



Hearing Loss Associated with US Military Combat Deployment

*Timothy S. Wells
Amber D. Seelig
Margaret A. K. Ryan
Jason M. Jones
Tomoko I. Hooper
Isabel G. Jacobson
Edward J. Boyko*



Naval Health Research Center

Report No. 13-59

The views expressed in this article are those of the authors and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, nor the U.S. Government. Approved for public release: distribution is unlimited.

This research has been conducted in compliance with all applicable federal regulations governing the protection of human subjects in research.

*Naval Health Research Center
P.O. BOX 85122
San Diego, California 92186-5122*

Hearing loss associated with US military combat deployment

Timothy S. Wells¹, Amber D. Seelig^{2,3}, Margaret A. K. Ryan⁴, Jason M. Jones⁴, Tomoko I. Hooper⁵, Isabel G. Jacobson², Edward J. Boyko^{3,6}

¹Advanced Analytics Optum, Ann Arbor, MI, San Diego, CA, ²Naval Health Research Center, ⁴Naval Hospital Camp Pendleton, San Diego, CA, ⁵Department of Preventive Medicine and Biometrics, Uniformed Services University of the Health Sciences, Bethesda, MD, ³Epidemiologic Research and Information Center, VA Puget Sound Health Care System, Seattle, WA, ⁶Department of Medicine, University of Washington, Seattle, WA, USA

Abstract

The objective of this study was to define the risk of hearing loss among US military members in relation to their deployment experiences. Data were drawn from the Millennium Cohort Study. Self-reported data and objective military service data were used to assess exposures and outcomes. Among all 48,540 participants, 7.5% self-reported new-onset hearing loss. Self-reported hearing loss showed moderate to substantial agreement ($k = 0.57-0.69$) with objective audiometric measures. New-onset hearing loss was associated with combat deployment (adjusted odds ratio [AOR] = 1.63, 95% confidence interval [CI] = 1.49-1.77), as well as male sex and older age. Among deployers, new-onset hearing loss was also associated with proximity to improvised explosive devices (AOR = 2.10, 95% CI = 1.62-2.73) and with experiencing a combat-related head injury (AOR = 6.88, 95% CI = 3.77-12.54). These findings have implications for health care and disability planning, as well as for prevention programs.

Keywords: Combat disorders, hearing loss, military personnel

Introduction

The association between US military service and hearing loss continues to receive significant attention, especially in light of recently completed and ongoing combat deployments in Iraq and Afghanistan.^[1-4] Nearly one-half million US veterans are currently receiving over \$1 billion annually in Department of Veterans Affairs (VA) compensation for hearing loss.^[5] As a result, hearing loss is the most common service-connected disability.^[6] Traditionally, most hearing loss associated with military service has been caused by high intensity and/or impulse noise.^[1] In recent years, an increasing number of US service members have hearing loss as a result of being in proximity to the detonation of explosive devices in the Iraq and Afghanistan operations.^[7] For example, deployment has been observed to increase the risk of hearing loss, with 71% of soldiers returning from Iraq or Afghanistan reporting

exposure to loud noise, and more than 15% of returnees reporting ringing in their ears.^[8]

Hearing loss is a significant health and readiness issue for the US military since afflicted personnel exposed to hazardous noise are more likely to suffer additional hearing damage,^[9] and service members with hearing loss attrite at a higher rate from military service than those with normal hearing.^[10] Yet, population-based studies to describe the association between deployment and hearing loss are limited. A study of US Army soldiers who visited audiology clinics noted that hearing loss was identified in 68.6% of post-deployment diagnoses and 4.0% of non-deployment-related diagnoses.^[11] One population-based study that utilized a number of International Classification of Diseases, 9th Revision, Clinical Modification diagnostic codes for hearing loss found annual incidence rates between 19.3 and 22.2/1000; however, the study did not include deployment as an exposure and was limited to active-duty service members.^[1] Patient-based studies have reported hearing loss in 15% of patients with tympanic membrane perforation admitted to Brooke Army Medical Center,^[7] and 19% of patients admitted to a rehabilitation center with comorbid traumatic brain injury.^[12]

The present study uses data from the Millennium Cohort Study, the largest prospective study of military personnel to

| Access this article online | |
|---|--|
| Quick Response Code: | Website: www.noiseandhealth.org |
|  | DOI: 10.4103/1463-1741.149574 |
| | PubMed ID: *** |

date, which follows participants to evaluate whether military service exposures are associated with long-term health outcomes. Given the large sample of deployed participants in the Millennium Cohort, this study offers a unique opportunity to prospectively evaluate the association between military deployment and hearing loss among members of all service branches including active duty, Reserve, and National Guard members. The objective of this study was to examine the association between military deployment and subsequent hearing loss.

