Impact of Persistent Combat-Related PTSD on Heart Disease and Chronic Disease Comorbidity in Aging Vietnam Veterans

Steven D. Stellman, PhD, Anica Pless Kaiser, PhD, Brian N. Smith, PhD, Avron Spiro, PhD, and Jeanne Mager Stellman, PhD

Objectives: To assess combat and combat-related posttraumatic stress disorder (PTSD) as risk factors for heart disease and noncardiac chronic disease comorbidity in deployed Vietnam veterans 50 years post-War. **Methods:** A random sample of 12,400 veterans was surveyed in 1984 & 1998, and a deployed subset (n=729) in 2000. Outcomes included probable PTSD and history of diagnosed chronic illnesses. **Results:** Twenty-eight percent reported a diagnosed heart condition; combat exposure in Vietnam was a significant predictor (odds ratio = 1.92, 95% confidence interval = 1.13–3.31). Veterans with heart disease reported significantly more comorbid chronic illnesses, including arthritis and respiratory conditions: sleep apnea, emphysema, and asthma. Chronic illnesses were reported more often by men with PTSD. **Conclusions:** Emerging evidence suggests that 50 years after Vietnam combat and associated PTSD may contribute to heart disease and comorbid conditions.

Keywords: aging, cardiometabolic conditions, chronic diseases, combat, disability, heart disease, posttraumatic stress disorder, PTSD, stress disorders, posttraumatic/epidemiology, Vietnam veterans

CME Learning Objectives

After completing this enduring educational activity, the learner will be better able to:

- Assess combat and combat-related posttraumatic stress disorder (PTSD) as risk factors for heart disease and non-cardiac chronic disease comorbidity in deployed Vietnam veterans 50 years post-war.
- Discuss the psychological effects of PTSD combat and how it may exacerbate the risk of developing heart disease.
- Outline the impact of combat-related trauma on long-term health.

A substantial body of research has shown posttraumatic stress disorder (PTSD) to be associated with subsequent development of cardiovascular disease (CVD).[1–7] The American Heart Association has acknowledged that PTSD is associated with objective measures of cardiovascular health and function along with "traditional" CVD risk factors.[8] A PTSD diagnosis in veterans has consistently been shown to be strongly related to their exposure to military combat.[9] In 1983, we began a cohort study of American Legionnaire Vietnam veterans (wave 1) among whom we observed, at least a decade after their combat experiences in Vietnam, a strong dose-response relationship between combat stress and probable PTSD. We also found higher levels of anxiety and depression among those with more combat exposure and PTSD symptoms.[10]

The strength of the observed relationships persisted at the 14-year follow-up (wave 2, 1998).[11] In 2020 (wave 3), we surveyed a subset of the cohort that, after extensive database searches, we believed to be alive and who had been deployed to Vietnam. The wave 3 survey was thus 35-year postenrollment and about a half-century postcombat exposure. In a companion study focusing on the time course of PTSD, in this cohort, we found the dose-response relationship between combat and PTSD in 2020 to be nearly as strong as that observed in 1984, that 9% of the cohort fell into the current probable PTSD category, 10% were classified as having had probable PTSD at an earlier wave, and another 25% had experienced subthreshold PTSD in at least one of the three survey waves.

Further, throughout the 35-year observation period, combat-related PTSD was also associated with depression and nonspecific somatic complaints.[11–13] Mental, physical, and social outcomes were substantially worse among veterans with current PTSD compared with those with no PTSD history, whereas those with subthreshold symptomatology experienced intermediate levels of adverse outcomes. In 1984, we had found that those exposed to military combat exhibited a wide range of physical illnesses including arthritis, ulcers, genitourinary problems, nervous system diseases, and liver diseases including hepatitis, which was unusual for a group of men who had been healthy enough to have been inducted into military service and deployed to a war zone. At that time, their average age was 36.5 years.[10,14,15]

From the Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, New York (S.D.S.); National Center for PTSD Behavioral Science Division, VA Boston Healthcare System, Boston, Massachusetts (A.P.K.); VA New England Geriatric Research Education and Clinical Center, Boston, Massachusetts (A.P.K.); Department of Psychiatry, Boston University Chobanian & Avedisian School of Medicine, Boston, Massachusetts (A.P.K., B.N.S., A.S.); National Center for PTSD Women's Health Sciences Division, VA Boston Healthcare System, Boston, Massachusetts (B.N.S.); Massachusetts Veterans Epidemiology Research and Information Center, VA Boston Healthcare System, Boston, Massachusetts (A.S.); Department of Epidemiology, Boston University School of Public Health, Boston, Massachusetts (A.S.); and Department of Health Policy and Management, Mailman School of Public Health, Columbia University, New York, New York (J.M.S.).

