Am. J. Trop. Med. Hyg., 60(5), 1999, pp. 758–766

INCREASED POSTWAR SYMPTOMS AND PSYCHOLOGICAL MORBIDITY AMONG U.S. NAVY GULF WAR VETERANS

GREGORY C. GRAY, KEVIN S. KAISER, ANTHONY W. HAWKSWORTH, FRANK W. HALL, AND ELIZABETH BARRETT-CONNOR

Emerging Illness Division, Naval Health Research Center, San Diego, California; Department of Family and Preventive Medicine, University of California, San Diego, School of Medicine, San Diego, California; Department of Pathology, Naval Medical Center, San Diego, California

Abstract. To investigate reports on war-related morbidity, 527 active-duty Gulf War veterans and 970 nondeployed veterans from 14 Seabee commands were studied in 1994 with a questionnaire, sera collection, handgrip strength, and pulmonary function testing. The questionnaire assessed postwar symptoms, war exposures, and screened for chronic fatigue syndrome, post-traumatic stress disorder, and psychological symptoms suggesting neurosis (Hopkins Symptom Checklist). Sera were tested with four nonspecific reactant assays: C-reactive protein, transferrin, ferritin, and haptoglobin. Gulf War veterans reported a higher prevalence for 35 of 41 symptoms, scored higher on psychological symptom scales, were more likely to screen for post-traumatic stress disorder, had lower handgrip strength, and had higher serum ferritin assay results. Numerous comparisons of these morbidity outcomes with 30 self-reported exposures demonstrated many associations, but no unique exposure or group of exposures were implicated. Morbidity data are consistent with other postwar observations, but the etiology for morbidity findings remains uncertain.

United States veterans of the Persian Gulf War have complained of diverse symptoms and illnesses since the fighting ceased in March 1991. Thus far, studies of mortality,[1–3] hospitalizations,[4,5] and birth defects to progeny[6,7] have not explained these infirmities. Thousands of systematic comprehensive clinical evaluations of these veterans at federal hospitals have failed to identify a unique syndrome or an unusual collection of symptoms.[8–12] After weeks of deliberation, expert scientific panels have given direction for further research[13–16] but they have not satisfied the many questions surrounding the health of Gulf War veterans.

In terms of reporting postwar morbidity, some of the earliest and more vocal Gulf War veterans have been those who were attached to Naval Mobile Construction Battalion 24 during the war.[15,17,18] This U.S. Navy Reserve unit of approximately 600 construction workers (Seabees) served alongside several similar commands of regular active-duty Navy Seabees during the conflict.

In an effort to search for possible etiologic exposures, we compared postwar symptoms and morbidity between Gulf War veteran and nondeployed veteran Seabees who had remained on active duty since the war.

MATERIALS AND METHODS

Study population. Mobile construction battalion personnel build and maintain U.S. Navy and Marine Corps bases, ports, field deployment facilities, and foreign embassies. These activities are accomplished through annual deployments, often involving up to six months of foreign travel. Before, during, and after the Gulf War fighting, many Seabees worked throughout Saudi Arabia in preparing airports, building ammunition supply points, constructing roads, and improving the living conditions of other deployed troops.[19] They often worked in small teams and experienced many unique environmental and geographical exposures.

Active-duty Seabees who remained in the U.S. Navy after the war and were serving at one of two large Seabee centers were selected as a study population. This population had several advantages. Seabees had served in the same tasks and at the same sites as did symptomatic Reserve Gulf War veteran Seabees. Active-duty Seabees had not been questioned regarding their exposures during the Gulf War. In contrast, Reserve Seabees had been the subject of a number of news stories and several previous symptoms surveys, which could have influenced their reporting. Active-duty Seabees' frequent routine foreign deployments provided data on epidemiologically important exposures among both Gulf War veterans and nondeployed veterans. In contrast to many large operational groups, most active-duty Seabees could be surveyed between their deployments by visiting just two U.S. sites (where all major Seabee commands are based), reducing logistical requirements for the study.

Eligibility was determined by comparing Seabee command rosters with service entry data obtained from the Defense Manpower Data Center (Seaside, CA). Members of 14 regular active-duty U.S. Navy Seabee commands at Port Hueneme, California and Gulfport, Mississippi who had served from September 1990 until the time of the survey in 1994 were eligible for this study.

Data collection. This study was approved by the Committee for the Protection of Human Subjects at the Naval Health Research Center (San Diego, CA) and endorsed by the Institute of Medicine (Washington, DC).[16] In late 1994 and early 1995, epidemiologic teams made three visits to each of the two Seabee Centers. Eligible Seabees were assembled in large classrooms where research staff explained the study's purpose and invited Seabees to participate. Written informed consent was obtained from each participant. The study consisted of an eight-page questionnaire, height and weight measurements, handgrip strength tests, the donation of clinical specimens (sera, whole blood, and clean-catch urine), and a pulmonary function test in a 20% systematic sample of subjects. The questionnaire was introduced by research staff and self-completed by the study subjects. Clinical specimens were preserved at −70°C. Study personnel were not informed of Gulf War status when conducting physiologic tests or serologic assays.

The questionnaire collected information regarding prewar medical history, war exposures, symptoms occurring for one

or more months since July 1990, geographic service areas during the Gulf War, postwar hospitalizations, and postwar pregnancy outcomes. Exposure and symptom questions were based upon the deployment activities of Gulf War veterans and lists of potential exposure risk factors and symptoms.[13,14,20] Questions were also included to screen for chronic fatigue syndrome[21] and post-traumatic stress disorder.[22] Additionally, questions from the Hopkins Symptom Checklist were included to provide scoring for five psychological symptom dimensions: somatization, obsessive-compulsive, interpersonal sensitivity, depression, and anxiety.[23] This standardized, 58-item, self-report symptom inventory has been used in numerous populations to screen for symptoms and behaviors consistent with anxiety and depression neuroses.[23]

Pulmonary function test. Spirometry testing was performed using a spirometer with a Fleisch-type pneumotach flow measuring device (Koko, Louisville, CO). Testing was conducted by a registered pulmonary function technologist according to the American Thoracic Society criterion: a minimum of three efforts with the best two efforts being within 5% of each other for combined forced expiratory volume in one second and forced vital capacity. The best measurements from these two efforts were corrected to body temperature and pressure saturated with water vapor.[24] Results were further adjusted for age, height, race, and smoking status.

Handgrip strength test. Height and weight measurements were made using a medical scale. Handgrip strength was measured for each individual using a hand-held dynamometer (Jamar, Lafayette, IN). The subject was instructed to use the dominant hand with the elbow bent at a 90° angle.[25] Three consecutive maximum efforts were averaged. Results were adjusted for age, height, gender, and race.