Methods

The Millennium Cohort Study, launched in 2001, is a longitudinal cohort study designed to assess the effects of US military service on the health of participants over a follow-up period of at least 21 years. The study utilizes a comprehensive questionnaire, completed approximately every 3 years by participants via mail and a secure Internet system. A random sample of US military members from all service branches and components who were on active rosters as of October 2000 was selected for the first enrollment panel. This panel was enrolled from 2001 to 2003 ($n = 77,047$, 36.0% response rate) and was oversampled for women, Reserve/Guard personnel, and individuals deployed to southwest Asia, Bosnia, or Kosovo from 1998 to 2000. Additional details on study methodology and response rates have been published elsewhere.^[13-15] The eligible population for these analyses included participants from the first enrollment panel who completed at least one follow-up questionnaire (first follow-up from 2004 to 2006 or second follow-up from 2007 to 2008) and did not self-report significant hearing loss at baseline ($n = 57,593$). Participants were excluded from these analyses if they deployed before baseline or completed any of their assessments while deployed. Additionally, participants were excluded if they were missing relevant outcome or covariate data. The final study population included 48,540 participants. This study was approved by the institutional review board at the Naval Health Research Center, and all Millennium Cohort members are voluntary participants.

Data for this study were obtained from the Millennium Cohort Study questionnaire as well as electronic military records. The questionnaire collects self-reported demographic, health, behavioral, and exposure data, such as hearing loss, tobacco use, and combat-related experiences. Electronic military records, including age, sex, service branch, service component, military occupation, education level, marital status, military separation status, and deployment dates, were provided by the Defense Manpower Data Center. When available, self-reported data were used to supplement electronic data from personnel records to minimize missing data. In addition, this study utilized audiometric data, maintained by the Defense Occupational and Environmental Health Readiness System-Hearing Conservation data repository,^[16] when available, to

validate self-reported hearing loss data. Military personnel in a hearing conservation program have audiometric testing at least annually. All military personnel have audiometric testing, at a minimum, at the time of entrance, at the time of discharge, and to assess readiness prior to any deployment or other hazardous duty.

Exposures

Combat deployment, the exposure of interest for the primary analyses, was defined as having deployed to Operation Iraqi Freedom or Operation Enduring Freedom or in support of these conflicts and having personally:

1. Witnessed a death due to war, disaster, or tragic event;
2. Witnessed instances of physical abuse;
3. Been exposed to dead or decomposing bodies;
4. Been exposed to maimed soldiers or civilians; or
5. Been exposed to prisoners of war or refugees.

Those who had deployed with combat exposures were compared with those who had deployed without combat exposures and with those who had not deployed.

Secondary analyses examined a subset of the study population who had deployed and completed the 2007-2008 Millennium Cohort questionnaire that included questions regarding exposure to improvised explosive device (IED) blast- and combat-related head trauma. These secondary analyses assessed hearing loss in relation to blast and combat-related head trauma.

Additional variables, including self-reported smoking status, and exposure to pesticides, chemicals, and occupations requiring the use of personal protective equipment (PPE), were included in all models. Chemical exposure was defined as self-reported routine skin contact with paint and/or solvents and/or other hazardous substances during the past 3 years. Pesticide exposure was defined as self-reported exposure to pesticides, including creams, sprays, or uniform treatments, or pesticides applied in the environment or around living facilities, during the past 3 years. Occupations requiring PPE were defined as occupational hazards requiring protective equipment, such as respirators or hearing protection during the past 3 years. Smokers were defined as those who reported smoking at least 100 cigarettes in their lifetime. Past smokers were differentiated from current smokers if they reported to have successfully quit smoking. Never-smokers were those who had never smoked 100 cigarettes in their lifetime.

Outcomes

Hearing loss was assessed using the Millennium cohort questionnaire, which includes the baseline question: "Has your doctor or other health professional ever told you that you have any of the following conditions? with the response being significant hearing loss." The question was modified in

follow-up questionnaires to describe new hearing loss over “the last 3 years,” based on the study design of re-surveying participants at approximately 3-year intervals. Participants who did not self-report hearing loss at baseline, but later positively endorsed self-reported hearing loss during a follow-up survey, were classified as having new-onset self-reported hearing loss.

