Original Investigation

Risk Factors Associated With Suicide in Current and Former US Military Personnel

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IMPORTANCE Beginning in 2005, the incidence of suicide deaths in the US military began to sharply increase. Unique stressors, such as combat deployments, have been assumed to underlie the increasing incidence. Previous military suicide studies, however, have relied on case series and cross-sectional investigations and have not linked data during service with postservice periods.

OBJECTIVE To prospectively identify and quantify risk factors associated with suicide in current and former US military personnel including demographic, military, mental health, behavioral, and deployment characteristics.

DESIGN, SETTING, AND PARTICIPANTS Prospective longitudinal study with accrual and assessment of participants in 2001, 2004, and 2007. Questionnaire data were linked with the National Death Index and the Department of Defense Medical Mortality Registry through December 31, 2008. Participants were current and former US military personnel from all service branches, including active and Reserve/National Guard, who were included in the Millennium Cohort Study (N = 151 560).

MAIN OUTCOMES AND MEASURES Death by suicide captured by the National Death Index and the Department of Defense Medical Mortality Registry.

RESULTS Through the end of 2008, findings were 83 suicides in 707 493 person-years of follow-up (11.73/100 000 person-years [95% CI, 9.21-14.26]). In Cox models adjusted for age and sex, factors significantly associated with increased risk of suicide included male sex, depression, manic-depressive disorder, heavy or binge drinking, and alcohol-related problems. None of the deployment-related factors (combat experience, cumulative days deployed, or number of deployments) were associated with increased suicide risk in any of the models. In multivariable Cox models, individuals with increased risk for suicide were men (hazard ratio [HR], 2.14; 95% CI, 1.17-3.92; $P = .01$; attributable risk [AR], 3.5 cases/10 000 persons), and those with depression (HR, 1.96; 95% CI, 1.05-3.64; $P = .03$; AR, 6.9/10 000 persons), manic-depressive disorder (HR, 4.35; 95% CI, 1.56-12.09; $P = .005$; AR, 35.6/10 000 persons), or alcohol-related problems (HR, 2.56; 95% CI, 1.56-4.18; $P < .001$; AR, 7.7/10 000 persons). A nested, matched case-control analysis using 20:1 control participants per case confirmed these findings.

CONCLUSIONS AND RELEVANCE In this sample of current and former military personnel observed July 1, 2001-December 31, 2008, suicide risk was independently associated with male sex and mental disorders but not with military-specific variables. These findings may inform approaches to mitigating suicide risk in this population.

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Despite universal access to health care services, mandatory suicide prevention training, and other preventive efforts, suicide has become one of the leading causes of death in the US military in recent years.[1-3] Suicide rates across the population of active-duty US military personnel began to increase sharply in 2005 from a baseline rate of 10.3 to 11.3 per 100 000 persons to a rate of 16.3 per 100 000 persons in 2008, with the highest rates among Marine Corps and Army personnel (19.9 and 19.3 per 100 000 persons).[4] Since 2009, suicide rates among those on active-duty status have stabilized at approximately 18 per 100 000.

Despite this increase, suicide remains a rare outcome that is challenging to study. Studies among military populations have not been able to adequately examine the association between deployment characteristics and suicide following military discharge.[2,5,6] Military separations due to medical or administrative reasons (eg, mental disorders, substance misuse, misconduct) are likely to bias incidence figures and risk-factor estimates in studies that fail to link records between active service and postmilitary periods.[6] Separation of service members with mental disorders, for example, could lead to underestimates of incidence or risks associated with these conditions in studies based only on active-duty members, and possibly overestimates in studies that only involve veterans.[6,7] Previous studies have not linked US Department of Defense data with national death records, thus limiting the ability to conduct comprehensive studies across inservice and postservice time periods.

Understanding the circumstances and factors leading to suicide in military members and identifying appropriate interventions is of high priority to military and civilian leaders. This study prospectively examined and quantified factors associated with suicide risk in a large population of active, Reserve, and National Guard members across all branches of the military during and following service.

Methods

Study Population

Launched in 2001, the Millennium Cohort Study is the largest longitudinal US military study. Designed to prospectively evaluate the health impact of serving in the military, it is a study drawn from randomly selected samples of US military service members on rosters as of October 2000 (panel 1, July 2001-June 2003), October 2003 (panel 2, June 2004-February 2006), and October 2006 (panel 3, June 2007-December 2008) including members from all service branches and components. Panel 1 was a probability-based sample of the entire military population with oversampling for women, Reservist/National Guardsmen, and those who had previously deployed. Designed to augment panel 1, personnel invited to join panels 2 and 3 had 1 to 3 years of military service and were oversampled for Marines and women. Of those contacted (n = 491 659), a baseline questionnaire and consent to volunteer was provided by 151 597 service members, resulting in a 31% cumulative baseline response rate. The cohort has been shown to have minimal response bias and although similar to the US military population in 2008, members of the cohort are proportionately more likely to be women and younger (17-24 years old) (≥10% likely); and college educated, of white non-Hispanic race/ethnicity, and serving in the Air Force (>5% likely) at baseline.[8] Cohort participants are requested to complete a survey approximately every 3 years regarding mental, behavioral, and functional health, regardless of their current military status. Detailed descriptions of the study population and methods have been published elsewhere.[8,9] For this analysis, the population included eligible participants from the first 3 panels who completed a baseline questionnaire and did not have missing or undetermined cause of death information (99.9% of all participants). Due to the relatively low number of suicides in the cohort, data from these 3 panels were combined for all analyses. This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research (Protocol [Naval Health Research Center] NHRC.2000.0007).