Nonspecific reactant serum assays. If a significant number of study Gulf War veterans were chronically ill, one might expect nonspecific reactant assays to reflect abnormalities. Four such tests were selected to evaluate study subject sera: C-reactive protein, transferrin, ferritin, and haptoglobin. These assays are sensitive markers for numerous chronic and infectious diseases.[26]

The C-reactive protein, transferrin, and haptoglobin assays were performed on a Beckman Array (Beckman Coulter, Inc., Fullerton, CA) using a rate nephelometric method.[27] The ferritin assay was performed using a micro-particle enzyme immunoassay method.[28] Commercially available quality control sera with known concentrations of each analyte were included with each set of determinations.

Due to an extremely skewed data distribution, serum C-reactive protein data were translated to two categories (normal range and elevated) and examined using chi-square tests. Serum ferritin, transferrin, and haptoglobin data were adjusted for gender and age and examined with linear regression techniques.

Survey reliability/validity. Reliability of the study instrument was tested by administering the survey a second time to a random-number generated sample of 131 study subjects 5–9 months subsequent to the initial survey. The medical and service records of 119 subjects were reviewed using random-number selection to validate their responses to the initial questionnaire.

Deployment data. Gulf War service was determined by response to a question regarding military service in the Persian Gulf during Operations Desert Storm or Desert Shield.

Data analyses and statistics. Demographic and symptom data were univariately compared using *t*-tests, Wilcoxon rank sum test, or chi-square tests. Age was determined as of July 31, 1991. Marital status was determined by survey response. Odds ratios (ORs) and 95% confidence intervals (CIs) were determined using Cornfield or exact methods.[29] Physiologic measurements were adjusted using multivariate linear regression methods. Kappa agreement statistics were calculated for select questions among individuals who completed the survey twice, and among individuals whose medical and service records were reviewed by the investigators.

RESULTS

Demographic characteristics of participants. After informed consent was obtained, 1,497 study subjects were enrolled (527 Gulf War veterans and 970 nondeployed veterans). Unit participation ranged from 26.1% to 71.0% of eligible Seabees. Upon enrollment, approximately 20% of identified Seabees were unavailable to provide informed consent due to leave, recent transfer, recent retirement, and schedule conflicts. An estimated 53% of eligible Seabees chose to participate. There were no differences between participants and nonparticipants with respect to age group, race, marital status, and service entry intellectual aptitude scores. Anecdotal comments suggested that some nonparticpants claimed they were too busy to give the time, some loathed the phlebotomy, and some exhibited distrust of the investigators.

Surveyed Gulf War veterans were attached to 14 unique Navy commands during the Gulf War, most commonly Navy Mobile Construction Battalions 1, 3, 4, 40, and 74. They chiefly served in Bahrain, near Al Jubail or Ras Al Mishab, Saudi Arabia. Less than 25 Seabees were stationed on board Navy warships during any one month of the Gulf War period.

The demographic characteristics of Gulf War veterans and nondeployed veterans (Table 1) were similar, with the exceptions that nondeployed veterans were older, had more education, and were more often female.

Self-reported symptoms since July 1990. Prolonged ($\geq$ 1 month) symptoms after the war were reported by 55.8% of Gulf War veterans and 31.7% of nondeployed veterans. In addition, Gulf War veterans reported a significantly higher prevalence for 35 of 41 symptoms. We empirically selected the 22 symptoms with a prevalence of at least 5% among Gulf War veterans for presentation and analysis (Table 2).

Self-reported Gulf War exposures. Gulf War veterans were more likely than nondeployed veterans to report exposure to 26 of 30 listed exposures (Table 3). To reduce the number of exploratory comparisons, we considered the 11 exposures with a prevalence of at least 5% among Gulf War veterans and an OR $\geq$ 3.0 (Gulf War veteran: nondeployed veteran) for further study.

Pulmonary function, handgrip strength, and nonspecific reactant serum tests. After adjusting for age, height, race, and smoking there was no statistically significant difference between Gulf War veterans and nondeployed veterans with respect to pulmonary airway function (Table 4). Additionally, pulmonary function did not differ between

TABLE 1

Selected characteristics of regular active-duty U.S. Navy Seabees in the Seabee symptom study, by Gulf War deployment status

Variable	Gulf War veterans (n = 527)	Nondeployed veterans (n = 970)	*P*
Mean age (years)	28.4	29.5	<0.001*
Mean height (cm)	175.4	175.6	0.85*
Mean weight (kg)	85.2	85.0	0.79*
Race (%)			
White	74.8	77.6	
Black	9.8	9.9	
Other	15.4	12.5	0.30†
Currently married (%)	72.7	76.8	0.14†
Gender (%)			
Male	98.9	95.5	
Female	1.1	4.5	0.001†
Education (%)			
High school	62.2	51.1	
> High school	37.8	48.9	0.001†
Hospitalized since July 1990 (%)			
None	74.0	75.9	
One or more	26.0	24.1	0.433†
Pregnancies since July 1990 (%)			
≥ 1 live birth	85.9	87.6	
Other outcome‡	14.1	12.4	0.310†

* By Wilcoxon rank sum test.
† By chi-square test.
‡ Includes stillbirths, miscarriage/spontaneous abortions, ectopic pregnancies, and elective induced abortion.

TABLE 2

Self-reported symptoms for one or more months since July 1990 by Gulf War status*

Symptom	Percent of Gulf War veterans (n = 527)	Percent of non-deployed veterans (n = 970)	Odds ratio	95% confidence interval
Unusual fatigue	20.1	5.4	4.4	3.1–6.4
Forgetfulness	19.0	3.5	6.5	4.2–9.9
Trouble sleeping	14.6	4.9	3.4	2.3–5.0
Sleepy all the time	14.6	3.1	5.4	3.4–8.5
Rash	14.4	3.8	4.3	2.8–6.5
Roving joint pain	14.2	4.6	3.4	2.3–5.1
Severe headache	13.3	3.3	4.5	2.9–7.1
Unusual anger	10.1	3.0	3.6	2.2–6.0
Diarrhea	9.7	2.9	3.6	2.2–6.0
Unusual irritability	9.5	2.6	4.0	2.4–6.7
Cough	9.1	5.2	1.8	1.2–2.8
Loss of interest	8.9	4.0	2.3	1.5–3.7
Sore throat	7.8	3.9	2.1	1.3–3.3
Shortness of breath	7.4	2.0	4.0	2.2–7.3
Unusual muscle pains	7.0	2.0	3.8	2.1–6.9
Night sweats	7.0	1.7	4.5	2.4–8.5
Depression	6.8	2.8	2.6	1.5–4.4
Chest pains	6.3	2.2	3.0	1.7–5.5
Chronic anxiety	6.1	1.9	3.4	1.8–6.4
Confusion	5.5	1.1	5.1	2.4–10.9
Joint swelling	5.3	2.1	2.7	1.4–5.0
Generalized muscle weakness	5.3	1.3	4.1	2.0–8.5

* U.S. Navy Seabees were studied during the period September 1994 through June 1995. Only symptoms that were reported by at least 5% of Gulf War veterans are shown.