Objective audiometric data were dichotomized using the VA standards for impaired hearing.^[16] For VA purposes, impaired hearing is considered a disability when the audiometric hearing threshold in any of the frequencies (500, 1000, 2000, 3000, or 4000 Hz) is 40 dB or greater; or when the auditory thresholds for at least three of these frequencies are 26 dB or greater. Note that the VA definition also includes those who have speech recognition scores <94%, but the audiometric database did not contain this additional information.

Statistical analyses

Initial descriptive analyses included frequencies, percentages, and Chi-square tests to describe the variables within the population. Multivariable logistic regression was used for the primary model to determine the odds of new-onset self-reported hearing loss in relation to combat deployment, while adjusting for all covariates noted previously. All variables were assessed at baseline except for military separation and deployment experiences, which were assessed throughout the study period. Secondary analyses using multivariable logistic regression included an assessment of the relations between hearing loss and exposure to blasts and combat-related head trauma among a deployed subset of this study group who had completed a baseline survey in 2001, deployed between 2004 and 2007, and completed the 2007 survey. Multicollinearity was assessed using a variance inflation factor of 4 or greater to identify potentially collinear variables.

Validation of self-reported hearing loss was evaluated by comparing Millennium Cohort survey data and objective audiometric data. VA criteria for hearing impairment were applied as described previously, to define audiometrically “normal” or “abnormal” hearing. Each self-report of hearing loss (yes/no) was evaluated based on the time stamp of the survey and the timing of available audiometric data. Self-report of “yes” hearing loss was considered valid if any preceding audiogram was abnormal. Self-report of “yes” hearing loss was considered invalid if any subsequent audiogram was normal. In addition, those without a preceding validating test who also lacked a subsequent invalidating test and had all abnormal audiograms after self-report were considered to have valid hearing loss. Consistent criteria were applied to validate the absence of hearing loss. Self-report of “no” hearing loss was considered valid if any subsequent audiogram was normal. Self-report of “no” hearing loss was considered invalid if any previous audiogram was abnormal. In addition, those without a subsequent validating

test, who also lacked a previous invalidating test, and had all normal audiograms prior to self-report, were considered to have valid absence of hearing loss. All self-reports were independently assessed, and the degree of nonrandom agreement between the audiometric data and self-reported data was calculated using the kappa statistic.^[17] A kappa value between 0.6 and 0.8 was considered substantial agreement, and a kappa value between 0.4 and 0.6 was considered moderate agreement.^[18] In addition, a sensitivity analysis was conducted using multivariable logistic regression to examine the odds of self-reported new-onset hearing loss among only those subjects with a validated audiometric record.

Data management and statistical analyses were performed using SAS software, version 9.3 (SAS Institute, Inc., Cary, North Carolina).

Results

This study included 48,540 Millennium Cohort Study participants, of whom 3660 (7.5%) self-reported new-onset hearing loss during follow-up. Demographic, military, and behavioral characteristics for those who reported new-onset hearing loss, in comparison with those who reported no hearing loss during the study period, are shown in Table 1. In this comparison, all differences were statistically significant ($P < 0.001$) with the exception of service component.

Multivariable logistic regression was used to calculate adjusted odds ratios (AORs) for new-onset hearing loss [Table 2]. In this analysis, Millennium Cohort Study participants who were deployed with combat experience had increased odds (AOR = 1.63, 95% confidence interval [CI] = 1.49-1.77) of reporting new-onset hearing loss compared with those who were not deployed. In this adjusted model, male sex, being born before 1970 (compared with those born in 1980 or later), or being currently married were all demographic characteristics associated with increased odds of new-onset self-reported hearing loss. Conversely, those of black non-Hispanic race/ethnicity (compared with other race/ethnicity) were at decreased odds of new-onset self-reported hearing loss. Military-specific characteristics with increased odds of hearing loss were serving in the Army, Navy/Coast Guard, or Marines (compared with serving in the Air Force), reporting exposures to occupational hazards that required PPE (including hearing protection) or routine contact with chemicals, or exposure to pesticides. Conversely, officers, those serving in the Reserve/National Guard (compared with active duty), those serving as health care specialists (compared with functional support specialists), and those separated from the military had lower adjusted odds of reporting new-onset hearing loss. Finally, past or current smokers (compared with never smokers) had increased adjusted odds of reporting new-onset hearing loss.