Suicide

Suicide deaths were identified, during and following military service, using mortality data from the National Death Index and the Department of Defense Medical Mortality Registry (DoD MMR).[10-13] The DoD MMR, maintained in the Mortality Surveillance Division of the Armed Forces Medical Examiner System, contains detailed information on all US military active-duty deaths, including Reserve and National Guard members in an activated status, regardless of geographic location.[14] The DoD MMR also includes detailed information on any former military members who died while serving as civilians or contractors during the current operations. A previous study found that National Death Index together with DoD MMR captured 99% of deaths in this cohort.[15] Consistent with this previous study, a participant was identified as a decedent if the cohort data and information provided by the mortality data sources had an exact agreement on at least 2 personal identifiers consisting of Social Security number, first and last name, and full date of birth. Deaths as a result of suicide were identified using *International Classification of Diseases, 10th Revision* codes X60-X84, Y87, and U03.

Deployment

Deployment, a time-dependent variable, was based on DoD personnel files obtained from the Defense Manpower Data Center. Service members were identified as deploying in support of operations in Iraq and Afghanistan from September 11, 2001, through December 31, 2008 (ie, Operation Iraqi Freedom [OIF] and Operation Enduring Freedom [OEF]), based on direct report from personnel offices of the service branches or report of receiving imminent danger pay, hardship duty pay, or combat zone tax exclusion benefits. Participants who did not deploy in support of OIF/OEF prior to December 31, 2008 were classified as not deployed for the entire study period. Others were classified as not deployed until the first date of deployment, at which time they were classified as deployed (with or without combat experience) for the remaining follow-up time.

Combat experience was assessed using data from the Millennium Cohort and the Post-Deployment Health Assessment (PDHA) surveys. Data from the PDHA, a survey administered to all service members within 30 days of returning from deployment, were obtained from the Armed Forces Health Surveillance Center for members from all service branches. The PDHA asks respondents about encountering dead bodies or seeing people killed, discharging a weapon, and feeling in great danger of being killed during their most recent deployment. The Millennium Cohort survey includes a question that asks, "During the past 3 years, have you been personally exposed to any of the following? (do not include TV, video, movies, computers, or theater): (1) witnessing a person's death due to war, disaster, or tragic event, (2) witnessing instances of physical abuse (torture, beating, rape), (3) dead and/or decomposing bodies, (4) maimed soldiers or civilians, and (5) prisoners of war or refugees." Among those deployed, combat experience was identified by an affirmative response to 1 or more of these experiences from either questionnaire. Cumulative days deployed and number of deployments were based on the total number of days deployed and number of deployments, respectively, in support of OIF/OEF from 2001 through 2008. Deployment experience to the 1991 Gulf War or to Bosnia, Kosovo, or Southwest Asia between 1998 and 2000 was assessed as a separate variable referred to as "pre-2001 deployment experience."

Covariates

Self-reported physical functioning was assessed at baseline using the physical component score of the Medical Outcomes Study Short Form 36-Item Survey for Veterans (SF-36V).[16,17] In order to examine if those at the extremes of the scale were at increased or decreased risk for suicide, physical functioning was categorized into 3 levels (<15th percentile, 15th-85th percentiles, and >85th percentile), consistent with previous publications.[18]

Previous research has indicated that individuals who die by suicide are more likely to have experienced adverse life events.[19] Consequently, the presence of stressful life events was assessed using Millennium Cohort Study questions and a modified version of the Social Readjustment Rating Scale scoring system.[20] Based on severity, each type of stressful life event, such as experiencing divorce or severe illness, was assigned a point value (between 48 and 83 points) and then collectively scored. Based on the summation of baseline scores, participants were categorized as having either low/mild (<200 points) or moderate/major (≥200 points) life stress.

The mental and behavioral covariates (including posttraumatic stress disorder [PTSD], depression, manic-depressive disorder, panic/anxiety syndromes, heavy or binge drinking, and alcohol-related problems) were analyzed using 2 distinct methods: (1) assessed using only baseline data and (2) assessed using all available data for each individual (responses from 1-3 questionnaires).

PTSD was assessed using the PTSD Checklist-Civilian Version (PCL-C), a 17-item self-reported measure and a question that asked participants if they had ever been diagnosed with PTSD from a health professional.[21] A positive PTSD screen was based on reporting a moderate or higher level of at least 1 intrusion symptom, 3 avoidance symptoms, and 2 hyperarousal symptoms, criteria established by the *Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition (*DSM-IV*).[22] Participants who screened positive or reported ever being diagnosed with PTSD were classified as having PTSD.

Similarly, depression was assessed using the 9 depression items of the Patient Health Questionnaire (PHQ). The scoring algorithm that corresponds to the depression diagnosis from the *DSM-IV* was used to identify individuals with a positive depression screen.[23] Participants who screened positive or reported ever having a depression diagnosis were classified as having depression. Similarly 15 panic items and 6 generalized anxiety items from the PHQ were used to assess presence of panic or other anxiety syndromes.[24,25] Manic-depressive disorder was identified by those who reported that a doctor or other health professional ever diagnosed them with manic-depressive disorder.