Gulf War veterans who complained of postwar shortness of breath and other Gulf War veterans ($P > 0.08$).

Gulf War veterans had a lower adjusted mean handgrip strength measurement than did nondeployed veterans (Table 4). In addition, the 28 Gulf War veterans who reported muscle weakness also had a lower adjusted mean handgrip strength value than did the other 492 Gulf War veteran subjects ($P < 0.03$).

Gulf War veterans and nondeployed veterans had similar reactant assay results for C-reactive protein, transferrin, and haptoglobin (Table 4). The results for the fourth assay, serum ferritin, were statistically different, with Gulf War veterans having a higher adjusted mean result. However, adjusted mean ferritin values for both groups were within normal limits, and there was no statistical difference between Gulf War veterans and nondeployed veterans with respect to the number of survey respondents who had assay levels in excess of the normal range (OR = 1.5, 95% CI = 0.97–2.3).

Psychological morbidity screening and dimension scoring. On the questionnaire, no respondent met the symptom criteria for chronic fatigue syndrome as described by Fukuda and others.[21] Gulf War veterans were more likely than nondeployed veterans to report symptoms consistent with post-traumatic stress disorder (15.2% versus 9.0%, respectively, OR = 1.8, 95% CI = 1.3–2.5). Gulf War veterans scored higher in each of the five symptom dimension scales of the Hopkins Symptom Checklist profiles: somatization, obsessive-compulsive disorder, interpersonal sensitivity, depression, and anxiety (Table 5).

Symptoms and psychological outcomes versus war exposures. Among Gulf War veterans, nearly all symptom and post-traumatic stress disorder responses were statistically associated with nearly all of the 11 most common Gulf War exposures (Table 6). Comparisons of temporal (by month) and geographical (by location) Gulf War exposures with screening for post-traumatic stress disorder and with self-reporting collections of symptoms failed to implicate specific exposures. Exploratory multivariate modeling also failed to reduce the important associations. When specific exposures were isolated or stratified upon, Gulf War veterans were consistently at greater risk of screening for post-traumatic stress disorder compared with nondeployed veterans (Table 7). No single exposure or group of exposures were implicated as likely etiologic.

Physiologic outcomes versus war exposures. To determine if the abnormal handgrip and serum ferritin test results might be associated with specific Gulf War exposures, we compared these outcomes with 11 of the most common Gulf War exposures (Table 8). For 10 of the 11 war exposures, exposed personnel had nonsignificantly better handgrip strength values than nonexposed personnel. The exception, self-reported receipt of botulism vaccine, was not statistically associated with handgrip strength. Elevated serum ferritin levels were also not significantly associated with any of the 11 exposures.

Reliability and validity. Reliability and validity were assessed separately for the different types of questions in the survey. Questions regarding demographics, health habits, and deployment exposures ranged from fair to excellent agreement (Table 9). However, the reliability and validity of self-reported symptom and health history data were poor.

DISCUSSION

Our survey findings are consistent with those of other investigators. We found that veterans self-reported a high prevalence of diverse postwar symptoms[10,16,18,20,30–35] and have ev-

TABLE 3
Self-reported exposures since July 1990, by Gulf War status*

Exposure	Gulf War veterans (n = 527) percent	Nondeployed veterans (n = 970) percent	Odds ratio	95% confidence interval
Flies/mosquitoes/other insects	75.1	62.9	2.4	1.7–3.5
Diesel fuel	65.3	50.6	2.3	1.7–2.9
Sandstorms	53.7	10.4	13.5	10.1–18.1
Typhoid vaccine (injection)	49.9	40.5	2.0	1.5–2.6
Dirty, unsanitary conditions	44.0	28.5	2.3	1.8–2.9
Malaria pills	42.9	28.0	2.7	2.1–3.5
Immune globulin (injection)	40.8	18.9	4.5	3.4–6.0
Insecticide spray	34.9	29.5	1.6	1.3–2.1
Smoke from oil well fires	33.4	0.6	117	49.2–295.1
Pyridostigmine bromide	32.5	0.1	682	103.3–13,207.0
Anthrax vaccine	30.2	1.4	40.7	22.5–74.9
Airplane fuel burning in tent heaters	20.7	7.4	3.8	2.7–5.3
Emissions from petroleum plants	17.3	3.0	9.3	5.9–14.9
Ciprofloxacin	15.4	0.4	67.6	23.6–219.1
Artillery smoke	14.6	7.8	2.5	1.7–3.5
Plague vaccine	14.4	9.7	2.1	1.5–3.0
Petroleum solutions sprayed over large areas	14.4	4.6	4.5	3.0–6.8
Close contact with dead animals	13.7	9.0	1.7	1.2–2.4
Ammonia fumes	10.8	10.6	1.3	0.9–1.9
Botulism vaccine	8.5	0.9	14.4	6.7–32.1
Direct contact with prisoners of war	7.4	0.7	11.4	4.9–28.1
Emissions from steel plants	4.2	1.8	3.1	1.5–6.1
Fumes from the destruction of munitions	4.2	1.9	2.9	1.5–5.7
Burning insecticide	3.4	0.7	6.3	2.4–16.7
Chemical warfare	3.2	2.1	3.1	1.5–6.3
Raw (unprocessed) milk	2.3	1.4	1.8	0.8–4.2
Meningococcus vaccine	1.7	0.6	4.2	1.4–13.4
Depleted uranium munitions	1.7	0.8	2.5	0.9–7.2
Wore a flea collar for more than one day	1.5	0.4	3.8	1.0–15.0
Biological warfare	1.3	0.2	12.4	2.4–86.8

* U.S. Navy Seabees were studied during the period September 1994 through June 1995.

idence of more postwar psychological morbidity than their peers.[4,33,35–37] Increased symptom reporting and psychological morbidity are difficult to study retrospectively in that both are recognized sequelae of war[36,38,39] and both are often comorbid conditions.[40–42] It is difficult to determine if any individual exposures in the Gulf War might have increased their incidence. Consistent with other investigations,[10,32,34,35] most of the self-reported symptoms were associated with most of the self-reported war exposures (Table 6). If a single exposure or group of exposures was responsible for increased postwar symptoms, such exposures might stand out from other exposures. Yet, both by univariate and multivariate methods, we could not isolate or implicate specific war exposures.