Table 1: Distribution of demographic, military and behavioral characteristics of 48,540 Millennium Cohort participants in relation to hearing status

| Characteristic | No hearing loss <i>n</i> = 44,880 | | New-onset hearing loss <i>n</i> = 3660 | | <i>P</i> |
|---|--------------------------------------|------------|---|------------|----------|
| | <i>n</i> | Percentage | <i>n</i> | Percentage | |
| Sex | | | | | |
| Male | 30,953 | 69.0 | 3163 | 86.4 | <0.001 |
| Female | 13,927 | 31.0 | 497 | 13.6 | |
| Birth cohort | | | | | |
| Pre1970 | 27,849 | 62.1 | 2729 | 74.6 | <0.001 |
| 1970-1979 | 14,898 | 33.2 | 806 | 22.0 | |
| 1980+ | 2133 | 4.8 | 125 | 3.4 | |
| Race/ethnicity | | | | | |
| White nonHispanic | 31,122 | 69.3 | 2748 | 75.1 | <0.001 |
| Black nonHispanic | 6215 | 13.9 | 296 | 8.1 | |
| Other | 7543 | 16.8 | 616 | 16.8 | |
| Education | | | | | |
| Some college or less | 31,553 | 70.3 | 2732 | 74.6 | <0.001 |
| Bachelor's or higher | 13,327 | 29.7 | 928 | 25.4 | |
| Marital status | | | | | |
| Currently married | 28,698 | 63.9 | 2701 | 73.8 | <0.001 |
| Not currently married | 16,182 | 36.1 | 959 | 26.2 | |
| Military pay grade | | | | | |
| Enlisted | 32,975 | 73.5 | 2840 | 77.6 | <0.001 |
| Officer | 11,905 | 26.5 | 820 | 22.4 | |
| Service component | | | | | |
| Active duty | 24,617 | 54.9 | 2003 | 54.7 | 0.885 |
| Reserve/National Guard | 20,263 | 45.2 | 1657 | 45.3 | |
| Branch of service | | | | | |
| Army | 20,329 | 45.3 | 1955 | 53.4 | <0.001 |
| Air Force | 14,070 | 31.4 | 855 | 23.4 | |
| Navy/Coast Guard | 8452 | 18.8 | 628 | 17.2 | |
| Marine Corps | 2029 | 4.5 | 222 | 6.1 | |
| Occupational category | | | | | |
| Combat specialists | 8393 | 18.7 | 881 | 24.1 | <0.001 |
| Electronic equipment repair | 4044 | 9.0 | 299 | 8.2 | |
| Health care specialists | 5511 | 12.3 | 288 | 7.9 | |
| Communications/intel | 3222 | 7.2 | 244 | 6.7 | |
| Other technical | 1125 | 2.5 | 97 | 2.7 | |
| Functional support/admin | 9829 | 21.9 | 645 | 17.6 | |
| Electrical/mechanical equipment repair | 5720 | 12.8 | 598 | 16.3 | |
| Craft workers | 1307 | 2.9 | 134 | 3.7 | |
| Service and supply | 3739 | 8.3 | 353 | 9.6 | |
| Students, trainees, other | 1990 | 4.4 | 121 | 3.3 | |
| Deployment experience* | | | | | |
| Not deployed | 29,970 | 66.8 | 2126 | 58.1 | <0.001 |
| Deployed without combat | 7612 | 17.0 | 529 | 14.5 | |
| Deployed with combat | 7298 | 16.3 | 1005 | 27.5 | |
| Exposed to occupational hazards requiring PPE | | | | | |
| No | 21,945 | 48.9 | 1382 | 37.8 | <0.001 |
| Yes | 22,935 | 51.1 | 2278 | 62.2 | |
| Routine skin contact with chemicals | | | | | |
| No | 33,769 | 75.2 | 2353 | 64.3 | <0.001 |

