnel.
b Risk ratios were adjusted for age in 2005 (<46 years vs. ≥46 years), gender, race (white vs. all others), rank (enlisted vs. officer or warrant officer), service branch (Air Force/Navy vs. Army/Marine Corps), service type (active vs. Guard or Reserve), body mass index (weight (kg)/height (m)²); underweight/normal (<25.0) vs. overweight (25.0–29.9) or obese (≥30.0), and current cigarette smoking.

difference between the 2 groups (1). In addition, a review of the 1995 baseline survey results showed that participants’ health in 1995 was not a good predictor of whether they would participate in the 2005 survey. Approximately 20% of nonrespondents were truly not interested in responding to the survey (Web Table 1). It is unlikely that a low response rate alone would account for the poorer health observed among Gulf War veterans compared with nondeployed Gulf War-era veterans.

In summary, the health of Gulf War veterans worsened during the 10-year period from 1995 to 2005 in comparison with the nondeployed Gulf War-era veterans, as shown by a higher proportion of incidence cases and/or a greater proportion of persistence cases. Deployed veterans were more likely than nondeployed veterans to report persistent poor health and new onset of poor health on the adverse health indices (functional impairment, limitation of activities, repeated clinic visits, recurrent hospitalizations, perceived health of fair or poor, chronic fatigue syndrome-like illness, and PTSD). For the chronic diseases studied, the persistence risk was not significantly higher in the deployed group, while the incidence risk was significantly higher among Gulf veterans, even after controlling for relevant covariates.

ACKNOWLEDGMENTS

Author affiliations: Institute for Clinical Research, Inc., Washington DC VA Medical Center, Department of Veterans Affairs, Washington, DC (Bo Li); Environmental Epidemiology Service, Office of Public Health, Department of Veterans Affairs, Washington, DC (Clare M. Mahan, Han K. Kang); Health Services Research and Development Service, Department of Veterans Affairs, Washington, DC (Seth A. Eisen); Department of Psychiatry, F. Edward Hebert School of Medicine, Uniformed Services University of the Health Sciences, Bethesda, Maryland (Charles C. Engel); and Deployment Health Clinical Center, Walter Reed Army Medical Center, Washington, DC (Charles C. Engel).

This work was supported by the Department of Defense under contract DAMD 17-02-1-0200 and by the Department of Veterans Affairs.

The authors acknowledge Stephanie Green Eber, Dr. Aaron I. Schneideman, and Dr. Steven S. Coughlin for useful discussions.

Conflict of interest: none declared.

REFERENCES