Heavy weekly drinking was defined as consumption of more than 14 drinks per week for men or 7 drinks per week for women.[26-28] Binge drinking was defined as reporting of drinking 5 or more drinks for men or 4 or more drinks for women on at least 1 day or occasion during the past year.[29] Participants who met the threshold for either drinking condition were classified as heavy or binge drinkers. Assessed using questions from the PHQ, alcohol-related problems were determined by endorsement of at least 1 of 5 problems (eg, driving after having several drinks or drinking alcohol even though a physician suggested stopping) in the last 12 months.

Demographic and military-specific data were obtained at baseline from electronic personnel files maintained by the Defense Manpower Data Center including sex, date of birth, educational level, marital status, race/ethnicity, military rank, service component, service branch, occupation, and date of separation from the military. Age and military service status were assessed as time-dependent variables. Those participants who did not separate from the military were classified as current service members. All others were classified as current service members until their date of separation, at which time they were classified as former service members for the remaining follow-up time.

Statistical Analysis

The overall crude suicide rate as well as the age- and sex-adjusted (direct standardization based on the 2000 US population) suicide rate per 100 000 person-years were calculated. Characteristics by suicide deaths were compared using crude suicide rates and χ^2 tests. Person-years for OIF/OEF deployment and military service status were calculated using the time-varying status for the crude suicide rates. Attributable risk (AR), also referred to as risk difference, was calculated by subtracting the incidence of suicide in the unexposed group from the incidence of suicide in the exposed group, presented as the number of suicide cases per 10 000 persons. The population AR percent was calculated as the prevalence of the risk factor among the suicide deaths multiplied by the hazard ratios (HRs) minus 1

divided by the HR multiplied by 100 (prevalence among cases × [(HR−1)/HR] × 100%). Cox proportional hazards modeling was used to estimate unadjusted and age- and sex-adjusted HRs and 95% CIs for suicide. Multivariable Cox proportional hazards models to assess the association between deployment and suicide completion were built using a backwards elimination algorithm that initially included all variables significantly associated with suicide (P <.05) after age and sex adjustment (sex, depression, manic-depressive disorder, heavy or binge drinking, alcohol-related problems). Deployment was forced into these models, with covariates removed sequentially until the final model included only significant ones (P <.05). The multivariable Cox proportional hazards models were performed 2 ways: (1) factors were assessed at baseline with the inclusion of deployment as a time-dependent variable; and (2) factors were assessed as time-dependent variables, except sex. For example, using the latter method, participants who screened positive for a mental or behavioral condition on their second (or third) questionnaire were classified as having that condition for the remaining time of their follow-up period. For all Cox models, participants were censored at the date of a nonsuicide death or the end of the study period (December 31, 2008). Person-days for each participant were calculated from the date of baseline survey completion to the date of death (suicide or nonsuicide death) or end of study. For inclusion into each Cox model, participants had to have complete data for all variables in that model. The proportionality assumption for recent deployment was verified by assessing the correlation between the Schoenfeld residuals and person-days.

In an effort to further investigate the military-specific risk factors and underlying mental disorders, a nested case-control analysis was conducted that matched each suicide case to 20 control participants on birth year (within 2 years), sex, race/ethnicity, marital status, enrollment (within 180 days), service branch, and military rank. Similar to the multivariable Cox model, deployment and variables that were significantly (P < .05) associated with suicide were entered into a conditional logistic regression model (deployment, depression, manic-depressive disorder, heavy or binge drinking, and alcohol-related problems). Covariates were removed in the same manner as the multivariable Cox model, yielding a final model that included only significant variables (P < .05). To be considered for inclusion into the nested case-control analysis, participants had to have complete data on all the matching characteristics as well as the variables that were significantly associated with suicide after age and sex adjustment. All reported P values were 2 sided. Data management and statistical analyses were performed using SAS software version 9.3 (SAS Institute, Inc).

Results

Of the 151 597 Millennium Cohort participants (77 047 in panel 1, 31 110 in panel 2, and 43 440 in panel 3), 151 568 were eligible for analysis. Eight participants were excluded due to missing or undetermined cause of death data. The study population was composed of the remaining 151 560 participants (99.9% of all participants), of whom 646 (0.4%) died between 2001 and 2008. Of the decedents, 83 (12.8% of total deaths) were the result of suicide, during a total of 707 493 person-years of observation, yielding a crude rate of 11.73 (95% CI, 9.21-14.26) suicides per 100 000 person-years or an age- and sex-adjusted rate of 9.60 (95% CI, 7.10-12.10) suicides per 100 000 person-years. Crude suicide rates (per 100 000 person years) were highest among those with manic-depressive disorder (87.55, 95% CI, 10.84-164.30; n = 5), alcohol-related problems (27.67, 95% CI, 16.83-38.52; n = 25), and depression (26.94, 95% CI, 14.83-39.05; n = 19). Those with a suicide death were proportionately more likely, compared with all other participants, to have the following characteristics: fewer cumulative deployment days, combat specialist occupation, pre-2001 deployment experience, male sex, depression, manic-depressive disorder, heavy or binge drinking, and alcohol-related problems (**Table 1** and **Table 2**).

Unadjusted proportional hazards models revealed that those deployed to the current operations with or without combat were not significantly more likely to have a suicide death than those who did not deploy (HR, 1.15; 95% CI, 0.68-1.96 with combat experience; HR, 1.17; 95% CI, 0.63-2.16 without combat experience; P = .82) (**Table 3** and **Table 4**). Unadjusted significant risk factors for suicide included occupation, male sex, educational attainment of some college or less, depression, manic-depressive disorder, heavy or binge drinking, and alcohol-related problems. After adjusting for age and sex, the same factors were significantly associated with suicide except that occupation and education were no longer significant and deployment for more than 365 days was inversely associated with suicide (Table 3 and Table 4). The magnitude of the HRs for deployment further diminished.