TABLE 4
Pulmonary function, handgrip strength, and nonspecific reactant serum test results by Gulf War status

Test	Normal range for males	Adjusted mean: Gulf War veterans (n = 527)	Adjusted mean: Non-deployed veterans (n = 970)	P*
Forced vital capacity (L)†	4–6.5‡	4.96	4.99	0.77
Forced expiratory volume in ls (L)†	3.4–5.3‡	4.05	4.04	0.81
Handgrip strength (kg)§	34–73[2]	47.8	48.8	0.02
C-reactive protein (mg/dl)¶	0–0.79	0.22	1.4	0.84#
Transferrin (mg/dl)**	210–361	319.7	322.5	0.42
Ferritin (ng/ml)**	20–300	131.4	116.2	0.02
Haptoglobin (mg/dl)**	33–171	132.1	135.7	0.37

* *P* value calculated using a *t*-test.
† Only males were included. Results were adjusted for age, height, race, and smoking status.
‡ Normal values vary by age, height, and gender.[24]
§ Adjusted for age, height, gender, and race.
¶ Unadjusted mean.
# Due to skewed data the *P* value was calculated by comparing subjects with values in excess of the normal range (>0.79) by chi-square test.
** Adjusted for age and gender.

More interesting were the associations of physiologic test results and nonspecific reactants with war exposures (Table 8). We reasoned that perhaps these more objective outcomes would implicate specific exposures. Certainly, the 11 exposures we so evaluated have been the subject of considerable discussion.[14,16,30,43,44] A number of investigators have implicated sand as a possible cause of respiratory and immune disease.[45,46] Subgroups of Gulf War veterans received immune globulin, anthrax, and botulism vaccines, and it has been alleged these treatments may be associated with postwar illnesses.[14,16,47] Exposure to petroleum and petroleum emissions were common in the Gulf War and have been the subject of much discussion.[14,16,43,47] Pyridostigmine bromide and ciprofloxacin tablets were issued to Gulf War veterans as countermeasures for nerve agent attack and anthrax biological warfare attack.[14,16,43,47] Some veterans who ingested these tablets have suggested that they might be a cause of their postwar symptoms.[48,49] Contact with prisoners of war has also been identified as a possible risk factor for postwar morbidity.[50]

TABLE 5
Psychological dimension scores from the Hopkins Symptom Checklist according to Gulf War status

Hopkins Symptom Checklist psychological dimension	Mean score ± SD: Gulf War veterans (n = 527)	Mean score ± SD: Nondeployed veterans (n = 970)	Wilcoxon rank sum test	Mean score ± SD: Scores from patients with clinically diagnosed depressed neuroses[23]
Somatization	1.40 ± 0.41	1.24 ± 0.29	<0.0001	1.89 ± 0.53
Obsessive-compulsive	1.43 ± 0.52	1.22 ± 0.36	<0.0001	2.30 ± 0.68
Interpersonal sensitivity*	1.34 ± 0.46	1.19 ± 0.31	<0.0001	2.33 ± 0.67
Depression	1.24 ± 0.37	1.14 ± 0.24	<0.0001	2.62 ± 0.63
Anxiety	1.15 ± 0.28	1.06 ± 0.15	<0.0001	2.45 ± 0.68

* One of the questions for this dimension was inadvertently left out of the questionnaire: ''feeling that people are unfriendly or dislike you''.

Pulmonary function tests are a sensitive measure of pulmonary airway disease and both during and after the war, Gulf War veterans had respiratory illnesses.[44,51–54] Some scientists have postulated that unusual respiratory-borne pathogens[16,55] or sand exposure[45,46] might explain Gulf War veteran postwar morbidity. Although chronic respiratory complaints have been reported among Gulf War veterans,[32,37] with 7.4% of the participants in the present study reporting shortness of breath for 30 or more days, surveyed Gulf War veterans showed no evidence of impaired pulmonary airway function.

Similarly, many Gulf War veterans have complained of fatigue and muscle weakness since returning from the war.[31,43] Our handgrip strength test showed a small but statistically significant difference in performance between Gulf War veterans and nondeployed veterans (Table 4), as well as between symptomatic and asymptomatic Gulf War veterans. However, when specific war exposures were compared with handgrip strength among Gulf War veterans, no war exposure was uniquely implicated as etiologic (Table 8). Some of the exposures tested, such as pyridostigmine, have been implicated in other reports as a biologically plausible cause of muscle weakness.[56—59]

Gulf War veterans and nondeployed veterans had similar serum reactant assay results for C-reactive protein, transferrin, and haptoglobin, but they had elevated serum ferritin levels. None of the war exposures was statistically associated with elevation of ferritin levels and no leads for more additional exposure research were identified. Serum ferritin is an extremely sensitive indicator of iron storage status, with hyperferritinemia occurring in the setting of numerous disorders associated with iron overload (hemochromatosis,[60] sickle cell disease,[61] and thalassemia[62]). Additionally, hyperferritinemia serves as a nonspecific marker for a variety of neoplasms,[63–65] infectious diseases,[66–68] alcohol ingestion,[69] and a sedentary lifestyle.[70] While we examined self-reported data regarding a number of chronic diseases as well as recent alcohol ingestion experience, we were unable to explain dif-

TABLE 6
Relative odds of symptom outcomes by exposures among Gulf War veterans*

Symptom outcome	Sand-storms	Immune globulin	Smoke from oil well fires	Pyrido-stigmine	Anthrax vaccine	Airplane fuel burning in tent heaters	Emissions from petroleum plants	Cipro-floxacin	Petroleum solutions sprayed over large areas	Botulism vaccine	Direct contact with prisoners of war
Unusual fatigue	2.7	5.8	2.3	3.1	2.3	2.1	2.0	4.5	3.1	3.4	
Forgetfulness	2.1	3.1	2.9	3.7	2.5	2.1		3.0		4.6	2.8
Trouble sleeping		3.1		2.1	2.0			3.2		4.7	
Sleepy all the time	2.3	4.6	3.7	4.4	3.3	2.4		4.3	2.9	4.8	
Rash	2.7	2.1	2.1	2.9	2.2	1.9	2.3	3.0	2.2		
Roving joint pain			2.4	2.7		2.6		2.7		3.6	3.2
Severe headache		2.8		2.4		2.2		3.1		2.7	
Unusual anger		2.9				3.4				3.1	
Diarrhea											
Unusual irritability		8.1	2.7	3.9	2.6			2.6		4.4	
Cough		3.6	3.2	2.6		2.3			2.6	4.4	
Loss of interest			2.9	2.9	3.4	3.3	3.0	3.3	2.8	4.5	
Sore throat				2.6		2.9					3.5
Shortness of breath			2.6						3.0		
Unusual muscle pains	2.7		3.0	4.2	4.5			4.0		4.2	
Night sweats	2.5	5.0	4.0	4.1	4.4			4.4	4.8	4.3	
Depression			3.4							4.5	
Chest pains				2.7							
Chronic anxiety											
Confusion			5.7	5.0	3.1	4.3	4.1	6.8		4.9	5.0
Joint swelling		4.2	3.2	3.8	4.0	3.1			5.4	5.2	
Generalized muscle weakness											
Post-traumatic stress disorder	4.1		3.0	2.6	2.1		3.0		3.0	2.7	

* Symptoms and exposure data were self-reported by 527 Gulf War Veterans. Numbers reflect only odds ratios with 95% confidence intervals that exclude 1. Post-traumatic stress disorder was screened for by questionnaire using criteria reported in the *Diagnostic and Statistical Manual of Mental Disorders*, fourth edition.[22] This was a nonstandardized screening designed to detect differences in populations and should be interpreted with caution.