ORCID: 0000-0003-4217-7819
ORCID: 0000-0002-4803-0191
ORCID: 0000-0003-4539-1220
ORCID: 0000-0003-4080-8621
ORCID: 0000-0003-4370-6866

S.D.S. and J.M.S. are co-senior authors.

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Address correspondence to: Steven D. Stellman, PhD, Foundation for Worker, Veteran, and Environmental Health, Inc, 117 St Johns Place, Brooklyn, NY 11217 (sds@workerveteranhealth.org).

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Others have also observed PTSD to be associated with chronic physical illnesses. Indeed, more than 25 years ago, Boscarino[16] reported greater risks of digestive, musculoskeletal, nervous system, and respiratory disorders, as well as nonsexually transmitted infectious diseases and endocrine-nutritional-metabolic disorders, following severe stress exposures in military service. Veterans of more recent combat have developed arthritis and other comorbidities at a rate higher than the civilian population.[17]

Given the increasing attention to PTSD as a potential contributor to heart disease, and the expanding focus on PTSD as a potential predictor of emphysema and other nonneoplastic lung diseases,[18] it was appropriate to investigate whether concurrent illnesses might also be linked to PTSD as well as to determine whether the previously observed relationships continued in our long-established cohort. We analyze the prevalence of heart disease, associated cardiometabolic symptoms, and other chronic diseases in this cohort of surviving, aging Vietnam veterans. It should be noted that the American Legionnaire dataset provides insight into a military veteran cohort now approximately 50 years post its war-zone deployment, and thus represents an unusual opportunity to elucidate the long-term impact of combat and PTSD symptoms on heart disease, associated cardiometabolic symptoms, as well as other chronic illnesses commonly experienced by older veterans.

METHODS

Sample

The Columbia University–American Legion study is a prospective cohort study of 12,400 male veterans of the Vietnam War randomly chosen from American Legion Post membership rosters in six States: Colorado, Indiana, Maryland, Minnesota, Ohio, and Pennsylvania. By design, veterans deployed to Vietnam were oversampled and comprise 42% of the cohort. The full sample was surveyed by mail in 1984 and 1998. Details of the first two waves have been provided previously.[11,19] A third survey wave in 2020 was restricted to 729 men who were two-time respondents thought to be still living following National Death Index and commercial data searches; born 1945–1953; military service 1963–1973; and deployed to Vietnam. Of these, 507 responded; 18 additional deaths were identified, and 26 surveys were undeliverable (74% response rate). Mailed surveys contained a $5 enclosure; upon completion, respondents received an additional $20, with an option to donate it to The American Legion. Additional details of wave 3 have been reported previously.[20]

Combat

Combat exposure was assessed at waves 1 and 2, using an eight-item Likert scale with five response options (never to very often; range 8–40).[9,19,21] Internal consistency was high (Cronbach α: 0.96 at wave 1, 0.94 at wave 2); a high level of agreement between combat exposure measurements at the two times was indicated by a κ of 0.88.[22] Here we use wave 1 scores, since they are closer in time to the event, except that we use wave 2 scores for 25 men missing wave 1 items, given the high level of consistency in reporting combat.[22] Five veterans with no combat data were excluded from analyses involving combat. We report combat exposure as a continuous score or alternatively as a two-level variable (lower combat 8–25, higher combat 26–40) for comparability with previous reports.[23]

PTSD

Definitions and methods of assessing PTSD via questionnaire have evolved during the past four decades. To maintain comparability over time, participants completed the same 18-item PTSD checklist at all three waves, using a 5-point item response (never to very often, total score range 18–90, with "low" PTSD symptom scores indicated by scores 18–26 and "high" PTSD symptom scores indicated by scores 49–90). Items on this checklist refer specifically to Vietnam War experiences.[10,11] Total PTSD score reliability was excellent at each wave (Cronbach α: 0.93 in 1984, 0.95 in 1998, 0.96 in 2020).[10,11] For veterans with one ($n = 16$) or two ($n = 4$) missing items, PTSD total scores were imputed by replacing the missing item(s) with the person-specific mean of the completed items.

