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Research Submission

Headache Disorders in the Millennium Cohort: Epidemiology and Relations With Combat Deployment

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Objective.—Characterize migraine and other headache disorders within a large population-based US military cohort, with an emphasis on the temporal association between military deployment and exposure to combat.

Background.—Little research has been published on the prevalence of headache disorders in the US military population, especially in relation to overseas deployments and exposure to combat. A higher than expected prevalence of migraine has previously been reported among deployed US soldiers in Iraq, suggesting an association. Headache disorders, including migraine, could have important effects on the performance of service members.

Methods.—A total of 77,047 US active-duty, Reserve, and National Guard members completed a baseline questionnaire between July 2001 to June 2003 for the Millennium Cohort Study. Headache disorders were assessed using the following survey-based measures: self-reported history of provider-diagnosed migraine, recurrent severe headache within the past year, and recent headaches/bothered a lot within the past 4 weeks. Follow-up surveys were completed on average 3 years after baseline (mean = 2.7 years; range = 11.4 months to 4.5 years).

Results.—The overall male and female prevalence of self-reported headache conditions at baseline were: provider-diagnosed migraine, 6.9% and 20.9%, respectively; recurrent severe headache, 9.4% and 22.3%, respectively; and bothered a lot by headaches, 3.4% and 10.4%, respectively. Combat deployers had significantly higher odds of any new-onset headache disorders than non-deployers (adjusted odds ratios = 1.72 for men, 1.84 for women; 95% confidence intervals, 1.55-1.90 for men, 1.55-2.18 for women), while deployers without combat exposure did not.

Conclusions.—Deployed personnel with reported combat exposure appear to represent a higher risk group for new-onset headache disorders. The identification of populations at higher risk of development of headache provides support for targeted interventions.

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Key words: migraine, headache symptom, incidence, cohort study, military personnel

Abbreviations: AOR adjusted odds ratio, CI confidence interval, PTSD post-traumatic stress disorder, TBI traumatic brain injury

(*Headache* 2011;●●:●●-●●)

Although the impact of headaches in the military is significant, there remains a paucity of published research on the prevalence of headache disorders in the active-duty military population.¹⁻⁴ There were 106,837 ambulatory visits to military treatment facilities with a primary diagnosis of a headache disorder in US military active-duty personnel in 2007, corresponding to 5.4 visits per 100 person-years for migraine and 3.5 visits per 100 person-years for all non-migraine headache.⁵ Headache disorders also accounted for a substantial proportion of ambulatory visits to civilian facilities by active-duty military members.⁶ Since research in the civilian population suggests that only about half of migraineurs consult physicians for headache, these figures are likely conservative.^{7,8} Headache disorders remain one of the top 10 reasons for an involuntary medical discharge from the military.⁹

In a 2008 study, military personnel who had been recently deployed in support of the operations in Iraq and Afghanistan were interviewed by neurologists about headache symptoms.³ Surprisingly high rates of migraine and other headache were found in this predominantly young male cohort. Notably, most of the individuals identified as migraineurs (those reporting symptoms in the previous 12 months) were newly diagnosed, with only 25% reporting that they had received a medical diagnosis of migraine prior to the study. A 2008 study of US Army Officer trainees had similar findings, concluding that headaches are a common and underdiagnosed condition.⁴

Based on studies in the civilian population, headache or migraine sufferers among military members may exhibit higher than expected prevalence of prior head or neck injury, depression or anxiety disorders, post-traumatic stress disorder (PTSD), traumatic brain injury (TBI), and other chronic pain disorders.¹⁰⁻¹⁵ There is significant clinical overlap among these conditions, with patients often being diagnosed with more than 1 condition. A greater

understanding of the prevalence of headache in the deployed military population, and in particular those exposed to combat, may result in the development of interventions and effective therapeutic modalities for military members not only with headache, but with multiple neuropsychiatric conditions that have headache as a component. The development of new-onset headaches in our military cohort is thus a critical focus of this study since the longitudinal design allows the assessment of temporal relationships to deployment. Both post-traumatic and post-deployment headaches have not been well studied in active-duty or Reserve/National Guard military populations, and much is still unknown regarding headache disorders among those who have or have not been deployed to combat theaters of operations. In order to address these concerns, we used a survey database that contained multiple questions regarding headache disorders and exposure to combat, linked with electronic record of military deployment dates.

METHODS

To determine the prevalence of headaches in the US military, we utilized data from the Millennium Cohort Study, a 21-year longitudinal study launched in 2001 prior to the operations in Iraq and Afghanistan. The primary goal of the Millennium Cohort Study is to evaluate the impact of military service, including deployments and other occupational exposures, on the long-term health of US service men and women. A random sample of the 2.2 million US military members serving as of October 1, 2000 was invited to participate in the baseline cohort from 2001 to 2003. Women were oversampled and comprised approximately 25% of the study population. The original cohort has been described elsewhere in more detail.¹⁶

The current study population consists of consenting participants who completed both the baseline and first follow-up questionnaires. Of the 77,047 par-

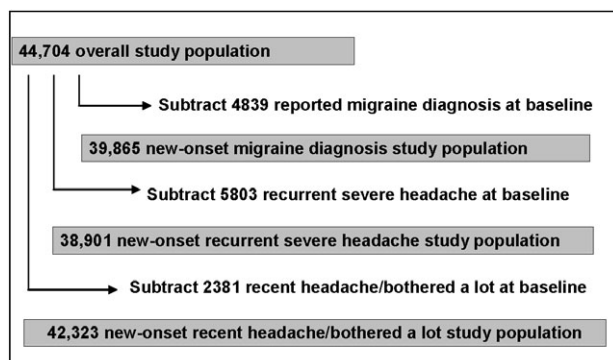


Fig 1.—Headache subgroup analysis participants.