TABLE 7

Relative odds of screening for post-traumatic stress disorder (Gulf War veterans versus nondeployed veterans) by self-reported exposure

Exposure	Gulf War veterans (no. exposed)	Non-deployed veterans (no. exposed)	Post-traumatic stress disorder*	
			Odds ratio	95% CI
Sandstorms	283	101	2.16	1.04–4.57
Immune globulin (injection)	215	183	2.03	1.02–4.08
Smoke from oil well fires	176	6	1.42	0.15–69.0
Pyridostigmine bromide	171	1	NA	NA
Anthrax vaccine	159	14	1.57	0.32–15.1
Airplane fuel burning in tent heaters	109	72	1.25	0.52–3.01
Emissions from petroleum plants	91	29	0.84	0.31–2.31
Ciprofloxacin	81	4	NA	NA
Petroleum solutions sprayed over large areas	76	45	1.45	0.50–4.31
Botulism vaccine	45	9	1.42	0.23–15.7
Direct contact with prisoners of war	39	7	0.65	0.08–8.04

* Post-traumatic stress disorder was screened for by questionnaire using criteria reported in the *Diagnostic and Statistical Manual of Mental Disorder*, fourth edition.[22] This was a nonstandardized screening designed to detect differences in populations and should be interpreted with caution. CI = confidence interval, NA = not applicable.

ferences in serum ferritin assay results between Gulf War veterans and nondeployed veterans.

Gulf War veterans had higher scores than nondeployed veterans for all five dimensions of the Hopkins Symptom Checklist; nevertheless, with the exception of somatization, their scores were low compared with individuals clinically diagnosed with psychological disorders (Table 5).[23] Gulf War veterans' higher scores for somatization, the reporting of symptoms that have no pathophysiologic explanation, are consistent with a modern national trend of decreased tolerance for mild symptoms.[71]

The Hopkins Symptom Checklist has been used to screen populations for anxiety,[72] depression,[72] and post-traumatic stress disorder,[73] as well as to follow therapeutic interventions.[74] Using linear regression, we compared the Hopkins Symptom Checklist dimensions with individual exposures and found that each of the psychological symptom dimensions was associated with many of the war exposures. As with the univariate studies of symptoms and exposures, we were again unable to isolate unique specific war exposures for more comprehensive study.

Recently, investigators from the University of Texas Southwestern Medical Center (Dallas, TX) found frequent symptom reporting among 249 Seabee reservists from Naval Mobile Construction Battalion 24 who were veterans of the Persian Gulf War.[75] Through factor analyses, they derived a number of symptom factors and have postulated several clinical syndromes,[18] which they hypothesize may be associated with specific exposures during the Gulf War.[75,76] It is interesting that among our study subjects, many of whom slept and worked in the same areas as did the Battalion 24 Seabees, the reported war exposures were quite different. Haley and Kurt[76] identified the wearing of pet flea collars and the alleged exposure of a chemical weapons attack as important risk factors for two of their syndromes. Few of our survey respondents reported these exposures. While Haley and Kurt implicated pyridostigmine bromide as an important risk factor for muscle weakness,[76] our handgrip strength testing did not validate this finding.

One might reason that our study, like other studies of Persian Gulf War veterans,[10,32,33] failed to identify unique war exposures causing postwar morbidity because the wrong questions were asked or the wrong populations were queried. Perhaps the sickest Gulf War veteran Seabees had

TABLE 9

Agreement statistics reflecting survey reliability and health record validation

Questionnaire data	Reliability*	Validity†
Demographic (5 responses)	0.89–1.00	0.41–0.76
Diagnoses (23 responses)	−0.01–1.00	−0.02–0.48
Symptoms (41 responses)	−0.01–0.86	NA
Exposures (30 responses)	0.60–0.70	NA
Other (15 responses)	0.51–0.67	0.59–0.66

* Reliability kappa statistics were calculated based upon conducting a repeat survey of 131 study subjects 5 to 9 months after original survey completion.
† Validation kappa statistics were calculated by reviewing the personnel and medical records of 119 study subjects. NA = not applicable.

TABLE 8

Handgrip strength and serum ferritin tests versus Gulf War exposures among Gulf War veterans

Exposure	Handgrip strength (kg)			Serum ferritin (ng/ml)		
	Adjusted mean exposed*	Adjusted mean nonexposed*	*P*†	Adjusted mean exposed‡	Adjusted mean nonexposed‡	*P*†
Sandstorms	46.1	45.1	0.90	100.0	109.1	0.79
Immune globulin (injection)	42.5	40.0	0.99	105.4	127.7	0.96
Smoke from oil well fires	49.9	48.0	0.99	93.6	113.3	0.96
Pyridostigmine	47.1	46.4	0.82	91.9	103.1	0.83
Anthrax vaccine	49.0	48.4	0.76	101.4	116.4	0.89
Airplane fuel burning in tent heaters	47.5	46.8	0.75	111.2	112.4	0.54
Emissions from petroleum plants	43.4	43.0	0.65	103.7	105.3	0.54
Ciprofloxacin	41.9	41.0	0.81	90.7	109.0	0.88
Petroleum solutions sprayed over large areas	50.2	48.9	0.90	97.6	113.4	0.86
Botulism vaccine	39.9	41.0	0.21	62.8	83.0	0.84
Direct contact with prisoners of war	47.7	45.7	0.94	102.0	106.7	0.60

* Adjusted for age, height, gender, and race.
† One sided *P* value.
‡ Adjusted for age and gender.

already departed from the military. However, we did include a comprehensive list of questions that addressed nearly every hypothesis regarding Gulf War exposures and these 527 Gulf War veteran Seabees did self-report an elevated prevalence of symptoms compared with 970 nondeployed veteran Seabees. Additionally, other study data have demonstrated that Gulf War veterans were not separating from military service for medical reasons at higher rates than nondeployed veterans.[4] While we are continuing to examine these data and more symptom studies are in progress, with more likely to be conducted in the future,[16,30] the body of published symptom literature and the poor reliability of symptom reporting suggest that such future studies will also fail to implicate unique exposures.[12] It is doubtful that we will implicate or rule out specific war exposures as a cause of postwar morbidity without more objective exposure and clinical data.