Cardiovascular and Other Chronic Disease Endpoints

In the 2020 survey, participants were given a checklist of chronic conditions common in older populations and asked to indicate those with which they had been diagnosed by a physician or other health professional. For our purpose, heart disease was identified from a reported history of heart disease, stroke, or angina. We further defined a broader measure suggestive of cardiometabolic disease as the number of medically diagnosed conditions reported from a list consisting of heart disease, stroke, angina, hypertension, diabetes, and elevated cholesterol (range 0 to 6), reasoning that the latter three comprise a group of conditions that may increase one's risk of heart disease.[24] The medical checklist included 12 additional chronic illnesses: cancer, chronic obstructive pulmonary disease or emphysema, asthma, thyroid disease, arthritis, motor neuron diseases, cognitive illnesses, gastroesophageal reflux disease (GERD), sleep apnea, chronic kidney disease, liver diseases including hepatitis, and eye and ear disorders. We used a count of these 12 conditions as an index of chronic disease comorbidity (range 0 to 12).

Body Mass Index, Smoking, and Drinking

Body mass index (BMI) at each wave was calculated from reported height and weight, expressed in kg/m^2. At each wave, participants were defined as never, ex-, or current smokers, from which we constructed a lifetime smoking pattern: lifelong nonsmoker, long-term ex-smoker, recent ex-smoker (cessation reported at wave 3 only), and current smoker. Alcohol consumption was assessed at wave 3 using the Alcohol Use Disorders Identification Test, AUDIT-C, comprising three questions of 0–4 points each on frequency and amount of consumption for a total of 12 possible points. In men, 4 points and above is considered "problem drinking."[25]

Statistical Analysis

We compared mean values of continuous variables (eg, combat, PTSD) between those with and without a history of heart disease using *t* tests, and distributions of categorical variables such as service branch and education using chi-squared tests. We compared the mean values of combat and PTSD among persons with different numbers of health conditions via analysis of variance. We calculated odds ratios (ORs) and their 95% confidence intervals (CIs) for the association of heart disease history with combat or PTSD using logistic regression, with adjustment for BMI, smoking, and alcohol consumption where indicated, and evaluated associations between continuous variables with ordinary least squares regression. Because of the very narrow age distribution of the sample (67–75 years, mean 72.5, SD 1.6), we did not adjust for age. Mediation analyses were carried out using regression-based path analysis via the Hayes PROCESS macro.[26] The indirect effect was the product of standardized coefficients for the path from combat to PTSD and the path from PTSD to heart disease, with the 95% CI estimated via bootstrapping. Analyses were carried out using SPSS v. 28.

The study was approved by Columbia University Institutional Review Board and by Solutions IRB. The STROBE guidelines for observational studies checklist is appended in the Supplementary Digital Content (http://links.lww.com/JOM/B797).

RESULTS

Descriptives

The sample is all-male (fewer than 0.4% of US military in Vietnam were women) with mean age 72.5 (96% aged 70 to 75). Distributions of demographic and behavioral variables are displayed in Table 1, which shows that heart disease history did not vary with military service branch or rank, education, income, or marital status. A total of 143 men (28.2%) reported a history of heart disease. Overall, one third (33%) were high school graduates, 44% had some college or vocational school, and 13% were college graduates; 85% were married, 7% widowed, 5% divorced or separated, and 3% never married.

Men who smoked at waves 1 and 2 but who had quit by wave 3 had significantly greater heart disease risk compared with never-smokers (OR = 2.11, 95% CI = 1.003–4.45), which was unexpectedly greater than the OR for current smokers at wave 3 (OR = 1.53, 95% CI = 0.69–3.39), most likely due to selective survival, since many lifelong smokers had died before wave 3. The OR for long-time quitters (those who smoked only before wave 1, at wave 1, or at wave 2) was not significantly different from unity (OR = 1.36, 95% CI = 0.77–2.39), as expected.[27] While nearly one half of the sample (214 or 46.1%) were obese, BMI was significantly greater among those with prevalent heart disease (31.0 vs 29.6, $P < 0.01$). Alcohol consumption was not associated with heart disease, whether measured as the AUDIT-C score or categorized as problem drinking.