Table 1: Continued

| Characteristic | No hearing loss <i>n</i> = 44,880 | | New-onset hearing loss <i>n</i> = 3660 | | <i>P</i> |
|---|--------------------------------------|------------|---|------------|----------|
| | <i>n</i> | Percentage | <i>n</i> | Percentage | |
| Yes | 11,111 | 24.8 | 1307 | 35.7 | |
| Pesticide exposure | | | | | |
| No | 29,640 | 66.0 | 1986 | 54.3 | <0.001 |
| Yes | 15,240 | 34.0 | 1674 | 45.7 | |
| Smoking | | | | | |
| Never smokers | 26,311 | 58.6 | 1781 | 48.7 | <0.001 |
| Past smokers | 11,618 | 25.9 | 1177 | 32.2 | |
| Current smokers | 6951 | 15.5 | 702 | 19.2 | |
| Military separation | | | | | |
| No | 33,819 | 75.4 | 2858 | 78.1 | <0.001 |
| Yes | 11,061 | 24.7 | 802 | 21.9 | |
| Proximity to IED blast [†] | | | | | |
| No | 3007 | 76.5 | 169 | 54.0 | <0.001 |
| Yes | 925 | 23.5 | 144 | 46.0 | |
| Combat-related head trauma [‡] | | | | | |
| No | 3899 | 99.2 | 292 | 93.3 | <0.001 |
| Yes | 33 | 0.8 | 21 | 6.7 | |

*Deployment occurred after baseline, [†]Self-report of close proximity to an IED blast as reported on 2007 questionnaire among those whose first deployment occurred between their 2004 and 2007 Millennium Cohort follow-up questionnaire (*n* = 4245), [‡]Self-report of combat-related head trauma as reported on 2007 questionnaire among those whose first deployment occurred between their 2004 and 2007 Millennium Cohort follow-up questionnaire (*n* = 4,245), IED = Improvised explosive device, PPE = Personal protective equipment

Results from the subanalysis indicated that among persons who deployed and completed the 2007-2008 questionnaire (*n* = 4245), 1069 reported proximity to a blast, of whom 144 (13.5%) reported new-onset hearing loss. Fifty-four deployers reported combat-related head trauma, of whom 21 (38.9%) reported new-onset hearing loss. Two separate logistic regression analyses that included all variables (except for deployment/combat experience) were performed on the data of the subset of participants who had been deployed during the study period, to assess the relations between combat-related head trauma or blast exposure and new-onset hearing loss [Table 3]. Participants who reported combat-related head trauma were more than 6 times as likely to report new-onset hearing loss (AOR = 6.88, 95% CI = 3.77-12.54). Similarly, participants who reported blast exposure were more than twice as likely to report new-onset hearing loss (AOR = 2.10, 95% CI = 1.62-2.73).

The audiometric validation procedure allowed for one audiometry record to correspond with one self-reported record from each survey time period. Among the 48,540 individuals included in this study, there were 63,481 self-reports of hearing status during the study period validated among 25,987 Millennium Cohort participants. There was moderate to substantial agreement between self-reported hearing and audiometric data at each survey cycle, with kappa values of 0.69 (95% CI = 0.67-0.71), 0.60 (95% CI = 0.58-0.62), and 0.57 (95% CI = 0.56-0.59) for the self-