More likely than a specific exposure as a cause of postwar morbidity are the aggregate exposures of wartime deployment. Certainly, the many stressors of war military service have historically been associated with increased symptom reporting and psychological morbidity, both mild and incapacitating.[30,33,36,39,77–79] Our self-reported symptom and posttraumatic stress disorder outcomes were associated with many of the war exposures, thus supporting this hypothesis (Table 6). Additionally, when we stratified upon reporting individual exposures, Gulf War veterans remained at increased odds of reporting symptoms consistent with posttraumatic stress disorder for many of the exposures, suggesting that none of the exposures was individually implicated (Table 7).

Our survey has a number of strengths. It was conducted among regular, active-duty personnel who have made numerous foreign deployments and experienced military-related exposures both inside and outside the Persian Gulf area for at least four years. Our study had an internal comparison cohort from which to contrast Gulf War veteran symptoms and morbidity. Many reports of Gulf War related morbidity have been anecdotal and without such an appropriate comparison group.[80–82] Our study populations, who worked full time as military personnel, are less likely to have confounding occupational exposures than reserve populations,[18] who perform their military duties only several days each month.

Our survey also has a number of limitations. With so many comparisons, it is likely that some of the statistically significant findings may have occurred by chance. Our findings should be viewed in light of the many perceptual and response biases likely to be operant in this setting.[83,84] Recall bias is particularly evident in the symptom reliability data from this study (Table 9).

The present survey results confirm that many Gulf War veterans report a high prevalence of postwar symptoms and have evidence for psychological morbidity. Although two of six physiologic or laboratory tests differed between study groups, we were unsuccessful in identifying a specific war exposure that might explain these test differences. It seems likely that no one war exposure is etiologic for postwar symptom reporting. Instead, our findings are consistent with the thesis that the aggregate stressors of war are a more likely explanation.

Acknowledgments: We thank the following individuals for most helpful assistance and recommendations in conducting this research: Dr. Gary D. Gackstetter (Department of Defense, Health Affairs, Washington, DC); Dr. Stephen Nice, Dr. Frank C. Garland, and Christopher G. Blood (Naval Health Research Center, San Diego, CA); Dr. S. William Berg (Hampton Health Department, Hampton, VA); Dr. F. Stephen Wignall (Freeport Malaria Control, Irian Jaya, Indonesia); Diane T. Holland (University of California, San Diego, CA); James A. Clenney and Cassandra A. Spears (Naval Branch Medical Clinic, Gulfport, MS); Peter D. Saunders, Gregory A. Newton, Tony R. Barnes, and David J. Stein (20th Naval Construction Regiment, Gulfport, MS); Rene Villarreal, Aristeo S. Punzal, and Zerrick A. Patriana (Naval Branch Medical Clinic, Port Hueneme, CA); William L. Rudich and Sandra L. Rae (31st Naval Construction Regiment, Port Hueneme, CA); Dr. Han K. Kang (Environmental Epidemiology Service, Department of Veterans Affairs, Washington, DC); Michael A. Dove (Management Information Division, Department of Defense Manpower Data Center, Seaside, CA); Dr. Robert F. DeFraites and Dr. David N. Cowan (Walter Reed Army Institute of Research, Washington, DC); and Dr. Terry L. Thomas (Uniformed Services University of the Health Sciences, Bethesda, MD).

Financial support: This represents report no. 97-19, supported by the Naval Medical Research and Development Command, Bethesda, Maryland, Department of the Navy, under work unit no. NMRDC.WR.00097 (6423).

Disclaimer: The views expressed in this article are those of the authors and do not reflect the official policy or position of the Department of the Navy, Department of Defense, or the U.S. Government.

Authors' addresses: Gregory C. Gray, Kevin S. Kaiser, and Anthony W. Hawksworth, Emerging Illness Division, Naval Health Research Center, PO Box 85122, San Diego, CA 92186-5122. Frank W. Hall, Department of Pathology, Naval Medical Center, 34800 Bob Wilson Drive, San Diego, CA 92134. Elizabeth Barrett-Connor, Department of Family and Preventive Medicine 0607, University of California, San Diego, 9500 Gilman Drive, San Diego, CA 92093-0607.

Reprint requests: Gregory C. Gray, Emerging Illness Division, Naval Health Research Center, PO Box 85122, San Diego, CA 92186-5122.

REFERENCES

1. Helmkamp J, 1994. United States military casualty comparisons during the Persian Gulf War. *J Occup Med 36:* 609–615.
2. Writer J, DeFraites R, Brundage J, 1996. Comparative mortality among US military personnel in the Persian Gulf region and worldwide during Operations Desert Shield and Desert Storm. *JAMA 275:* 118–121.
3. Kang H, Bullman T, 1996. Mortality among US veterans of the Persian Gulf War. *N Engl J Med 355:* 1498–1504.
4. Gray GC, Coate BC, Anderson CM, Kang HK, Berg SW, Wignall FS, Knoke JD, Barrett-Connor E, 1996. The postwar hospitalization experience of US veterans of the Persian Gulf War. *N Engl J Med 335:* 1505–1513.
5. Knoke JD, Gray GC, 1998. Hospitalizations for unexplained illnesses among US Persian Gulf War veterans. *Emerg Infect Dis 4:* 211–219.
6. Penman A, Tarver R, Currier M, 1996. No evidence of increase in birth defects and health problems among children born to Persian Gulf War veterans in Mississippi. *Mil Med 161:* 1–6.
7. Cowan DN, DeFraites RF, Gray GC, Goldenbaum MB, Wishik SM, 1997. The risk of birth defects among children of Persian Gulf War veterans. *N Engl J Med 336:* 1650–1656.
8. Kang H, Dalager N, Lee K, 1995. *Health Surveillance of Persian Gulf War Veterans: a Review of the Department of Veterans Affairs Persian Gulf Registry and in-Patient Treatment Files.* Washington, DC: Environmental Epidemiology Service Department of Veterans Affairs.
9. Joseph S, The Comprehensive Clinical Evaluation Program Evaluation Team, 1997. A comprehensive clinical evaluation of 20,000 Persian Gulf War veterans. *Mil Med 162:* 149–155.