Participants who completed the baseline questionnaire (July 2001 to June 2003), 55,021 completed the first follow-up questionnaire (June 2004 to February 2006). Follow-up surveys were completed on average 3 years after baseline (mean = 2.7 years; range = 11.6 months to 4.5 years). For the overall analysis, we excluded service members who deployed and returned prior to submission of their baseline questionnaire ($n = 2067$), were deployed during their baseline or first follow-up questionnaires ($n = 3221$), endorsed all 40 provider-diagnosed medical conditions at baseline or follow-up ($n = 115$), were missing outcome data (2470 migraine, 623 severe headache, 517 headache/bothered a lot), or were missing

covariate data ($n = 1304$), leaving a study population of 44,704 participants.

For the assessment of new-onset headache disorders, participants who reported provider-diagnosed migraine at baseline ($n = 4839$), severe headache at baseline ($n = 5803$), or headache/bothered a lot at baseline ($n = 2381$) were further excluded from each non-mutually exclusive subgroup analysis, leaving a final study population of 39,865 participants for the new-onset migraine analysis, 38,901 for the new-onset severe headache analysis, and 42,323 for the new-onset recent headache/bothered a lot analysis (Fig. 1). Additionally, for any new-onset headache disorders, we excluded individuals missing outcome or covariate data ($n = 6073$) in the subgroup analysis, leaving a final study population of 38,631 for the analysis of any new-onset headache disorder.

Migraine and Other Headache Disorders.—Migraine and headache history was assessed via 3 questions on the Millennium Cohort Study survey (Fig. 2). The denominator for new-onset proportion calculations excluded participants who reported the specified headache disorders at baseline. Non-headache sufferers were defined as participants who reported “no” to the respective headache questions at baseline and follow-up. New-onset migraine, severe headache, or headache/bothered a lot were defined as

Baseline Assessment			
Has your doctor or other health professional EVER told you that you have any of the following conditions?			
Migraine headaches	NO	YES	
	☐	☐	
DURING THE LAST 12 MONTHS , have you had persistent or recurring problems with any of the following conditions?			
Severe headache	NO	YES	
	☐	☐	
DURING THE LAST 4 WEEKS , how much have you been bothered by any of the following problems?			
Headaches	NOT BOTHERED	BOTHERED A LITTLE	BOTHERED A LOT
	☐	☐	☐
Follow-Up Assessment			
In the last 3 years , has your doctor or other health professional told you that you have any of the following conditions?			
Migraine headaches	NO	YES	
	☐	☐	
In the last 3 years , have you had persistent or recurring problems with any of the following?			
Severe headache	NO	YES	
	☐	☐	
During the last 4 weeks , how much have you been bothered by any of the following problems?			
Headaches	NOT BOTHERED	BOTHERED A LITTLE	BOTHERED A LOT
	☐	☐	☐

Fig 2.—Headache questions from the Millennium Cohort Study survey.

participants who answered “no” to the respective headache questions at baseline, and “yes” at follow-up. Any new-onset headache disorder was defined as participants having new-onset migraine, severe headache, and/or headache/bothered a lot at follow-up, compared with those who reported “no” to all 3 new-onset outcomes at follow-up. Participants with missing outcome data were not included in the comparison group.

Deployment Data.—Deployment data were obtained from the Defense Manpower Data Center, based on in- and out-of-theater dates from the military contingency tracking system. Deployment in support of the operations in Iraq and Afghanistan between baseline and follow-up surveys were categorized as non-deployed, deployed without reported combat exposures, and deployed with combat exposures.¹⁷ Combat exposure was defined as reporting any of the following in the past 3 years on the follow-up questionnaire: personally witnessing a person’s death due to war, disaster, or tragic event; personally witnessing instances of physical abuse (torture, beating, rape); and personally being exposed to dead and/or decomposing bodies, maimed soldiers or civilians, or prisoners of war or refugees.¹⁸ Of the 44,704 in our study population, 11.4% were deployed and not exposed to combat, 11.5% were deployed and exposed to combat, and 77.1% were not deployed between the 2 survey assessments.

Demographic and Military Service Characteristics.—Study participants were classified by sex, birth year (before 1960, 1960–1969, 1970 and later), race/ethnicity (non-Hispanic white, non-Hispanic black, other), military pay grade (enlisted, officer), service branch (Army, Air Force, Navy/Coast Guard, Marine Corps), and broad military occupation category (combat specialist, healthcare specialist, other) at baseline. Data were obtained from the Defense Manpower Data Center.

Primary Co-Morbidities and Behavioral Characteristics.—The Primary Care Evaluation of Mental Disorders Patient Health Questionnaire, embedded in the Millennium Cohort Study questionnaire, was used to assess depression symptoms, panic or other anxiety symptoms, and alcohol-related problems at baseline. Screen-positive depression, or

self-reported provider-diagnosed depression, was used to define depression symptoms or diagnosis.

Post-traumatic stress disorder symptoms were assessed through responses to the PTSD Checklist-Civilian Version embedded in the Millennium Cohort Study questionnaire, using the sensitive criteria as described in the PTSD Checklist-Civilian Version.¹⁹ Screen-positive PTSD, or self-reported provider-diagnosed PTSD, was used to define PTSD symptoms or diagnosis.

Bodily pain was assessed using the Medical Outcomes Study Short Form 36-Item Health Survey for Veterans, based on 2 items from the baseline questionnaire.²⁰ The first item asks whether participants had bodily pain during the past 4 weeks, and the second item asks how much did the pain interfere with normal work (both work outside the home and housework) during the past 4 weeks. The second item immediately follows the first on the questionnaire. Bodily pain scores were calculated, ranging from 0 to 100, with higher scores indicating less bodily pain. There was no difference in the 2 quartiles with less bodily pain (>50th to 75th percentile, and >75th percentile), thus these quartiles were combined.