A total of 145 387 participants were included in the final Cox model, including 78 suicide deaths. The final multivariable Cox model included the following statistically significant covariates: male sex (HR, 2.14; 95% CI, 1.17-3.92; P = .01; AR, 3.5/10 000; population attributable risk percent [PAR%], 43.6%), depression (HR, 1.96; 95% CI, 1.05-3.64; P = .03; AR, 6.9/10 000; PAR%, 11.2%), manic-depressive disorder (HR, 4.35; 95% CI, 1.56-12.09; P = .005; AR, 35.6/10 000; PAR%, 4.8%), and alcohol-related problems (HR, 2.56; 95% CI, 1.56-4.18; P <.001; AR, 7.7/10 000; PAR%, 18.4%) (**Table 5**). Deployment, assessed as a 3-level variable, was not associated with suicide in this final model. When the 3-level deployment variable was replaced first with cumulative days deployed and then the number deployments in the final model, neither deployment factor was associated with suicide; all other factors remained unchanged. Results were also consistent in the alternate final Cox model with the mental and behavioral factors assessed as time-dependent variables. Depression (HR, 2.05; 95% CI, 1.15-3.65; P = .01; AR, 5.0/10 000), manic-depressive disorder (HR, 4.18; 95% CI, 1.64-10.63; P = .003; AR, 26.9/10 000), and alcohol-related problems (HR, 2.28; 95% CI, 1.40-3.72; P <.001; AR,

Table 1. Military Characteristics of Millennium Cohort Participants by Suicide Death

Characteristic[a]	Crude Suicide Rate/100 000 Person-Years (95% CI)	No. (%)[b]	
		Nonsuicide (n = 151 477)	Suicide Death (n = 83)
OIF/OEF deployment[c]			
Not deployed	10.70 (7.67-13.72)	72 635 (48.0)	48 (57.8)
Deployed without combat	12.80 (5.84-19.76)	32 657 (21.6)	13 (15.7)
Deployed with combat	12.39 (6.82-17.96)	45 435 (30.0)	19 (22.9)
No. of deployments[c]			
0	13.13 (9.41-16.84)	72 635 (48.0)	48 (57.8)
1	11.32 (6.59-16.05)	46 291 (30.6)	22 (26.5)
>1	8.81 (4.02-13.60)	32 551 (21.5)	13 (15.7)
Cumulative days deployed[c]			
0	13.13 (9.41-16.84)	72 635 (48.0)	48 (57.8)
1-90	14.62 (1.81-27.43)	6950 (4.6)	5 (6.0)
91-180	18.36 (7.97-28.74)	14 833 (9.8)	12 (14.5)
181-365	9.77 (4.46-15.08)	31 230 (20.6)	13 (15.7)
>365	4.58 (0.57-8.59)	25 829 (17.1)	5 (6.0)
Military rank[d]			
Junior enlisted	13.43 (9.22-17.65)	82 362 (54.4)	39 (47.0)
Noncommissioned officer	10.98 (7.05-14.91)	42 793 (28.3)	30 (36.1)
Officer	9.73 (4.63-14.82)	26 322 (17.4)	14 (16.9)
Service component			
Reserve/National Guard	10.62 (6.88-14.35)	54 560 (36.0)	31 (37.3)
Active	12.52 (9.11-15.92)	96 917 (64.0)	52 (62.7)
Service branch			
Army	12.98 (9.10-16.86)	67 209 (44.4)	43 (51.8)
Navy/Coast Guard	8.59 (3.51-13.67)	27 437 (18.1)	11 (13.3)
Marine Corps	11.24 (1.39-21.09)	13 310 (8.8)	5 (6.0)
Air Force	11.78 (7.07-16.50)	43 521 (28.7)	24 (28.9)
Occupation			
Combat specialist	15.08 (8.47-21.69)	26 851 (17.7)	20 (24.1)
Health care	9.16 (2.38-15.95)	16 250 (10.7)	7 (8.4)
Functional support, service and supply	9.43 (5.19-13.67)	42 603 (28.1)	19 (22.9)
Mechanical or electrical repair	17.97 (11.54-24.40)	36 526 (24.1)	30 (36.1)
Other	5.39 (1.40-9.39)	29 214 (19.3)	7 (8.4)
Pre-2001 deployment experience[e]			
No	11.77 (8.79-14.75)	122 613 (80.9)	60 (72.3)
Yes	11.63 (6.88-16.38)	28 864 (19.1)	23 (27.7)
Military service status[f]			
Current service member	11.04 (8.24-13.83)	108 869 (71.9)	60 (72.3)
Former service member	14.04 (8.30-19.77)	42 608 (28.1)	23 (27.7)

Abbreviations: OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom.

[a] Assessed at baseline except participants' deployment and military service status. Cumulative days deployed, occupation, and pre-2001 deployment status were statistically significant (P <.05).

[b] Percentages are based on the population size for each group but exclude individuals with missing data, therefore, percents may not sum to 100.

[c] Based on OIF/OEF deployment September 11, 2001-December 31, 2008. Crude suicide rates for OIF/OEF deployment were based on time-varying status in which the status was fixed for number of deployments and cumulative days deployed.

[d] Ranks include junior enlisted (E1-E4), noncommissioned officer (E5-E9), and officer (O1-O10 and W1-W5).