Table 2: AOR of reporting new-onset hearing loss

| Characteristic* | n = 48,540 | |
|---|------------|-----------|
| | AOR | 95% CI |
| Deployment experience | | |
| Not deployed | 1.00 | |
| Deployed without combat | 0.98 | 0.89-1.09 |
| Deployed with combat | 1.63 | 1.49-1.77 |
| Sex | | |
| Female | 1.00 | |
| Male | 2.02 | 1.82-2.25 |
| Birth cohort | | |
| 1980 and later | 1.00 | |
| 1970-1979 | 0.82 | 0.67-1.01 |
| Before 1970 | 1.73 | 1.40-2.12 |
| Race/ethnicity | | |
| Other | 1.00 | |
| White nonHispanic | 1.09 | 0.98-1.20 |
| Black nonHispanic | 0.63 | 0.54-0.73 |
| Education | | |
| Some college or less | 1.00 | |
| Bachelor's or higher | 0.95 | 0.85-1.07 |
| Marital status | | |
| Not currently married | 1.00 | |
| Currently married | 1.16 | 1.07-1.27 |
| Military pay grade | | |
| Enlisted | 1.00 | |
| Officer | 0.72 | 0.63-0.82 |
| Service component | | |
| Active duty | 1.00 | |
| Reserve/National Guard | 0.86 | 0.79-0.93 |
| Branch of service | | |
| Air Force | 1.00 | |
| Army | 1.76 | 1.61-1.93 |
| Navy/Coast Guard | 1.31 | 1.17-1.46 |
| Marine Corps | 1.85 | 1.58-2.18 |
| Occupational category | | |
| Functional support specialists | 1.00 | |
| Combat specialists | 1.11 | 0.99-1.25 |
| Electronic equipment repair | 0.91 | 0.78-1.06 |
| Health care specialists | 0.85 | 0.73-0.98 |
| Communications/intelligence | 0.94 | 0.81-1.10 |
| Other technical | 0.96 | 0.76-1.20 |
| Electrical/mechanical equipment repair | 1.05 | 0.92-1.19 |
| Craft workers | 1.06 | 0.87-1.30 |
| Service and supply handlers | 1.12 | 0.98-1.29 |
| Students, trainees, other | 0.91 | 0.74-1.12 |
| Smoking | | |
| Never smokers | 1.00 | |
| Past smokers | 1.27 | 1.17-1.38 |
| Current smokers | 1.27 | 1.15-1.40 |
| Exposed to occupational hazards requiring PPE | | |
| No | 1.00 | |
| Yes | 1.18 | 1.09-1.28 |
| Routine skin contact with chemicals | | |
| No | 1.00 | |
| Yes | 1.21 | 1.11-1.31 |
| Pesticide exposure | | |
| No | 1.00 | |

Table 2: Continued

| Characteristic* | n = 48,540 | |
|---------------------|------------|-----------|
| | AOR | 95% CI |
| Yes | 1.29 | 1.20-1.39 |
| Military separation | | |
| No | 1.00 | |
| Yes | 0.81 | 0.74-0.89 |

*All characteristics shown are included in the multivariable model, AOR = Adjusted odds ratio, CI = Confidence interval, PPE = Personal protective equipment

Table 3: AOR of reporting new-onset hearing loss in relation to combat-related head trauma and exposure to IED blast among deployed service members

| Characteristic* | n = 4245 | | | |
|----------------------------|----------|-----------|------|--------------|
| | AOR | 95% CI | AOR | 95% CI |
| IED | | | | |
| No | 1.00 | | | |
| Yes | 2.10 | 1.62-2.73 | | |
| Combat-related head trauma | | | | |
| No | | | 1.00 | |
| Yes | | | 6.88 | (3.77-12.54) |

*Adjusted for sex, birth year, education, marital status, race/ethnicity, smoking status, pay grade, service component, service branch, occupation, use of PPE, separation from the military and exposure to pesticides or chemicals, AOR = Adjusted odds ratio, CI = Confidence interval, PPE = Personal protective equipment, IED = Improvised explosive device

reported data from 2001, 2004, and 2007, respectively. The percent positive and percent negative agreement were also calculated for each year. The percent positive agreement for 2001, 2004, and 2007 were 83.0%, 56.9%, and 51.1%, respectively, while the percent negative agreement for 2001, 2004, and 2007 were 96.0%, 97.3%, and 97.7%, respectively.

Results from the sensitivity analysis examining new-onset hearing loss among only those subjects with a validated audiometric record indicated consistent findings for all measures of association and significance levels (data not shown).

Discussion

To our knowledge, this is the first large-scale prospective study of a military cohort to describe self-reported hearing loss after military deployment that was validated with audiometric data. In this study, we observed moderate to substantial agreement between self-reported hearing loss and hearing loss defined by audiometric data. Millennium Cohort participants who were deployed with combat experience had a 1.6-fold increased odds for reporting new-onset hearing loss compared with non-deployers. Furthermore, in analyses limited to deployed participants, being in close proximity to an explosive blast or experiencing head trauma were strongly associated with new-onset hearing loss. These findings quantify an important health risk faced by US service members who deploy to combat environments.

Individuals with the occupational code of “combat specialists” were 11% more likely to report hearing loss, but this association was not statistically significant. Given that combat experience was associated with a statistically significant increased risk for self-reported hearing loss, it would seem logical to observe the same for combat specialists. The apparent lack of an association may be partially attributable inherent limitations in the DoD Occupational Conversion Index. For example, some “combat specialists” do not actively participate in ground combat that includes discharging weapons.