Cigarette smoking was assessed using the baseline questionnaire with participants categorized as non-smoker, past smoker, and current smoker. Smoking status was based on self-report of lifetime smoking of at least 100 cigarettes (5 packs), a successful attempt to quit smoking, and cigarette use in the past year.

Statistical Analysis.—Proportions of migraine or headache disorders at baseline and follow-up, as well as new-onset proportions were calculated. Univariate analyses, including Pearson’s chi-square test of association, were completed to investigate unadjusted associations between new-onset provider-diagnosed migraine and other headache disorders and deployment. Multivariable logistic regression was used to investigate the adjusted odds of new-onset migraine and other headache outcomes by deployment status. Multicollinearity was assessed using a variance inflation factor of >4 as the threshold. Confounders were retained in the adjusted model if the variable changed the measure of association between the headache disorder and deployment by >10%. Interactions

between deployment and sex, as well as deployment and birth year, were tested and considered significant at $P \leq .10$. All statistical analyses were performed using SAS software, version 9.2 (SAS Institute, Inc., Cary, NC, USA). This study was approved by the institutional review board of the Naval Health Research Center and the research was conducted in compliance with all applicable federal regulations governing the protection of human subjects in research (protocol NHRC.2000.0007).

RESULTS

Prevalence of Headache and Migraine.—Results of descriptive analysis of self-reported headache disorders at baseline and follow-up are displayed in Table 1, with column results for all 3 headache categories by demographic and military service characteristics. The overall baseline prevalence of self-reported, provider-diagnosed headache conditions among male service members ($n = 32,295$) were: 6.9% ($n = 2240$) for migraine, 9.4% ($n = 3033$) for recurrent severe headache, and 3.4% ($n = 1088$) headaches/bothered a lot in the past 4 weeks. The overall baseline prevalence among female service members ($n = 12,409$) were: 20.9% ($n = 2599$) for migraine, 22.3% ($n = 2770$) for recurrent severe headache, and 10.4% ($n = 1293$) for headaches/bothered a lot in the past 4 weeks (Table 1).

Among those self-reporting any type of headache, there was considerable overlap in the 3 categories. Among male service members, new-onset headaches included 864 of 3115 (27.7%) individuals in more than 1 category, with 703 (22.6%) in 2 headache categories and 161 (5.2%) in all 3 (Fig. 3). New-onset headaches among female service members included 766 of 2347 (32.6%) individuals in more than 1 category, with 609 (25.9%) in 2 headache categories and 157 (6.7%) in all 3 (Fig. 3).

Deployment and Combat Exposure.—Combat deployers had a significantly higher odds of any new-onset headache disorder than non-deployers (adjusted odds ratio [AOR] = 1.72, 95% confidence interval [CI] 1.55-1.90 for men; AOR = 1.84, 95% CI 1.55-2.18 for women; Tables 2 and 3). However, deployers without combat did not have significantly increase odds of any new-onset headaches compared

to non-deployers (AOR = 1.07, 95% CI 0.95-1.21 for men; AOR = 0.96, 95% CI 0.80-1.14 for women). Similar trends were found in each of the separate new-onset outcomes of provider-diagnosed migraine, recurring severe headache, and recent headache/bothered a lot.

Other Covariates Associated With Headache.—Other baseline covariates that showed significantly elevated adjusted odds included younger age, enlisted pay grade, Army service, active-duty status, no alcohol-related problem, PTSD symptoms or diagnosis, depression symptoms or diagnosis, panic or other anxiety symptoms, and greater bodily pain.

In all headache outcomes, younger age was associated with higher odds of headache. In our statistical models, age inconsistently was shown to be an effect modifier of the association between deployment and headache disorders among male and female service members. Since these potential interaction terms were of limited clinical importance, they were, therefore, not shown in Tables 2 and 3. There was a significantly higher odds of headaches among enlisted military personnel compared with officers.

Having previous PTSD symptoms or diagnosis showed one of the highest odds of reporting new-onset provider-diagnosed migraine (AOR = 2.24, 95% CI 1.89-2.82 for men; AOR = 1.48, 95% CI 1.10-1.99 for women), as well as any new-onset headache disorders (AOR = 1.92, 95% CI 1.61-2.29 for men; AOR = 1.60, 95% CI 1.28-2.01 for women). Similarly, those with depression symptoms or diagnosis showed higher odds of any new-onset headache disorder for both male and female service members.

A higher level of baseline bodily pain increased the odds of later developing headaches. As the level of bodily pain increased so did the odds of developing headaches. In contrast, alcohol-related problems at baseline significantly decreased the odds of newly reported migraine diagnosis (AOR = 0.66, 95% CI 0.52-0.83 for men; AOR = 0.64, 95% CI 0.47-0.87 for women). This was similar for new-onset recurrent severe headache and any new-onset headache disorders, although there was no significant association for recent headache/bothered a lot. In the adjusted models there was no association between headaches and race/ethnicity or occupation.

Table 1.— Proportion of Baseline, Follow-Up, and New-Onset Headache Disorders Among Participants Who Completed the Follow-Up Survey