[e] Deployed to the 1991 Gulf War or to Bosnia, Kosovo, or Southwest Asia 1998-2000.

[f] Based on status at the end of follow-up (December 31, 2008). Crude suicide rates were based on time-varying status.

5.5/10 000) were significantly associated with suicide in addition to male sex (HR, 2.19; 95% CI, 1.20-4.02; P = .01; AR, 3.5/10 000).

Results from the final conditional logistic model of the nested case-control analysis (**Table 6**, n = 1617 including 77 suicide deaths) were also consistent with the final Cox model (Table 5). Depression (OR [odds ratio], 2.68; 95% CI, 1.46-4.93; P = .002), manic-depressive disorder (OR, 7.38; 95% CI, 2.13-25.61; P = .002), and alcohol-related problems (OR, 2.30; 95% CI, 1.35-3.91; P = .002) were significantly and independently associated with suicide. Again, there was no significant association between deployment and suicide.

In a subanalysis among Army personnel only, manic-depressive disorder (HR, 5.96; 95% CI, 1.82-19.49; P = .003; AR, 37.6/10 000) and alcohol-related problems (HR, 3.86; 95% CI, 2.05-7.27; P <.001; AR, 11.3/10 000) remained significantly associated with suicide in a reduced model. There was no evidence that deployment was associated with suicide (P = .54). However, this was based on 41 suicide cases, so lack of significance among other factors such as depres-

Table 2. Characteristics of Millennium Cohort Participants by Suicide Death

Baseline Characteristics[a]	Crude Suicide Rate/100 000 Person-Years (95% CI)	No. (%)[b]	
		Nonsuicide (n = 151 477)	Suicide Death (n = 83)
Sex			
Men	13.69 (10.44-16.94)	103 420 (68.3)	68 (81.9)
Women	7.12 (3.52-10.72)	48 057 (31.7)	15 (18.1)
Age, y			
<25	15.03 (9.56-20.49)	58 151 (38.4)	29 (34.9)
25-34	11.12 (6.93-15.31)	51 988 (34.3)	27 (32.5)
35-44	9.32 (5.01-13.62)	29 917 (19.8)	18 (21.7)
≥45	11.47 (3.98-18.96)	11 421 (7.5)	9 (10.8)
Education			
≤Some college	13.26 (10.20-16.33)	120 387 (79.5)	72 (86.7)
≥Bachelor's degree	6.68 (2.73-10.63)	31 070 (20.5)	11 (13.3)
Marital status			
Not married	11.32 (7.62-15.02)	78 623 (51.9)	36 (43.4)
Married	12.07 (8.62-15.52)	72 854 (48.1)	47 (56.6)
Race/ethnicity			
White non-Hispanic	12.27 (9.19-15.35)	107 038 (70.7)	61 (73.5)
Black non-Hispanic	6.50 (1.30-11.69)	19 101 (12.6)	6 (7.2)
Other	13.64 (6.96-20.32)	25 231 (16.7)	16 (19.3)
Physical component score, percentile[c]			
<15th	12.11 (5.53-18.69)	22 211 (14.7)	13 (15.7)
15th-85th	10.67 (7.77-13.57)	103 647 (68.4)	52 (62.7)
>85th	16.09 (8.21-23.98)	22 227 (14.7)	16 (19.3)
Life stressors[d]			
Low/mild	11.30 (8.61-13.99)	130 345 (86.0)	68 (81.9)
Moderate/major	15.16 (7.49-22.84)	19 148 (12.6)	15 (18.1)
PTSD[e]			
No	11.22 (8.66-13.77)	139 328 (92.0)	74 (89.2)
Yes	19.97 (6.92-33.02)	11 252 (7.4)	9 (10.8)
Depression[e]			
No	10.09 (7.62-12.57)	134 275 (88.6)	64 (77.1)
Yes	26.94 (14.83-39.05)	16 304 (10.8)	19 (22.9)
Manic-depressive disorder[f]			
No	11.08 (8.59-13.58)	146 327 (96.6)	76 (91.6)
Yes	87.55 (10.84-164.30)	1222 (0.8)	5 (6.0)
Panic or other anxiety[g]			
No positive screen	11.35 (8.82-13.89)	144 109 (95.1)	77 (92.8)
Positive screen	20.70 (2.56-38.84)	5962 (3.9)	5 (6.0)
Heavy or binge drinking[h]			
No positive screen	8.01 (5.04-10.98)	69 368 (45.8)	28 (33.7)
Positive screen	15.76 (11.59-19.92)	79 696 (52.6)	55 (66.3)
Alcohol-related problems[i]			
No positive screen	9.53 (7.08-11.98)	128 722 (85.0)	58 (69.9)
Positive screen	27.67 (16.83-38.52)	20 389 (13.5)	25 (30.1)

Abbreviations: *DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth ed*; PCL-C, PTSD Patient Checklist-Civilian Version; PHQ, Patient Health Questionnaire; PTSD, posttraumatic stress disorder; SF-36V, Short Form 36-Item Questionnaire for Veterans.

[a] Sex, depression, manic-depressive disorder, heavy or binge drinking, and alcohol-related problems were statistically significant (P <.05).

[b] Percentages are based on the population size for each group but exclude individuals with missing data, therefore, percents may not sum to 100.

[c] Computed using the SF-36V at baseline.

[d] Using a similar scoring mechanism,[20] life stress was based on major financial problems, violent or sexual assault, sexual harassment, severe illness or death of family member or loved one, and disabling illness or injury.