Combat Exposure, PTSD, and Heart Disease History

As shown in Table 1, a total of 103 veterans (21.6%) scored in the high combat category, for an unadjusted OR of 1.47 (95% CI = 0.92–2.34) compared with low-combat veterans, whereas 159 (34.1%) had a high PTSD score with a statistically significant unadjusted OR of 1.62 (95% CI = 1.07–2.46) compared with those having lower PTSD scores. The BMI-adjusted OR for high combat was 1.41 (95% CI = 0.86–2.36), whereas that for PTSD was 1.60 (95% CI = 1.04–2.46) (Table 2). These ORs were not materially changed by further adjustment for smoking.

The consistency of the relationship between combat and PTSD over time, as reported in our companion paper, provides support for attributing their PTSD to combat exposure in Vietnam, whereas the associations of both combat and PTSD with subsequent heart disease suggest that combat might be an underlying cause, with PTSD a possible mediator. Accordingly, we tested a model in which PTSD served as a mediator between combat and reported heart disease. This model had an R^2 of 0.43 ($P < 0.001$) and showed a significant PTSD-mediated "indirect effect" of combat on heart disease of 0.020 (95%

TABLE 1. Demographic, Lifestyle Characteristics, Combat, and PTSD by Self-Reported History of Heart Disease

Demographic Factors	**CHD History: No, *n* = 364**	**CHD History: Yes, *n* = 143**	
Age, yr, mean (SD)	72.4 (1.6)	72.6 (1.7)	*P* value: n.s.
Branch of Service	***n* (%)**	***n* (%)**	**OR (95% CI)**
Army	263 (72.5)	89 (62.7)	1.00 (ref.)
Navy	23 (6.3)	14 (9.9)	1.80 (0.89–3.65)
Air Force	49 (13.5)	27 (19.0)	1.63 (0.96–2.76)
Marines	28 (7.7)	12 (8.5)	1.27 (0.62–2.60)
Rank			
E1 to Cpl.	107 (29.4)	34 (23.9)	0.76 (0.48–1.18)
Above Cpl.	257 (70.6)	108 (76.1)	1.00 (ref.)
Education*			
High school or less	124 (34.2)	56 (39.4)	1.00 (ref.)
Some college	88 (24.2)	31 (21.8)	0.78 (0.47–1.31)
Vocational/technical	71 (19.6)	31 (21.8)	0.97 (0.57–1.64)
College graduate or above	80 (22.0)	24 (16.9)	0.66 (0.38–1.16)
Income†			
Under $50,000	135 (46.2)	66 (53.7)	1.35 (0.88–2.05)
$50,000 or higher	157 (53.8)	57 (46.3)	1.00 (ref.)
Marital status			
Married or living as a couple	267 (83.4)	109 (87.9)	1.00 (ref.)
Divorced or separated	21 (6.6)	9 (7.3)	1.05 (0.47–2.36)
Widowed	21 (6.6)	5 (4.0)	0.58 (0.21–1.59)
Single/never married	11 (3.4)	1 (0.8)	0.22 (0.03–1.75)
Lifestyle factors			
BMI, kg/m^2, mean (SD)	29.6 (5.3)	31.0 (6.0)	<0.01
AUDIT-C, mean (SD)	4.1 (2.8)	3.7 (2.7)	n.s.
Smoking habit			
Lifelong nonsmoker	81 (29.7)	23 (21.9)	1.00 (ref.)
Long-time quitter	132 (48.4)	51 (48.6)	1.36 (0.77–2.39)
Recent quitter	30 (11.0)	18 (17.1)	2.11 (1.003–4.45)
Current smoker	30 (11.0)	13 (12.4)	1.53 (0.63–3.39)
Exposures			
Combat score			
Low (8–25)	274 (80.4)	100 (73.5)	1.00 (ref.)
High (26–40)	67 (19.6)	36 (26.5)	1.47 (0.92–2.34)
PTSD score†			
Low (18–48)	230 (69.1)	77 (57.9)	1.00 (ref.)
High (49–90)	103 (30.9)	56 (42.1)	1.62 (1.07–2.46)

n.s., not significant, $P > 0.05$; ref., reference.
*Reported at wave 2 (1998).
†Reported at wave 3 (2020).