Characteristics*	Provider-Diagnosed Migraine, n (%)			Recurrent Severe Headache, n (%)			Recent Headache/Bothered a Lot, n (%)		
	Baseline†	Follow-Up‡	New-Onset§	Baseline†	Follow-Up‡	New-Onset§	Baseline†	Follow-Up‡	New-Onset§
Deployment									
Non-deployed	3946 (11.5)	3406 (9.9)	1241 (4.1)	4669 (13.5)	5860 (17.0)	2873 (9.6)	1947 (5.7)	2155 (6.3)	1336 (4.1)
Deployed no combat	380 (7.4)	344 (6.7)	148 (3.1)	495 (9.7)	696 (13.6)	401 (8.7)	189 (3.7)	254 (5.0)	178 (3.6)
Combat deployed	513 (10.0)	537 (10.5)	257 (5.6)	639 (12.5)	1134 (22.1)	693 (15.5)	245 (4.8)	387 (7.6)	283 (5.8)
Sex									
Male	2240 (6.9)	1941 (6.0)	879 (2.9)	3033 (9.4)	4155 (12.9)	2379 (8.1)	1088 (3.4)	1289 (4.0)	882 (2.8)
Female	2599 (20.9)	2346 (18.9)	767 (7.8)	2770 (22.3)	3535 (28.5)	1588 (16.5)	1293 (10.4)	1507 (12.1)	915 (8.2)
Baseline age, years									
<35	2251 (10.5)	2195 (10.3)	956 (5.0)	3106 (14.6)	4260 (20.0)	2276 (12.5)	1301 (6.1)	1600 (7.5)	1058 (5.3)
≥35	2588 (11.1)	2095 (9.0)	690 (3.3)	2697 (11.6)	3430 (14.7)	1691 (8.2)	1080 (4.6)	1196 (5.1)	739 (3.3)
Race/ethnicity									
Non-Hispanic white	3360 (10.6)	2861 (9.0)	1079 (3.8)	3947 (12.4)	5297 (16.7)	2770 (10.0)	1586 (5.0)	1880 (5.9)	1210 (4.0)
Non-Hispanic black	774 (14.2)	747 (13.7)	293 (6.3)	966 (17.8)	1193 (21.9)	556 (12.4)	440 (8.1)	493 (9.1)	305 (6.1)
Other	705 (9.4)	679 (9.1)	274 (4.0)	890 (11.9)	1200 (16.0)	641 (9.7)	355 (4.7)	423 (5.7)	282 (4.0)
Military pay grade									
Enlisted	3799 (11.7)	3493 (10.8)	1386 (4.9)	4868 (15.0)	6457 (20.0)	3317 (12.1)	2077 (6.4)	2427 (7.5)	1545 (5.1)
Officer	1040 (8.4)	794 (6.4)	260 (2.3)	935 (7.6)	1233 (10.0)	650 (5.7)	304 (2.5)	369 (3.0)	252 (2.1)
Service branch									
Army	2509 (11.8)	2336 (10.9)	928 (4.9)	3098 (14.5)	4192 (19.6)	2162 (11.9)	1303 (6.1)	1550 (7.3)	987 (4.9)
Air Force	1276 (9.7)	1055 (8.0)	392 (3.3)	1440 (10.9)	1927 (14.6)	1017 (8.7)	543 (4.1)	656 (5.0)	436 (3.5)
Navy/Coast Guard	895 (10.8)	744 (9.0)	255 (3.5)	1046 (12.6)	1285 (15.5)	634 (8.8)	444 (5.4)	484 (5.8)	303 (3.9)
Marine Corps	159 (8.4)	152 (8.0)	71 (4.1)	219 (11.6)	286 (15.1)	154 (9.2)	91 (4.8)	106 (5.6)	71 (4.0)
Service component									
Reserve/National Guard	2241 (11.1)	1764 (8.7)	623 (3.5)	2239 (11.1)	3033 (15.0)	1599 (8.9)	889 (4.4)	1067 (5.3)	701 (3.6)
Active duty	2598 (10.6)	2523 (10.3)	1023 (4.7)	3564 (14.6)	4657 (19.0)	2368 (11.3)	1492 (6.1)	1729 (7.1)	1096 (4.8)
Occupation									
Other	3408 (11.2)	3070 (10.1)	1197 (4.4)	4224 (13.9)	5592 (18.4)	2874 (11.0)	1781 (5.9)	2108 (6.9)	1345 (4.7)
Combat specialist	540 (6.0)	500 (5.6)	235 (2.8)	756 (8.5)	1077 (12.0)	616 (7.5)	260 (2.9)	340 (3.8)	245 (2.8)
Healthcare specialist	891 (16.8)	717 (13.5)	214 (4.9)	823 (15.5)	1021 (19.3)	477 (10.7)	340 (6.4)	348 (6.6)	207 (4.2)
Alcohol-related problem									
No	4381 (11.0)	3926 (9.8)	1503 (4.2)	5172 (13.0)	6875 (17.2)	3532 (10.2)	2135 (5.4)	2514 (6.3)	1602 (4.2)
Yes	458 (9.5)	361 (7.5)	143 (3.3)	631 (13.1)	815 (16.9)	435 (10.4)	246 (5.1)	282 (5.9)	195 (4.3)
Cigarette smoking									
Non-smoker	2634 (9.9)	2407 (9.1)	961 (4.0)	3106 (11.7)	4211 (15.9)	2204 (9.4)	1262 (4.8)	1525 (5.7)	1011 (4.0)
Past smoker	1340 (11.8)	1175 (10.3)	426 (4.2)	1548 (13.6)	2034 (17.9)	1039 (10.6)	642 (5.6)	727 (6.4)	447 (4.2)
Current smoker	865 (12.8)	705 (10.4)	259 (4.4)	1149 (17.0)	1445 (21.4)	724 (12.9)	477 (7.1)	544 (8.1)	339 (5.4)
PTSD symptoms or diagnosis									
No	4196 (9.9)	3757 (8.8)	1475 (3.8)	4920 (11.6)	6820 (16.0)	3679 (9.8)	1936 (4.6)	2386 (5.6)	1605 (4.0)
Yes	643 (30.1)	530 (24.8)	171 (11.4)	883 (41.3)	870 (40.7)	288 (23.0)	445 (20.8)	410 (19.2)	192 (11.3)
Depression symptoms or diagnosis									
No	3705 (9.1)	3371 (8.3)	1396 (3.8)	4429 (10.9)	6265 (15.4)	3469 (9.5)	1700 (4.2)	2156 (5.3)	1482 (3.8)
Yes	1134 (28.9)	916 (23.4)	250 (9.0)	1374 (35.1)	1425 (36.4)	498 (19.6)	681 (17.4)	640 (16.3)	315 (9.7)
Panic attack or anxiety symptoms									
No	4462 (10.2)	3933 (9.0)	1550 (4.0)	5250 (12.1)	7145 (16.4)	3811 (10.0)	2041 (4.7)	2521 (5.8)	1692 (4.1)
Yes	377 (33.1)	354 (31.1)	96 (12.6)	553 (48.5)	545 (47.8)	156 (26.6)	340 (29.8)	275 (24.1)	105 (13.1)
Bodily pain¶									
>50th percentile	568 (5.2)	507 (4.6)	250 (2.4)	456 (4.2)	893 (8.1)	647 (6.1)	129 (1.2)	284 (2.6)	238 (2.2)
>25-50th percentile	1698 (8.5)	1444 (7.2)	619 (3.4)	1874 (9.4)	2772 (13.9)	1660 (9.2)	579 (2.9)	847 (4.3)	657 (3.4)
0-25th percentile	2573 (18.7)	2336 (17.0)	777 (6.9)	3473 (25.2)	4025 (29.2)	1660 (16.1)	1673 (12.2)	1665 (12.1)	902 (7.5)