Using a large military audiometric database to validate self-reported hearing loss was a novel component of these analyses. US military service represents one of the few occupations with a requirement for regular audiometric testing of its members, and the maintenance of clinical audiometric data in a large electronic data repository is a unique attribute of the military health care system.^[19] It might have been assumed that study participants would not self-report hearing loss very accurately or consistently, especially in response to a single question on the survey. Hearing loss may be overreported when members learn they have to retake a hearing test for any reason; hearing loss may also be underreported when members fail to notice or acknowledge subtle changes in their hearing.^[20] The results from this study suggest that negative reports of hearing loss have substantial accuracy, while positive reports of hearing loss have moderate accuracy, based on comparison with objective audiometric data that would meet VA disability criteria for hearing impairment.^[16]

Finding that individuals who were deployed and had combat experiences were 1.6 times more likely to report new-onset hearing loss, compared with their nondeployed counterparts, appears to be a unique contribution to the epidemiologic study of hearing loss. One other study found an association between deployment and hearing loss, but the data were limited to an assessment of US Army soldiers.^[11] Another interesting and important contribution of the current study was the finding that deployed individuals without combat experiences were not at increased risk for new-onset hearing loss compared with nondeployed personnel. This implies that much of the hearing loss attributable to the deployment is related to specific combat experiences rather than to deployment itself. Combat may include a significant amount of impulse noise, characterized as noise with a duration of <1 second and with peak levels 15 dB louder than background noise.^[19] Sources of impulse noise include firing weapons or artillery, as well as detonation of explosive devices. A study conducted in Finland reported that combat and shooting exercises can reach peak noise levels of 180 dB,^[20] and researchers at the US National Institute for Occupational Safety and Health have stated that, “firing a weapon poses a significant risk of noise-induced hearing loss, if hearing protection is not worn”.^[21] Impulse noise in addition to continuous noise exposure has been reported to be more damaging to hearing than continuous

noise exposure alone.^[22,23] Compounding the problem may be the challenge of wearing hearing protection during combat operations. A study conducted among Canadian armed forces found that ground combat troops were hesitant to use hearing protection because they felt it reduced detection of auditory warnings and reduced communication among the team members.^[24] Although research is being conducted to develop appropriate hearing protection for combat, a 2009 study among US Army cadets found that most devices are lacking in performance and acceptance.^[25] These findings suggest that additional research is needed to design hearing protection devices that will meet the needs of ground combat forces.

As expected, subgroup analyses of the deployed study participants revealed that the likelihood of reporting new-onset hearing loss was increased with exposures to both combat-related head trauma and proximity to an explosive blast. Participants reporting head trauma related to combat were over 6 times more likely to report new-onset hearing loss, whereas those reporting proximity to a blast were approximately twice as likely to report new-onset hearing loss. Since the question on blast exposure relates to “having an IED or booby trap explode near you,” there could be some variability in how the word “near” is interpreted, and exposure at some distances may not have resulted in injury to the auditory system. We were not able to assess the nature of the blast, nor quantify proximity to the blast, use of hearing protection, or loss of consciousness. Combat-related head trauma is likely to include those exposed to blasts, as well as exposure to small arms fire, artillery, grenades, and physical assault. Besides the primary effects of blast overpressure, peripheral or central auditory system damage can occur from secondary effects (shrapnel and other blast-accelerated debris), and tertiary effects (body being thrown and impacting other objects). The most common types of blast-related injury involve middle and inner ear structures resulting in conductive, sensorineural, or mixed type of hearing loss. Pure sensorineural hearing loss is the predominant type occurring in blast-related traumatic brain injury and was reported to be nearly 60% in a study of inpatients at a VA rehabilitation unit.^[26] A recent study among US Army soldiers reported low levels of referral to audiology clinics following indications of noise-induced hearing loss and head injury on post-deployment health assessments,^[27] highlighting the importance of attention to these issues after any suspected exposure.

In addition to deployment, other key factors were associated with new-onset hearing loss in the multivariable analysis including male sex, increasing age, non-black race/ethnicity, tobacco use, exposure to other occupational hazards, contact with chemicals, and exposure to pesticides similar to previous reports.^[1,5,28-31] The consistency of findings observed here with other published studies lends further credibility to the use of new-onset self-reported hearing loss as a valid

measure in this population. In possible contrast, one previous study found increased odds of hearing loss among adult Hispanics who were unmarried,^[32] whereas in this study, married members were at increased odds for reporting new-onset hearing loss. No biologically plausible reason exists for the finding that married individuals were at increased risk for new-onset hearing loss in models that adjust for demographic variables. It may be that marriage was associated with other exposures that could not be assessed. It is also possible that this finding is due to correlation between marriage and age, and that birth-year cohorts incompletely adjusted for the age effect.