TABLE 2. Multivariate ORs and 95% CIs for Associations Between Combat or PTSD Symptom Score at Wave 3 (2020 With Reported History of Heart Disease,* Adjusted for BMI)

Variables	Beta	SE	OR	95% CI	*P*
High combat (combat score ≥26)	0.344	0.255	1.411	(0.856–2.325)	0.18
BMI	0.046	0.019	1.047	(1.008–1.087)	0.02
High PTSD (symptom score ≥49)	0.469	0.219	1.599	(1.041–2.456)	0.03
BMI	0.038	0.019	1.038	(1.000–1.078)	0.05

*Self-reported history of medically diagnosed coronary heart disease/myocardial infarction, stroke, or angina.

CI = 0.001–0.041). This model is consistent with PTSD as a candidate mechanism linking combat exposure to the development of heart disease, but it needs to be replicated in larger longitudinal studies.

Comorbidity of PTSD With Heart and Other Chronic Diseases

PTSD measured in 2020 was associated with the number of conditions comprising our cardiometabolic disease outcome (0 to 6 possible). The PTSD score was also associated with the number of reported chronic noncardiovascular conditions ($P < 0.01$) as shown in Table 3. The average number of comorbid illnesses indicated by veterans with heart disease was 2.83, compared with 1.84 conditions for those without heart disease ($P < 0.001$).

The prevalence of 12 noncardiovascular chronic conditions is shown in Table 4; eight are significantly associated with history of heart disease. It is noteworthy that three respiratory conditions (sleep apnea, emphysema, and asthma) were strongly associated with heart disease with ORs of 2.1, 3.3, and 2.0, respectively, even though the latter two illnesses were reported by less than one fourth of participants. We also found statistically significant associations between PTSD and four chronic illnesses (arthritis, emphysema, chronic kidney disease, and sleep apnea [Table 5]); all except the latter displayed a striking dose-response with the ORs increasing together with increasing PTSD score. PTSD score, in turn, is significantly related to level of combat exposure.

DISCUSSION

In this sample of Vietnam veterans, both combat and PTSD were significant predictors of reported heart disease. The association between combat and heart disease was especially high for veterans who experienced the most intense combat levels. Veterans who reported high levels of combat exposure were twice as likely to have been diagnosed with heart disease as compared with those who reported low levels of combat. The number of cardiometabolic conditions suggestive of metabolic syndrome was also greater in veterans judged to have current or prior PTSD compared with those judged never to have had PTSD over the 35-year observation period of the study.

As expected, lifestyle risk factors were predictive of reported heart disease, with BMI being the strongest predictor. Risks were unexpectedly higher among former smokers who had recently quit than among current smokers. Considering that the mean age of our population is 72 while the mean age at cardiac death in the United States is 64, this is likely a survivorship effect in which heavier smokers have already died, whereas others may have declined to respond since severe illness can be a barrier to participation in surveys.[28] We know, for example, that in this and both prior waves (1984 and 1998), smoking prevalence increased with intensity and duration of PTSD, and that 39% of veterans who completed wave 2 of this study but died before wave 3 were current smokers at wave 2 (1998), compared with 25% of those who completed wave 3 (2020). Even as early as wave 1, combat was associated with risk factors for chronic disease including hypertension and smoking.[23,29]

It is not surprising that aging veterans with a history of heart disease are also affected by additional chronic health conditions common in older populations. Especially noteworthy are arthritis, sleep apnea, and GERD, which were reported by 46.5%, 32.7%, and 23.5% of veterans, respectively. It is noteworthy that in a national survey 49% of adults with heart disease also had physician-diagnosed arthritis compared with 23% of the adult population as a whole.[30] In our study population, 58.0% of veterans with CHD also reported arthritis and, as noted above, those with the most intense PTSD scores exhibited a three-fold increased risk. These findings are consistent with those observed in later generations of veterans of Operations Enduring and Iraqi Freedom.[17]

Numerous mechanisms have been proposed to explain PTSD as a cause of heart disease. In the present study, the relevant outcome is prevalent heart disease. Prevalence is valuable for estimating disease burden and planning healthcare services, but is influenced both by the incidence of new cases and duration of the disease, making it difficult

TABLE 3. Association of Continuous PTSD Score at Wave 3 (2020 Survey) With the Number of Reported Medical Conditions Suggestive of Metabolic Syndrome (Range 0 to 6) and With the Number of Noncardiovascular Chronic Medical Conditions (0 to 12 Possible, Maximum Reported 6)

	Number of Conditions Suggestive of Metabolic Syndrome[*,†]			
Predictor	**Beta**	**SE**	**95% CI**	***P***
PTSD at wave 3	0.106	0.005	0.000–0.019	0.048
	Other Medical Conditions[‡,§]			
PTSD at wave 3	0.170	0.006	0.006–0.029	0.002

OLS regression results are adjusted for BMI and lifetime smoking habit.