* $P < .05$ unless otherwise noted from Pearson's chi-square test.|| $P \geq .05$ from Pearson's chi-square test.

†Baseline outcome among participants who completed a follow-up survey with deployment assessed between surveys.

‡Follow-up outcome among participants who completed a follow-up survey with deployment assessed between surveys.

§New-onset outcome excluding participants with previous outcome data at baseline.

¶Higher score indicates less bodily pain.

PTSD = post-traumatic stress disorder.

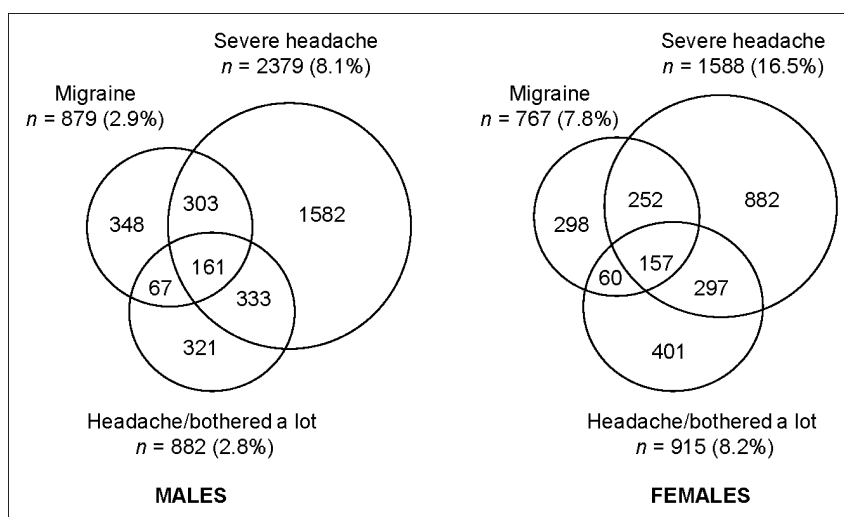


Fig 3.—Overlap in self-reported new-onset headache conditions.

DISCUSSION

Prevalence of Headache and Migraine.—The overall self-report at baseline of ever having a migraine diagnosis was 6.9% for men and 20.9% for women, which is consistent with previous studies of civilian populations.^{21,22} The prevalence of migraine in our military population is likely underestimated, since it is based on self-report of provider-diagnosed migraine, and the literature suggests that about half of migraineurs in civilian populations do not consult physicians and remain undiagnosed.^{7,8} Our overall change in migraine prevalence from baseline to follow-up was minimal in combat deployers (from 10.0% to 10.5%), although the magnitude of the increase may have been affected by the limited time of reporting (mean = 2.7 years; range = 11.4 months to 4.5 years) between the assessments. Additionally, since the baseline question assessed lifetime migraine, individuals with a history of childhood migraine only may have responded affirmatively to the migraine question at baseline and negatively on the follow-up questionnaire, which requested information for the past 3 years. The actual increase in the occurrence of migraine headache may therefore be higher.

In a recent review of serial, cross-sectional assessments of medical encounters for migraine in the active-duty military population, the post-deployment group had a higher frequency of migraines (2.5% of

men and 10.6% of women) than the pre-deployment group (1.7% of men and 7.8% of women).²³ In the current study, among the 6240 active-duty participants who deployed between baseline and follow-up surveys, we did not see a similar trend in significantly increased migraines after deployment (6.3% of men and 20.9% of women reported migraine prior to deployment, and 6.4% of men and 20.6% of women reported migraine at follow-up). It is possible that the other categories of self-reported headache that did show substantial increases in prevalence between baseline and follow-up could actually represent migraine headaches. A major difference between the previous Army studies and our current study is that the other studies captured headache immediately following deployment, while our study captured headache at follow-up survey, averaging approximately 11.3 months following return from deployment, likely representing more intermediate to long-term residual headache disorders.

Deployment and Combat Exposure.—We observed proportionately fewer headaches among those who deployed without combat than those who did not deploy (Table 1). Two factors may play a role in this observation. First, each military service has policies in place to ensure that only the healthiest personnel deploy, leaving behind a pool of deployment-ineligible personnel with various medical conditions, some with associated headache

Table 2.—Adjusted Odds of New-Onset Migraine and Other Headache Disorders Among Male Service Members