[e] Self-reported for ever being diagnosed or screened positive for PTSD (PCL-C) using the *DSM-IV* criteria or for depression using the PHQ-9.

[f] Self-reported for ever being diagnosed with manic-depressive disorder.

[g] Screened positive for panic or other anxiety syndrome (PHQ).

[h] Self-reported weekly consumption (>14 drinks for men, >7 for women); or per day or per occasion (>4 drinks for women, >5 drinks for men).

[i] Participants affirmed at least 1 of the 5 items from the PHQ alcohol questions.

sion may have been due to a deficiency of power, a shared variance between the mental health variables, or both combined. When manic-depressive disorder was removed and replaced with depression in the reduced model, depression became significant (HR, 2.34; 95% CI, 1.16-4.72; P = .02; AR, 7.4/10 000), and alcohol-related problems remained significantly associated with suicide.

Discussion

The US military combat deployments in Iraq and Afghanistan have been associated with a notable upward trend in suicides since 2005 that has led to considerable speculation as to the cause.[4,6] Using national and military mortality rec-

Table 3. Hazard Ratios for Suicide Among Millennium Cohort Participants by Military Categories

Characteristics[a]	Unadjusted HR (95% CI)	*P* Value	Age- and Sex-Adjusted HR (95% CI)	*P* Value
OIF/OEF deployment[b]				
Not deployed	1 [Reference]	.82	1 [Reference]	.98
Deployed without combat	1.17 (0.63-2.16)		1.04 (0.56-1.93)	
Deployed with combat	1.15 (0.68-1.96)		0.97 (0.56-1.68)	
No. of deployments[b]				
0	1 [Reference]	.46	1 [Reference]	.14
1	0.88 (0.53-1.45)		0.75 (0.45-1.25)	
>1	0.68 (0.37-1.26)		0.55 (0.29-1.02)	
Cumulative days deployed[b]				
0	1 [Reference]	.10	1 [Reference]	.04
1-90	1.12 (0.44-2.80)		1.01 (0.40-2.55)	
91-180	1.41 (0.75-2.66)		1.22 (0.64-2.03)	
181-365	0.76 (0.41-1.40)		0.63 (0.34-1.17)	
>365	0.36 (0.14-0.89)[c]		0.28 (0.11-0.70)[c]	
Military rank[d]				
Junior enlisted	1 [Reference]	.37	1 [Reference]	.80
Noncommissioned officer	0.76 (0.47-1.23)		0.84 (0.45-1.58)	
Officer	0.68 (0.37-1.26)		0.79 (0.38-1.64)	
Service component				
Active	1 [Reference]	.44	1 [Reference]	.86
Reserve/National Guard	0.84 (0.54-1.31)		0.96 (0.61-1.52)	
Service branch				
Army	1.10 (0.67-1.82)	.68	1.06 (0.64-1.76)	.63
Navy/Coast Guard	0.73 (0.36-1.49)		0.71 (0.35-1.45)	
Marine Corps	0.97 (0.37-2.56)		0.77 (0.29-2.04)	
Air Force	1 [Reference]		1 [Reference]	
Occupation				
Combat specialist	1.64 (0.69-3.87)	.02	1.23 (0.51-3.00)	.07
Health care	1 [Reference]		1 [Reference]	
Functional support, service and supply	1.03 (0.43-2.44)		0.93 (0.39-2.22)	
Electrical or mechanical repair	1.96 (0.86-4.46)		1.49 (0.64-3.49)	
Other	0.59 (0.21-1.68)		0.46 (0.16-1.33)	
Pre-2001 deployment experience[e]				
No	1 [Reference]	.82	1 [Reference]	.63
Yes	0.94 (0.58-1.53)		0.88 (0.54-1.46)	
Military service status				
Current service member	1 [Reference]	.49	1 [Reference]	.40
Former service member	1.19 (0.72-1.97)		1.24 (0.75-2.05)	

Abbreviations: HR, hazard ratio; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom.

[a] Assessed at baseline except participants' deployment and military service status.

[b] Based on OIF/OEF deployment September 11, 2001-December 31, 2008.

[c] HR and 95% CI were significant (*P* <.05). OIF/OEF deployment was assessed as a time-varying covariate in which the number of deployments and cumulative days deployed were assessed as fixed covariates based on status at the end of follow-up.

[d] Ranks include junior enlisted (E1-E4), noncommissioned officer (E5-E9), and officer (O1-O10 and W1-W5).

[e] Deployed to the 1991 Gulf War or to Bosnia, Kosovo, or Southwest Asia 1998-2000.

ords, this study is the first, to our knowledge, to prospectively follow US service members from all military branches and components to assess suicide during and after military service.

The findings from this study are not consistent with the assumption that specific deployment-related characteristics, such as length of deployment, number of deployments, or combat experiences, are directly associated with increased suicide risk. Instead, the risk factors associated with suicide in this military population are consistent with civilian populations, including male sex and mental disorders.[30] Studies have shown a marked increase in the incidence of diagnosed mental disorders in active-duty service members since 2005, paralleling the incidence of suicide.[31] This suggests that the increased rate of suicide in the military may largely be a product of an increased prevalence of mental disorders in this population, possibly resulting from indirect cumulative occupational stresses across both deployed and home-station environments over years of war. In addition to screening for and addressing mental health problems, further research is needed to more clearly understand the interrelationship of multiple risk factors leading to suicidal behaviors and the types and timing of interventions that may reduce or prevent death by suicide.