*Checklist components: hypertension, angina, heart attack/heart disease, stroke, diabetes, high cholesterol; range 0 to 6.

†*P* values for BMI were all *P*'s < 0.001 and for recent smoking cessation $P < 0.05$.

‡Checklist components: emphysema, asthma, thyroid disease, arthritis, motor neuron diseases, cognitive illnesses, GERD, sleep apnea, chronic kidney disease, liver diseases including hepatitis, eye and ear disorders, cancer, other conditions; possible range 0 to 12 but no veteran listed more than six conditions.

§*P* values for BMI were all *P*'s < 0.001.

TABLE 4. ORs for Association of Self-Reported Heart Disease History With Comorbid Chronic Illness at Wave 3 (2020)

Condition	*N* With Condition	Prevalence in Cohort %	Reported Heart Disease History	
			OR	95% CI
Eye and ear conditions	285	56.2	1.5	(0.99–2.2)
Arthritis*	236	46.5	1.9	(1.3–2.8)
Sleep apnea	166	32.7	2.1	(1.4–3.1)
GERD†	119	23.5	2.1	(1.4–3.2)
Cancer history	112	22.1	1.3	(0.9–2.1)
Emphysema	108	21.3	3.3	(2.1–5.2)
Asthma	80	15.8	2.0	(1.2–3.3)
Thyroid disease	76	15.0	2.1	(1.3–3.5)
Chronic kidney disease	62	12.2	1.2	(0.7–2.2)
Alzheimer or Parkinson	48	9.5	2.1	(1.2–3.9)
Liver disease‡	47	9.3	2.2	(1.2–4.1)
Motor neuron disease§	42	8.3	1.8	(0.96–3.5)

All ORs are adjusted for smoking and BMI.
*Includes osteoarthritis and rheumatoid arthritis.
†Gastroesophageal reflux disease.
‡Includes any type of hepatitis.
§Multiple sclerosis or amyotrophic lateral sclerosis.

to establish a causal relationship, let alone elucidate a mechanism. Nevertheless, because our assessment of PTSD uses questions based on combat experience in Vietnam, our data may have some mechanistic relevance, for which our preliminary mediation findings provide some support.

Individuals with PTSD frequently report a range of physical symptoms as well. Mechanisms undoubtedly involve the body's stress response systems and can involve neurobiological, psychological, and environmental factors.[31] In an older adult population, it is also to be expected that a substantial proportion of individuals will experience a variety of chronic illnesses. Survivors of the World Trade Center disaster with PTSD, for example, had four times the odds of also experiencing asthma and other lower respiratory symptoms compared with those without PTSD, whereas other comorbidities were strongly associated with disaster-related physical exposures.[32,33]

Our 35-year observation period is the longest reported in the literature, providing a unique opportunity to study the long-term health outcomes of aging veterans. While previous cohort studies have examined PTSD and its effects, most have a median observation period of only 7 years, with only a few Israeli studies following veterans for up to 20 years. These shorter studies primarily focus on younger veterans, making their findings less applicable to the growing number of veterans who are now in their 70s and dealing with multiple chronic conditions. Our study provides new data on the comorbidity of chronic diseases, particularly heart disease, which is especially prevalent in veterans with higher levels of combat exposure. Few other studies have linked these comorbidities with PTSD, making this aspect of our research especially novel. The aging veteran population, now grappling with a range of serious health issues, represents a significant cost burden for the Veterans Health Administration.[34] These findings underscore the importance of maintaining comprehensive healthcare services and suggest a need for further research into how military combat and related stressors contribute to long-term disease risk.

Our study is subject to several limitations, a principal one being veterans' self-report of medical conditions. Mitigating this, however, are several indicators of internal validity. These include the strong association between history of heart disease with BMI and recent smoking, and the observation that persons with reported heart disease endorsed on average 2.1 of three other conditions considered indicative of cardiometabolic disease (hypertension, diabetes, and elevated cholesterol) compared with an average of 1.5 from persons who did not report heart disease history ($P < 0.001$).