Covariates	Migraine (n = 879/ 30,055), OR† (95% CI)	Severe Headache (n = 2379/29,262), OR† (95% CI)	Headache/Bothered a Lot (n = 882/31,207), OR† (95% CI)	Any Headache Disorder (n = 3115/29,056), OR† (95% CI)
Deployment status				
Non-deployed	1.00	1.00	1.00	1.00
Deployed no combat	1.03 (0.82-1.29)	1.06 (0.93-1.22)	1.06 (0.85-1.33)	1.07 (0.95-1.21)
Deployed combat	1.53 (1.28-1.83)	1.79 (1.60-2.01)	1.41 (1.17-1.69)	1.72 (1.55-1.90)
Baseline age, years				
<35	1.00	1.00	1.00	1.00
≥35	0.93 (0.80-1.07)	0.81 (0.74-0.89)	0.87 (0.75-1.00)	0.84 (0.77-0.91)
Military pay grade				
Enlisted	1.00	1.00	1.00	1.00
Officer	0.52 (0.43-0.62)	0.44 (0.39-0.49)	0.40 (0.33-0.49)	0.45 (0.40-0.50)
Service branch				
Army	1.00	1.00	1.00	1.00
Air Force	0.74 (0.62-0.88)	0.76 (0.69-0.85)	0.72 (0.60-0.85)	0.76 (0.69-0.84)
Navy/Coast Guard	0.77 (0.63-0.94)	0.73 (0.64-0.83)	0.74 (0.60-0.90)	0.75 (0.67-0.84)
Marine Corps	1.03 (0.77-1.37)	0.76 (0.62-0.93)	0.86 (0.64-1.17)	0.75 (0.62-0.90)
Service component				
Reserve/National Guard	1.00	1.00	1.00	1.00
Active duty	1.39 (1.19-1.61)	1.28 (1.17-1.41)	1.35 (1.16-1.57)	1.34 (1.23-1.46)
Alcohol-related problem				
No	1.00	1.00	—	1.00
Yes	0.66 (0.52-0.83)	0.81 (0.70-0.92)	—	0.79 (0.70-0.90)
PTSD symptoms or diagnosis				
No	1.00	1.00	1.00	1.00
Yes	2.24 (1.73-2.89)	1.54 (1.26-1.89)	1.88 (1.46-2.41)	1.92 (1.61-2.29)
Depression symptoms or diagnosis				
No	1.00	1.00	1.00	1.00
Yes	1.40 (1.09-1.80)	1.56 (1.32-1.86)	1.53 (1.21-1.94)	1.78 (1.53-2.07)
Panic or other anxiety symptoms				
No	—	1.00	—	1.00
Yes	—	1.70 (1.29-2.25)	—	1.70 (1.33-2.17)
Bodily pain				
>50th percentile	1.00	1.00	1.00	1.00
>25-50th percentile	1.16 (0.95-1.42)	1.44 (1.28-1.63)	1.45 (1.17-1.81)	1.53 (1.36-1.71)
0-25th percentile	2.31 (1.89-2.82)	2.59 (2.28-2.94)	3.10 (2.50-3.85)	2.99 (2.67-3.36)

† Adjusted odds ratio for covariates shown. Dashes indicate covariates not adjusted in model. Bolding indicates statistical significance. CI = confidence interval; OR = odds ratio; PTSD = post-traumatic stress disorder.

symptoms. Second, men are more likely to deploy (25.8% of men deployed vs 15.3% of women), and men are less likely to have headaches than women. After adjusting for covariates in multivariable modeling, however, there were no significant differences in new-onset headache disorders between deployers without combat and non-deployers. This finding is noteworthy because it runs counter to the healthy deployer effect. It may be that the stresses of deployment counteract this expected advantage.

Multiple factors can predispose deployed military members to headache, including physical, dietary, and psychological factors. A recently published study of headache triggers in the US military revealed the most common categories as environmental factors, stress, consumption-related factors, and fatigue-related factors.²⁴ Deployed soldiers are more likely to be exposed to these triggers. Alternatively, the apparent stability of headache prevalence among deployers without combat may be due to successful integration

Table 3.—Adjusted Odds of New-Onset Migraine and Other Headache Disorders Among Female Service Members

Covariates	Migraine (n = 767/9810), OR† (95% CI)	Severe Headache (n = 1588/9639), OR† (95% CI)	Headache/Bothered a Lot (n = 915/11,116), OR† (95% CI)	Any Headache Disorder (n = 2347/9575), OR† (95% CI)
Deployment status				
Non-deployed	1.00	1.00	1.00	1.00
Deployed no combat	0.76 (0.57-1.03)	0.99 (0.81-1.20)	1.14 (0.89-1.46)	0.96 (0.80-1.14)
Deployed combat	1.51 (1.17-1.94)	1.95 (1.61-2.35)	2.02 (1.62-2.51)	1.84 (1.55-2.18)
Baseline age, years				
<35	1.00	1.00	1.00	1.00
≥35	0.72 (0.61-0.86)	0.70 (0.62-0.80)	0.73 (0.63-0.85)	0.71 (0.64-0.79)
Military pay grade				
Enlisted	1.00	1.00	1.00	1.00
Officer	0.54 (0.44-0.67)	0.58 (0.50-0.66)	0.53 (0.44-0.65)	0.57 (0.50-0.64)
Service branch				
Army	1.00	1.00	1.00	1.00
Air Force	0.74 (0.62-0.89)	0.84 (0.73-0.96)	0.89 (0.75-1.05)	0.85 (0.76-0.96)
Navy/Coast Guard	0.71 (0.57-0.88)	0.87 (0.74-1.02)	0.98 (0.81-1.18)	0.87 (0.76-1.00)
Marine Corps	0.64 (0.37-1.10)	0.81 (0.55-1.19)	0.86 (0.54-1.38)	0.83 (0.59-1.18)
Service component				
Reserve/National Guard	1.00	1.00	1.00	1.00
Active duty	1.34 (1.14-1.57)	1.33 (1.18-1.49)	1.30 (1.12-1.50)	1.28 (1.15-1.41)
Alcohol-related problem				
No	1.00	1.00	—	1.00
Yes	0.64 (0.47-0.87)	0.98 (0.80-1.20)	—	0.90 (0.75-1.07)
PTSD symptoms or diagnosis				
No	1.00	1.00	1.00	1.00
Yes	1.48 (1.10-1.99)	1.33 (1.02-1.72)	1.33 (1.02-1.73)	1.60 (1.28-2.01)
Depression symptoms or diagnosis				
No	1.00	1.00	1.00	1.00
Yes	1.38 (1.11-1.71)	1.31 (1.10-1.55)	1.45 (1.20-1.75)	1.55 (1.33-1.79)
Panic or other anxiety symptoms				
No	—	1.00	—	1.00
Yes	—	1.14 (0.83-1.58)	—	1.40 (1.06-1.86)
Bodily pain				
>50th percentile	1.00	1.00	1.00	1.00
>25-50th percentile	1.66 (1.32-2.08)	1.62 (1.39-1.89)	1.54 (1.25-1.90)	1.70 (1.49-1.94)
0-25th percentile	2.51 (1.99-3.17)	2.32 (1.97-2.73)	2.59 (2.10-3.21)	2.77 (2.41-3.20)