10. Kroenke K, Koslowe P, Roy M, 1998. Symptoms in 18,495 Persian Gulf War veterans. *J Occup Environ Med 40:* 520–528.
11. Wegman DH, Woods NF, Bailar JC, 1997. Invited commentary: how would we know a Gulf War syndrome if we saw one? *Am J Epidemiol 146:* 704–711.
12. Hyams K, Roswell R, 1998. Resolving the Gulf War syndrome question. *Am J Epidemiol 148:* 339–341.
13. Defense Science Board, 1994. *Final Report: Defense Science Board Task Force on Persian Gulf War Health Effects*. Washington, DC: Office of the Under Secretary of Defense for Acquisition and Technology.
14. National Institute of Health, 1994. National Institutes of Health Technology Assessment Workshop Panel: the Persian Gulf experience and health. *JAMA 272:* 391–396.
15. Institute of Medicine, 1995. *Health Consequences of Service During the Persian Gulf War: Initial Findings and Recommendations for Immediate Action.* Washington, DC: National Academy Press.
16. Institute of Medicine, 1996. *Health Consequences of Service During the Persian Gulf War: Recommendations for Research and Information Systems.* Washington, DC: National Academy Press.
17. Shenon P, 1996. Many Gulf War veterans tell of Iraqi chemical attack. *The New York Times (September 20):* A1, A12.
18. Haley R, Kurt T, Hom J, 1997. Is there a Gulf War syndrome? Searching for syndromes by factor analysis of symptoms. *JAMA 277:* 215–222.
19. Fedele K, 1991. The Seabees go to war. *Naval Civil Engineer* (*Summer)*: 3–13.
20. DeFraites RF, Wanat E, Norwood A, Williams S, Cowan D, Callahan T, 1992. *Investigation of a Suspected Outbreak of an Unknown Disease Among Veterans of Operation Desert Shield/Storm, 123rd Army Reserve Command, Fort Benjamin Harrison, Indiana, April 1992.* Washington, DC: Epidemiology Consultant Service, Division of Preventive Medicine, alter Reed Army Institute of Research.
21. Fukuda K, Strauss S, Hickie I, Sharpe M, Dobbins J, Komaroff A, 1994. The chronic fatigue syndrome: a comprehensive approach to its definition and study. *Ann Intern Med 121:* 953–959.
22. American Psychiatric Association, 1994. *Diagnostic and Statistical Manual of Mental Disorders.* Fourth edition. Washington, DC: American Psychiatric Association.
23. Derogatis L, Lipman R, Rickels K, Uhlenhuth E, Covi L, 1974. The Hopkins Symptom Checklist (HSCL): A measure of primary symptom dimensions. Pichot P, ed. *Psychological Measurements in Psychopharmacology: Modern Problems in Pharmacopsychiatry.* Basel, Switzerland: Karger, 79–110.
24. American Thoracic Society, 1987. Standardization of spirometry—1987 Update: Statement of the American Thoracic Society. *Am Rev Respir Dis 136:* 1285–1298.
25. Gill D, Reddon J, Renney C, Stefanyk W, 1985. Hand dynamometer: effects of trials and session. *Perceptual Motor Skills 61:* 191–195.
26. Keren D, 1994. *High Resolution Electrophoresis Immunofixation.* Second edition. Boston: Butterworth & Heinemann.
27. Sternberg J, 1977. A rate nephelometer for measuring specific proteins by immunoprecipitin reactions. *Clin Chem 23:* 1456–1464.
28. Forman D, 1980. The measurement and interpretation of serum ferritin. *Ann Clin Lab Sci 10:* 345–350.
29. Dean A, 1994. *Epi Info, Version 6: A Word Processing, Database, and Statistical Program for Epidemiology on Microcomputers.* Atlanta: Centers for Disease Control and Prevention.
30. Presidential Advisory Committee on Gulf War Veterans' Illnesses, 1996. *Final Report, December 1996.* Washington, DC: U.S. Government Printing Office.
31. U.S. Department of Health and Human Services, 1995. Unexplained illness among Persian Gulf veterans in an Air National Guard Unit: preliminary report - August 1990–March 1995. *MMWR Morb Mortal Wkly Rep 44:* 443–447.
32. The Iowa Persian Gulf Study Group, 1997. Self-reported illness and health status among Persian Gulf War veterans: a population-based study. *JAMA 277:* 238–245.
33. Malone J, Paige-Dobson B, Ohl C, DiGiovanni C, Cunnion S, Roy M, 1996. Possibilities for unexplained chronic illness among reserve units deployed in Operation Desert Shield/Desert Storm. *South Med J 89:* 1147–1155.
34. Goss Gilroy Inc., 1998. *Health Study of Canadian Forces Personnel Involved in the 1991 Conflict in the Persian Gulf.* Volume I. Ottawa, Ontario: Gos Gilroy, Inc.
35. Unwin C, Blatchley N, Coker W, Ferry S, Hotopf M, Hull L, Ismail K, Palmer I, David A, Wessely S, 1999. The health of United Kingdom servicemen who served in the Persian Gulf War. *JAMA 353:* 169–178.
36. Hyams K, Wignall F, Roswell R, 1996. War syndromes and their evaluation: from the US Civil War to the Persian Gulf War. *Ann Intern Med 125:* 398–405.
37. Stretch R, Wright K, Bliese P, Knudson K, Marlowe D, Hoover C, 1996. Psychological health of Gulf War-era military personnel. *Mil Med 161:* 257–261.
38. Sutker P, Uddo M, Brailey K, Allain A, 1993. War-zone trauma and stress-related symptoms in Operation Desert Shield/Storm returnees. *J Social Issues 49:* 33–49.
39. Ursano R, Norwood A, eds, 1996. *Emotional Aftermath of the Persian Gulf War-Veterans, Families, Communities, and Nations.* Washington, DC: American Psychiatric Press, Inc.
40. Pennebaker J, 1982. *The Psychology of Physical Symptoms.* New York: Springer-Verlag, Inc.
41. Kroenke K, Price R, 1993. Symptoms in the community. Prevalence, classification, and psychiatric comorbidity. *Arch Intern Med 151:* 2474–2480.
42. Pawlikowska T, Chalder T, Hirsch S, Wallace P, Wright D, Wessely S, 1994. Population based study of fatigue and psychological distress. *Br Med J 308:* 763–766.
43. Persian Gulf Veterans Coordinating Board, 1995. Unexplained illnesses among Desert Storm veterans: a search for causes, treatment, and cooperation. Report of the Persian Gulf Veterans Coordinating Board. *Arch Intern Med 155:* 262–268.
44. Hyams K, Hanson K, Wignall F, Escamilla J, Oldfield E, 1995. The impact of infectious diseases on the health of US troops deployed to the Persian Gulf during Operations Desert Shield and Desert Storm. *Clin Infect Dis 20:* 1497–1504.
45. Korenyi-Both A, Korenyi-Both A, Juncer D, 1997. Al Eskan disease: Persian Gulf syndrome. *Mil Med 162:* 1–13.
46. Korenyi-Both A, Molnar A, Korenyi-Both A, Fidelus-Gort R, 1992. Al Eskan disease: Desert Storm pneumonitis. *Mil Med 157:* 452–462.
47. Presidential Advisory Committee on Gulf War Veterans' Illnesses, 1996. *Interim Report, February 1996.* Washington, DC: U.S. Government Printing Office.
48. Quindlen A, 1994. Casualties of war. *The New York Times (October 5):* 23.
49. Nelson S, Muradian V, Fuentes G, 1994. Why are we sick? *Army Times (April 25):* 12–23.
50. Milmer I, Axelrod B, Pasquantonio J, Sillanpaa M, 1994. Is there a Gulf War syndrome? (letter). *JAMA 271:* 661.
51. Sinclair D, Hepburn N, Bowen J, Winfield C, 1991. Community-acquired pneumonia in the Gulf. *J R Army Med Corps 137:* 126–127.
52. Richards A, Hyams K, Watts D, Rozmajzl P, Woody J, Merrell B, 1993. Respiratory disease among military personnel in Saudi Arabia during Operation Desert Shield. *Am J Public Health 83:* 1326–1329.
53. Paparello S, Bourgeois A, Garst P, Hyams K, 1993. Diarrheal and respiratory disease aboard the hospital ship, USNS Mercy T-AH 19, during Operation Desert Shield. *Mil Med 158:* 392–395.
54. Hines J, 1993. A comparison of clinical diagnoses among male and female soldiers deployed during the Persian Gulf War. *Mil Med 158:* 99–101.
55. Nicolson G, Rosenberg-Nicolson N, 1995. Doxycycline treatment and Desert Storm (letter). *JAMA 273:* 618–619.
56. Abou-Donia M, Wilmarth K, Jensen K, Oehme F, Kurt T, 1996. Neurotoxicity resulting from coexposure to pyridostigmine