PTSD was determined via a questionnaire and not clinical interview, although the measure used in the current study is nearly identical to the PTSD Checklist (PCL), a well-validated and widely used self-report instrument with excellent psychometric properties.[35] Because the surviving sample is relatively small, our study is underpowered to provide more nuanced conclusions about risk predictors. This study is of survivors and thus excludes those who may have been most adversely affected by wartime combat experiences and suffered premature death. Also, living cohort members with the most severe symptoms may be less likely to participate in follow-ups, as we observed in wave 2[11,22] and in World Trade Center disaster studies.[28] However, the strong dose-response between combat and PTSD whose consistency we have observed over a 35-year span reinforces our analyses.

PTSD can be caused or exacerbated by a variety of traumatic experiences, especially when assessed after years or decades. The instrument used to measure PTSD is geared to Vietnam military service. While this does not exclude the contribution of other experiences or exposures to development of PTSD, we describe it as combat-related PTSD because of the strong quantitative combat-PTSD dose-response that has persisted for the majority of veterans' lifetimes.

A further limitation is restriction to male veterans who vastly outnumber women deployed to Vietnam, largely as nurses. Although not assigned to combat roles, many women were stationed in combat zones, facing hostile fire and other warzone stressors, which overlapped with some experiences of male veterans, and a revised validated warzone scale is now available.[36] However, women's experiences were qualitatively different and warrant separate study, and recent work demonstrates late-in-life effects of wartime stress on women veterans.[37] To address this, we have established a separate cohort of female veterans and civilians to examine their unique roles and experiences, and have previously reported on their physical and mental health outcomes, including PTSD, in relation to exposure to casualties, work stress, and sexual harassment; further analyses are underway.[38]

Despite such limitations, our study has key strengths, including data on health and relevant medical factors in a unique military cohort spanning several decades. It is noteworthy that our response rates with this cohort have remained high over time. The relationships observed in our American Legion cohort are probably a "best-case" scenario in that our participants are functioning at a high enough level to belong to a social organization (The American Legion) and to have survived and participated in three surveys over 35 years. The broader population of combat veterans may thus exhibit even less favorable associations between combat-related PTSD and subsequent development of heart disease and other chronic illnesses. Further, the relationship between PTSD and chronic illness in the general population may be even

TABLE 5. Multivariate ORs (and 95% CIs) for Association of PTSD With Arthritis, Sleep Apnea, Emphysema, and Chronic Kidney Disease, Via Logistic Regression, Adjusted for BMI and Lifetime Smoking Habit

PTSD*	Arthritis	Sleep Apnea	Emphysema	Chronic Kidney Disease
Low and medium	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
High	2.33 (1.43–3.79)	1.79 (1.07–2.99)	1.52 (0.85–2.73)	2.32 (1.19–4.53)

*PTSD score is categorized as low and medium (18–48, reference group) and high (49–90).

greater since ours is a cohort of men at one time physically fit enough to have been called to military service and sent to war. Our study also helps inform understanding of how emotional stress responses such as PTSD may mirror biochemical reactions.[39,40] Theoretical models have related PTSD to physical health outcomes,[41] and these models have been growing in complexity as understanding of the disorder has grown.[42] Indeed, PTSD has been called a metabolic disorder "in disguise,"[43] and the AHA labels stress-related CVD as a mind-body interaction. There is still much to learn about the complexity of mind-behavior-biochemical interactions.[6]

CONCLUSIONS

In this population of American Legionnaire deployed Vietnam veterans, followed for 35 years, PTSD stemming from their exposure to military combat in Vietnam was strongly associated with reported heart disease, indicators of cardiometabolic disease, and with lifestyle risk factors BMI and smoking. It is especially noteworthy that this relationship, which is consistent with the substantial literature linking PTSD to development of heart disease, has persisted at least a half-century after the War's end.

A variety of chronic conditions were observed to be comorbid with heart disease; three of these, arthritis, emphysema, and chronic kidney disease, were also associated with PTSD in a dose-dependent manner. The degree to which these additional conditions are causally related to PTSD stemming from military combat merits future study. The high prevalence of all of these chronic conditions in this aging cohort of Legionnaires lends strong support for the need for bolstering and expanding general medical services for the overall veteran population, especially as they age.

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Data Availability: The cohort was established 40 years ago before promulgation of data sharing guidelines. We do not have the participants' permission to share their data.

EQUATER network reporting guidelines: The manuscript adheres to STROBE guidelines for cohort studies.

AI: No artificial intelligence was utilized at any stage of this study.

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