†Adjusted odds ratio for covariates shown. Dashes indicate covariates not adjusted in model. Bolding indicates statistical significance. CI = confidence interval; OR = odds ratio; PTSD = post-traumatic stress disorder.

of preventive measures. Preventive measures may have included pre-deployment screening, efforts to mitigate the psychological and physical stresses of non-combat troops, and embedded medical personnel within the deployment bases with limited combat exposure.

Those exposed to combat, however, are generally positioned at forward-deployed locations that may have inherently higher levels of physical and psychological stressors, and less equipment and support staff to mitigate headache-inducing exposures (strenuous

physical exertion, elevated ambient temperatures, dehydration, prolonged uncomfortable postures, bright light, caffeine withdrawal/other dietary changes, and sleep disruption). Our study did not assess these exposures or dietary factors.

Although we were unable to capture data on TBI in our study population, our finding of increased headaches among combat deployers compared with non-deployers may in part be due to TBI or other injuries without TBI. Combat operations increase the risk of exposure to TBI, including blast-induced pres-

sure waves from improvised explosive devices. In 2008, Hoge et al found that after adjusting for PTSD and depression, mild TBI was significantly associated with headache.²⁵ The study reported physical symptoms of headache in 32% of patients with loss of consciousness, 18% with injury with altered mental awareness, 12% with other injury, and 8% with no injury. In our current study, almost twice as many deployers with combat exposure self-reported new-onset recurrent severe headaches than deployers without combat (15.5% vs 8.7%; Table 1). These numbers suggest that in addition to the combat exposures assessed, TBI or other injuries may play an important role in the association between exposure to combat during deployment and subsequent occurrence of headache disorders.

Although individuals completing surveys during deployment were excluded from overall analyses, we did perform a separate subgroup analysis that compared this group and non-deployers. Among men who were deployed during either the baseline or follow-up assessment, those without combat exposure were less likely to report recurrent severe headache than were non-deployers (AOR = 0.70; 95% CI 0.51-0.96). A similar association was not found among women. This suggests the possibility that the deploying male population has a lower baseline prevalence of headaches, but after deployment their headaches increase to the level of the non-deployed population. This finding provides support for continued preventive measures to mitigate headache-inducing factors. The subgroup of deployed men and women with combat exposure did not show an association with any of the new-onset headache categories.

Other Covariates Associated With Headache.—Younger age (<35 years at baseline) was associated with higher odds of newly reported recurrent headache, as well as any new-onset headache disorder at follow-up approximately 3 years later. No association with age was found among those with new-onset migraine or headache/bothered a lot. Previous studies have shown increased migraine prevalence up to about age 40 years with a subsequent decline over time.^{26,27} However, a study of frequent headaches (both with and without migrainous features) in a civilian population did not show a clear association with

age.²⁸ In our study, those in the older age group had fewer headaches, possibly because of the healthy worker effect since individuals with poor health are more likely to leave the work force, while those in good health are more likely to remain employed as they age. In the military, those who have debilitating headaches may voluntarily separate from military service at the end of their initial period of obligation (generally 4 to 6 years), particularly if limited performance of duties can negatively affect their career advancement potential within the organization. A headache disorder is one of the top 10 reasons for an involuntary medical discharge from the military, and pre-existing headache disorders is one of the most common conditions for military discharge. Ranked by service, it is fourth for the Marine Corps, sixth for Air Force, seventh for Army, and 13th for Navy.⁷ The Millennium Cohort Study follows participants even after separation from military service. In this study, we did not find a difference between separated personnel (13.3% of our cohort) and non-separated personnel (86.7%) who reported new-onset migraine, after adjusting for covariates (AOR = 1.06, 95% CI 0.88-1.29 for men; AOR = 1.07, 95% CI 0.86-1.32 for women).

Consistent with other published literature describing an association between lower socio-economic status and headaches, significantly more new-onset headaches occurred in enlisted service members, who may have lower socio-economic status compared with officers. According to previous studies, those who experience more frequent economic problems had almost twice the risk of recurrent headache or migraine.^{29,30} Having previous PTSD symptoms or diagnosis, depression symptoms or diagnosis, or panic or other anxiety symptoms were all associated with having higher odds of self-reported new-onset headache conditions. These findings are similar to what is found in the civilian population for these mental health conditions.^{12,31}

The odds of developing new-onset headaches increased as the level of bodily pain at baseline increased. A concern is lack of specificity for this variable in our questionnaire. Although the bodily pain questions were asked following 3 earlier sections that included questions about migraine or headaches,

some individuals may have considered bodily pain as including headache. Participants reporting headache at baseline (who may have double counted their headache as bodily pain) were excluded for our assessment of new-onset headaches. Among all of the variables, reports of bodily pain at baseline had the highest odds of self-reported new-onset headaches at follow-up. This suggests the potential for early preventive intervention in this subgroup to prevent or reduce the development of headaches. It may also indicate that certain individuals have a lower threshold for pain and a greater propensity to report any pain. Certainly, the association between headaches and other bodily pain supports a multidisciplinary approach to pain management within military treatment facilities.