Since data collection ended in 2008, we did not capture suicides in the most recent time period when the rates were

Table 4. Hazard Ratios for Suicide Among Millennium Cohort Participants

Characteristics[a]	Unadjusted HR (95% CI)	*P* Value	Age- and Sex-Adjusted HR (95% CI)	*P* Value
Sex				
Men	1.90 (1.09-3.33)[b]	.02	2.03 (1.15-3.56)[b]	.01
Women	1 [Reference]		1 [Reference]	
Age per 5-y increase	0.91 (0.80-1.03)	.13	0.89 (0.78-1.01)	.07
Education				
≤Some college	2.02 (1.07-3.81)[b]	.03	1.82 (0.94-3.51)	.07
≥Bachelor's degree	1 [Reference]		1 [Reference]	
Marital status				
Not married	0.97 (0.63-1.50)	.88	0.85 (0.52-1.39)	.52
Married	1 [Reference]		1 [Reference]	
Race/ethnicity				
White non-Hispanic	1 [Reference]	.27	1 [Reference]	.40
Black non-Hispanic	0.53 (0.23-1.22)		0.59 (0.26-1.38)	
Other	1.11 (0.64-1.93)		1.12 (0.65-1.95)	
Physical component score, percentile[c]				
<15th	1.13 (0.62-2.08)	.34	1.21 (0.66-2.22)	.37
15th-85th	1 [Reference]		1 [Reference]	
>85th	1.52 (0.87-2.66)		1.48 (0.84-2.59)	
Life stressors[d]				
Low/mild	1 [Reference]	.32	1 [Reference]	.06
Moderate/major	1.33 (0.76-2.33)		1.73 (0.97-3.08)	
PTSD[e]				
No	1 [Reference]	.09	1 [Reference]	.10
Yes	1.81 (0.91-3.62)		1.80 (0.90-3.60)	
Depression[e]				
No	1 [Reference]	<.001	1 [Reference]	<.001
Yes	2.70 (1.62-4.50)[b]		3.03 (1.80-5.08)[b]	
Manic depressive disorder[f]				
No	1 [Reference]	<.001	1 [Reference]	<.001
Yes	7.92 (3.20-19.60)[b]		7.92 (3.20-19.60)[b]	
Panic or other anxiety[g]				
No positive screen	1 [Reference]	.18	1 [Reference]	.15
Positive screen	1.85 (0.75-4.58)		1.96 (0.79-4.85)	
Heavy or binge drinking[h]				
No positive screen	1 [Reference]	.003	1 [Reference]	.02
Positive screen	1.99 (1.26-3.14)[b]		1.72 (1.07-2.76)[b]	
Alcohol-related problems[i]				
No positive screen	1 [Reference]	<.001	1 [Reference]	<.001
Positive screen	2.93 (1.83-4.69)[b]		2.64 (1.63-4.26)[b]	

Abbreviations: *DSM-IV, Diagnostic and Statistical Manual of Mental Disorders, Fourth ed*; HR, hazard ratio; PCL-C, PTSD Patient Checklist-Civilian Version; PTSD, posttraumatic stress disorder; PHQ, Patient Health Questionnaire; SF-36V, Short Form 36-Item Questionnaire for Veterans.

[a] Assessed at baseline except age (which was time-varying).

[b] HR and 95% CI were significant (*P* <.05).

[c] Computed using the SF-36V at baseline.

[d] Using a similar scoring mechanism,[20] life stress was based on major financial problems, violent or sexual assault, sexual harassment, severe illness or death of family member or loved one, and disabling illness or injury.

[e] Self-reported for ever being diagnosed or screened positive for PTSD (PCL-C) using the *DSM-IV* criteria or for depression using the PHQ-9.

[f] Self-reported for ever being diagnosed with manic-depressive disorder.

[g] Screened positive for panic or other anxiety syndrome (PHQ).

[h] Self-reported weekly consumption (>14 drinks for men, >7 for women); or per day or per occasion (>4 drinks for women, >5 drinks for men).

[i] Participants affirmed at least 1 of the 5 items from the PHQ alcohol questions.

the highest.[2] However, the study did include the 3 years with the sharpest statistically significant increases in suicides (seen especially in the Army and Marine Corps).[2] It is possible that the cumulative strain of multiple and lengthy deployments only began to be reflected in suicide rates toward the later stages of the conflicts, although the overall evidence points to the lack of any specific deployment-related effects.

The most important finding was that mental health problems, including manic-depressive disorder, depression, and alcohol-related problems, were significantly associated with an increase in the risk of suicide. These findings suggest that current prevention initiatives in the DoD and the Department of Veterans Affairs that address previous mental health disorders and involve screening and facilitation of high-quality treatment for mental and substance use disorders in primary care, specialty mental health care, and postdeployment settings have the greatest potential to mitigate suicide risk. However, there are limited studies that validate prevention initiatives and well-conducted program effectiveness trials should remain a high priority.