bromide, DEET, and permethrin: implications of Gulf War chemical exposures. *J Toxicol Environ Health 48:* 35–56.
57. Friedman A, Kaufer D, Shemer J, Hendler I, Soreq H, Tur-Kaspa I, 1996. Pyridostigmine brain penetration under stress enhances neuronal excitability and induces early immediate transcriptional response. *Nature Med 2:* 1382–1385.
58. Sharabi Y, Danon Y, Berkenstadt H, Almog S, Mimouni-Bloch A, Zisman A, Dani S, Atsmon J, 1991. Survey of symptoms following intake of pyridostigmine during the Persian Gulf War. *Isr J Med Sci 27:* 656–658.
59. Hubert M, Lison D, 1995. Study of muscular effects of short-term pyridostigmine treatment in resting and exercising rats. *Hum Exp Toxicol 14:* 49–54.
60. Addison G, Beamish MR, Hales CN, Hodgkins M, Jacobs A, Llewellin P, 1972. An immunoradiometric assay for ferritin in the serum of normal subjects and patients with iron deficiency and iron overload. *J Clin Pathol 25:* 326–329.
61. Lee M, Means RJ, 1995. Extremely elevated serum ferritin levels in a university hospital: associated diseases and clinical significance. *Am J Med 98:* 566–571.
62. Cohen A, Martin M, Schwartz E, 1981. Response to long-term deferoxamine therapy in thalassemia. *J Pediatr 99:* 689–994.
63. Ho S, Leung S, Leung W, Tsao S, Kwan W, Choi P, Johnson P, 1966. Strong association between hyperferritinaemia and metastatic disease in nasopharyngeal carcinoma. *Eur J Cancer B Oral Oncol 32B:* 242–245.
64. Dormer M, Abel U, Fritze D, Manke H, Drings P, 1983. Serum ferritin in relation to the course of Hodgkin's disease. *Cancer 529:* 2308–2312.
65. Aubert E, Schmidt C, 1985. Ferritin—a tumor marker in myeloid leukemia. *Cancer Detect Prev 8:* 297–302.
66. Takikawa T, Hayashi H, Nishimura N, Yano M, Isomura T, Sakamoto N, 1994. Correlation between serum levels of alanine aminotransferase and ferritin in male blood donors with antibody to hepatitis C virus. *J Gastroenterol 29:* 593–597.
67. Kirn D, Fredericks D, McCutchan J, Stites D, Shuman M, 1995. Serum ferritin levels correlate with disease activity in patients with AIDS and disseminated histoplasmosis. *Clin Infect Dis 21:* 1048–1049.
68. Held T, Trautmann M, Poggensee U, Mravak S, 1991. Ferritin as the earliest prognostic marker in a case of visceral leishmaniasis. *J Infect 23:* 103–104.
69. Bell H, Skinningsrud A, Raknerud N, Try K, 1994. Serum ferritin and transferrin saturation in patients with chronic alcoholic and non-alcoholic liver diseases. *J Intern Med 236:* 315–322.
70. Bartfay W, Bartfay E, Axelsson J, Sigurdsson S, Naimark B, 1995. The relationship of serum ferritin with sex and exercise in Canadians of Icelandic descent: implications for prevention of coronary artery disease. *Can J Cardiol 11:* 305–310.
71. Barsky A, Borus J, 1995. Somatization and medicalization in the era of managed care. *JAMA 274:* 1931–1934.
72. Winokur A, Guthrie M, Rickels K, Nael S, 1982. Extent of agreement between patient and physician ratings of emotional distress. *Psychosomatics 11:* 1135–1138.
73. Madakasira S, O'Brien K, 1987. Acute posttraumatic stress disorder in victims of a natural disaster. *J Nerv Ment Dis 175:* 286–290.
74. Steketee G, Doppelt H, 1986. Measurement of obsessive-compulsive symptomatology: utility of the Hopkins Symptom Checklist. *Psychiatry Res 19:* 135–145.
75. Haley R, Hom J, Roland P, Bryan W, Van Ness P, Bonte F, Devous MS, Mathews D, Fleckenstein J, Wians FJ, Wolfe G, Kurt T, 1997. Evaluation of neurologic function in Gulf War veterans: a blinded case-control study. *JAMA 277:* 223–230.
76. Haley R, Kurt T, 1997. Self-reported exposure to neurotoxic chemical combinations in the Gulf War: a cross-sectional epidemiologic survey. *JAMA 277:* 231–237.
77. Wolfe J, Brown P, Kelley J, 1993. Reassessing war stress: exposure and the Persian Gulf War. *J Social Issues 49:* 15–31.
78. Adler A, Vaitkus M, Martin J, 1993. Combat exposure and posttraumatic stress symptomatology among US soldiers deployed to the Gulf War. *Mil Psychol 8:* 1–14.
79. Landrigan P, Lashof J, Hamburg D, 1998. Re: Is Gulf War syndrome due to stress? The evidence reexamined. *Am J Epidemiol 148:* 404–405.
80. Nicolson N, 1995. Massive cover-up of Desert Storm illness source. *Criminal Politics (March):* 32–36.
81. Stern M, Eckman J, Offermann M, 1994. Aplastic anemia after exposure to burning oil (letter). *N Engl J Med 331*: 58.
82. Fumento M, 1997. Gulf Lore Syndrome. *Reason (March):* 23–33.
83. Lees-Haley P, Brown R, 1992. Biases in perception and reporting following a perceived toxic exposure. *Percept Mot Skills 75:* 531–544.
84. Southwick S, Morgan CI, Nicolaou A, Charney D, 1997. Consistency of memory for combat-related traumatic events in veterans of Operation Desert Storm. *Am J Psychiatry 154:* 173–177.