Alcohol is a known migraine trigger for many individuals; therefore, those with migraine symptoms may have a tendency to abstain or limit their alcohol intake.^{32,33} This could explain the finding of significantly fewer alcohol-related problems in service members reporting migraines.

We had expected combat occupations to be associated with headache disorders through increased exposure to environmental and emotional factors that could potentially trigger headaches. However, occupation was neither significantly associated with headache outcomes ($P > .05$) nor a potential confounding factor in univariate analysis and was therefore not included in the final adjusted models. Occupation-related risk factors may have been offset by more intensive training, increased attention to the process of acclimatization to deployments, or an increased emphasis on health maintenance at the combat unit level. Alternatively, it may be that the nature of the current operations in Iraq and Afghanistan is resulting in equally stressful deployment experiences for those in non-combat occupations. In the current battlefield environment, those in non-combat occupations may still find themselves forward deployed in support roles, and may have similar hardships associated with separation from family, relationship issues, and anxiety regarding improvised explosive devices, physical injury, or death.

Strengths and Limitations.—We recognize several limitations inherent in our study. The post-

deployment time frame is broad (mean = 11.4 months; median range = 1 day to 3.7 years), and we were not able to evaluate the interval from completion of the actual combat exposure until the follow-up questionnaire. Although we cannot determine exact dates for the new onset of headache disorders (during pre-deployment training, actual deployment, or the post-deployment period) since the survey question asks about symptoms or diagnoses during the last 3 years at follow-up, we did exclude participants with the condition at baseline and also ensured that deployment occurred between baseline and follow-up surveys. Another limitation is that we applied a very specific definition to categorize individuals as “combat deployed” using available data from this cohort study. As a result, it is possible that combat exposure misclassification could have occurred.

Even though it is preferable to classify the headache disorders by the International Classification of Headache Disorders, we were not able to determine the type of headaches experienced by the participants who responded to the frequent recurrent headache and recent headache questions. In a previous study utilizing data from the Millennium Cohort that examined percent agreement between self-reported medical conditions and electronic medical encounter data, self-reported migraine headaches had high negative agreement with medical encounter data at 95.0%, and only fair positive agreement at 39.2%.³⁴ The 2 additional headache questions, however, cast a broader net to identify headache disorders, some of which may be undiagnosed migraine.

Another limitation of this study is the inability to assess the lifetime prevalence of headache disorders at follow-up, since participants were only asked if they “ever” had the condition at baseline compared with “last 3 years” at follow-up. This study method, however, does allow the estimation of headache prevalence at baseline, and new-onset headache disorders at follow-up. We recognize that differences in study design and case definitions make direct comparisons to previously published studies difficult. Nevertheless, we feel that overall our findings are consistent with other published studies and likely generalizable to the military population as a whole, and perhaps other similar populations.

Despite these limitations, this study has several strengths. Our study population is a large occupational cohort with prospectively collected data, and we had the ability to assess a large number of covariates in addition to multiple headache measures. To our knowledge, this is the first study to prospectively examine associations between military deployment and self-reported migraine and other headache disorders in all service branches, as well as Reserve and National Guard components, even after separation from military service. The study addresses headache symptoms based on 3 separate survey responses, providing an opportunity to evaluate a broader range of headache conditions. It characterizes headache disorders related to combat deployment in support of the operations in Iraq and Afghanistan in a large mixed-gender, population-based cohort, with oversampling of female military members by design.

In this study, we did not evaluate job performance, lost duty days, use of medical resources through outpatient visits, limited duty or change in occupation, life stressors, sleep patterns, pain, or environmental conditions in relation to potential headache disorder. We were also not able to adjust for injury, particularly TBI. Further studies addressing these metrics may allow us to better understand, prevent, or treat headache disorders among military personnel, particularly those participating in combat operations, and may assist in development of modifications to pre-deployment screening, preventive measures while deployed, and treatment strategies for those returning from military deployment.

CONCLUSION

The results of our study confirmed that migraine and other headache disorders occur frequently in the US Armed Forces, and there is a significant increase in new-onset headaches and migraine among military personnel who are deployed with combat exposure. These findings may be applicable to short- and long-term policy measures to improve the health of deployable military personnel by raising awareness among physicians and patients about the necessity of correctly identifying different types of headaches in high-risk groups, counseling patients about potential individual headache triggers, and applying appropri-

ate treatment and follow-up. Further examination of environmental and socio-behavioral triggers is warranted to possibly lessen the burden of headaches and migraine among deployed service members.

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14. ABSTRACT Objective: Characterize migraine and other headache disorders within a large population-based US military cohort, with an emphasis on the temporal association between military deployment and exposure to combat. Background: A higher than expected prevalence of migraine has previously been reported among deployed US soldiers in Iraq, suggesting an association. Headache disorders, including migraine, could have important consequences for military service members' performance. Methods: A total of 77,047 US active-duty, Reserve, and National Guard members completed baseline and follow-up questionnaires for the Millennium Cohort Study. Headache disorders were assessed using the following survey-based measures: self-reported history of provider-diagnosed migraine, recurrent severe headache within the past year, and recent headaches/bothered a lot within the past 4 weeks. Results: Combat deployers had significantly higher odds of any new-onset headache disorders than nondeployers (adjusted odds ratio [AOR] = 1.72, 95% confidence interval [CI] = 1.55-1.90 for men; AOR = 1.84, 95% CI = 1.55-2.18 for women), while deployers without combat exposure did not. Conclusions: Deployed personnel with reported combat exposure appear to represent a higher risk group for new-onset headache disorders. The identification of populations at higher risk of development of headache provides support for targeted interventions. migraine, headache symptoms, incidence, cohort studies, military personnel					
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