The PAR%s indicate that suicide deaths could potentially be reduced (by approximately 18% and 11%) in this population as a whole, by preventing or eliminating alcohol-related problems and depression, respectively (assuming

Table 5. Multivariable Cox Proportional Hazards Model for Suicide Among Millennium Cohort Participants, 2001-2008 (n=145387)[a]

Characteristic	Adjusted HR (95% CI)	*P* Value
OIF/OEF deployment[b]		
Not deployed	1 [Reference]	.82
Deployed without combat	1.22 (0.65-2.26)	
Deployed with combat	1.00 (0.58-1.73)	
Sex		
Men	2.14 (1.17-3.92)[c]	.01
Women	1 [Reference]	
Depression[d]		
No	1 [Reference]	.03
Yes	1.96 (1.05-3.64)[c]	
Manic depressive disorder[e]		
No	1 [Reference]	.005
Yes	4.35 (1.56-12.09)[c]	
Alcohol-related problems[f]		
No positive screen	1 [Reference]	<.001
Positive screen	2.56 (1.56-4.18)[c]	

Abbreviations: HR, hazard ratio; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; PHQ, Patient Health Questionnaire.

[a] Model adjusted for all shown variables.

[b] Based on OIF/OEF deployment September 11, 2001-December 31, 2008.

[c] HR and 95% CI were significant (*P* <.05).

[d] Self-reported diagnosis or screening positive for depression using the PHQ-9 at baseline.

[e] Self-reported for ever being diagnosed with manic-depressive disorder.

[f] Participants affirmed at least 1 of the 5 items from the PHQ alcohol questions.

Table 6. Conditional Logistic Regression for Suicide Among Matched Millennium Cohort Participants, 2001-2008 (n=1617)[a]

Characteristic	Adjusted OR (95% CI)	*P* Value
OIF/OEF deployment[b]		
Not deployed	1 [Reference]	.86
Deployed without combat	1.16 (0.60-2.26)	
Deployed with combat	0.95 (0.51-1.75)	
Depression[c]		
No	1 [Reference]	.002
Yes	2.68 (1.46-4.93)[e]	
Manic-depressive disorder[d]		
No	1 [Reference]	.002
Yes	7.38 (2.13-25.61)[e]	
Alcohol-related problems[f]		
No	1 [Reference]	.002
Yes	2.30 (1.35-3.91)[e]	

Abbreviations: OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; OR, odds ratio; PHQ, Patient Health Questionnaire.

[a] Each suicide case was matched to 20 nonsuicide control cases matched on sex, race/ethnicity, marital status, birth year (within 2 y), enrollment (within 180 d), service branch, and rank. Model was adjusted for all shown variables.

[b] Based on OIF/OEF deployment September 11, 2001-December 31, 2008.

[c] Self-reported diagnosis or screening positive for depression using the PHQ-9 at baseline.

[d] Self-reported for ever being diagnosed with manic-depressive disorder.

[e] OR and 95% CI are significant (*P* <.05).

[f] Participants affirmed at least 1 of the 5 items from the PHQ alcohol questions.

that these observed associations are causal and that elimination of these risk factors do not affect distribution of other covariates). Despite the larger magnitudes of the HRs for manic-depressive disorder, the PAR% shows that preventing or eliminating this disorder would have a smaller effect (≈ 5% reduction) due to the very low prevalence of this disorder in this population. In addition, male sex was also a strong contributing factor to suicide deaths (44%) in this population. These findings provide further evidence that the prevention and quality treatment of these mental health disorders may prevent suicide deaths.

This study has several limitations. The findings are based on 83 suicide deaths so the study may have lacked statistical power to produce a stable and reproducible multivariable model. As with any prospective cohort study, nonresponse on the initial survey or loss to follow-up may introduce bias. However, objective national registry-based mortality data obtained for all cohort members minimizes bias due to loss to follow-up. Additionally, a previous study examining weighting for nonresponse among panel 1 members of this cohort indicated that prevalence rates are comparable to results of unweighted analysis for PTSD, depression, and eating disorders.[32] Although the study relied on the PHQ and PCL-C self-report screening measures, these measures are standardized validated instruments shown to be reliable in this cohort.[24,33,34] The questions used to assess combat experience were also self-reported and based on 2 different instruments, but combat experience based on self-report has consistently been shown to be associated with a variety of adverse health outcomes.[7,35] This study could also be influenced by misclassification of suicide on death certificates. There is some evidence that suicides are underreported on death certificates[36]; however, this method of cause-specific mortality ascertainment has been widely accepted and there is no reason to believe that cause-of-death reporting on death certificates would be influenced by the risk factor variables that were studied.[37,38] The main findings were based on baseline data that were assessed an average of 3 years (mean [SD] 3.23 [2.03] years) prior to suicide; however, results using all available survey data were consistent. This study was only able to cover the first 3 years of an increasing trend in suicides occurring in military service members that began around 2005, therefore additional research will be needed to confirm these results using data from later years. Lastly, data from the first 3 panels of the Millennium Cohort, which consisted of different enrollment criteria, were combined due to the low numbers of suicides in this study population.

Key strengths of the study that reinforce the validity of the findings include the linkage of records with national registry-based mortality data, the consistency of results between Cox modeling and the nested case-control methods, and the fact that the study spanned the 3-year time period when the greatest increase in military suicides occurred. In addition, this study included individuals from all service branches including active and Reserve members, as well as those who have retired or are no longer serving in the military.

In conclusion, this study prospectively quantified military-specific risk factors associated with suicide in a cohort of military members who were followed-up for as long as 7 years. In this sample of current and former US military personnel, mental health concerns but not military-specific variables were found to be independently associated with suicide risk. The findings from this study do not support an association between deployment or combat with suicide, rather they are consistent with previous research indicating that mental health problems increase suicide risk. Therefore, knowing the psychiatric history, screening for mental and substance use disorders, and early recognition of associated suicidal behaviors combined with high-quality treatment are likely to provide the best potential for mitigating suicide risk.

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