This study, as well as a previous study,^[10] found an increased risk for hearing loss among active duty compared with Reserve/Guard members. Serving in the military is associated with increased risk for hearing loss,^[33] and it is likely that serving in the Reserve/Guard means fewer hours of munitions-related noise exposure due to the non-continuous active-duty status of these US service members. Officers were at decreased odds for reporting new-onset hearing loss, as were members of the Air Force. These differences may reflect less hazardous noise exposures and/or increased compliance with hearing protection programs in these groups.

Observing that those who had separated from service were at lower odds for reporting new-onset hearing loss may appear counterintuitive. First, all members of the US military receive an audiogram prior to leaving the military, which would likely increase hearing loss diagnoses among those separating. Secondly, the literature suggests that those with hearing loss attrite from the military at a higher rate than those without hearing loss.^[10] Given that the prevalence of hearing loss was found to be greater among military veterans compared with civilians,^[33] it may be possible that this observation reflects the reduced risk for new-onset hearing loss associated with being a civilian in comparison with the increased risk associated with continued military service in this adjusted model.

There are a number of limitations to consider regarding this evaluation. The primary outcome was based on self-report in a health questionnaire. Audiometric testing data were available on approximately half of all participants. When available, audiometry data validated self-reported data. The validation scheme, while imperfect, assumed that normal hearing has the potential to become abnormal and that established abnormal hearing cannot return to normal, consistent with the physiology of noise-induced hearing loss. Several previous studies conducted in Australia, Brazil, and the United States of the accuracy of a single self-reported question on hearing loss reported sensitivities ranging from 0.71 to 0.78 and specificities from 0.56 to 0.76, compared with hearing impairment defined by audiometric testing.^[34-36] These studies evaluated older subjects, hence results of their validation testing may not apply to this younger population. One investigation recruited construction workers who face

occupational noise exposure, and with an average age of 42.8 years, this study population is perhaps more comparable to the Millennium Cohort participants;^[37] this study reported sensitivities of 0.87-0.88 and specificities of 0.68-0.74 for detection of lower frequency hearing loss using a question that elicited a rating of hearing ability on a 1 (excellent) to 5 (poor) scale, with fair or poor ratings defined as a positive self-report of hearing loss, and lower kappa values (0.25-0.45) were reported. In our study, validation of self-report of past diagnosis compared with audiometric testing was much stronger. The degree of misclassification may, therefore, be smaller in our study, but undoubtedly some nondifferential misclassification remains that reduced the magnitude of observed associations. However, a consistent result found from the sensitivity analysis performed on validated subjects is reassuring.

There were a number of variables used in this analysis that could not be perfectly measured and may have introduced misclassification. We were not able to directly measure hazardous noise levels associated with combat, and had to rely on our imperfect measure of combat as described previously. We adjusted for age using birth-year cohorts. This was done, in part, because such grouping provided consistent identification of participants who provided data across an 8 year span (2001-2008). Misclassification of true demographic characteristics may have occurred, most likely resulting in the reported association being weaker than the true association.

As with all surveys, <100% of those invited to participate opt to participate. As described in the first paragraph of the Methods, the first enrollment panel had a participation rate of 36%. As a result, the Cohort may not be representative of the entire military or those who deploy. However, previous investigations suggest that the Cohort is a representative population of military personnel who report reliably with minimal health related tendency for enrollment, and showed little non-response bias at the first follow-up.^[14,38-45]

We did not adjust for other important risk factors, including nonoccupational hazardous noise, such as recreational firearm use, and diabetes.^[46] We were unable to ascertain nonoccupational hazardous noise exposure. Although diabetes is another risk factor for hearing loss, individuals with diabetes are not able to join the US military. That said, a small percentage will develop diabetes and continue to serve. A recent study conducted using Millennium Cohort data reported the occurrence of diabetes during an approximate 3 year follow-up was 3/1,000 person-years. Therefore, very few members of this cohort had diabetes and the likelihood that important confounding resulted from this condition is extremely low.^[47]

Loss to follow-up represents another limitation, with 71% of subjects enrolled in 2001 completing the survey at either the

first or second follow-up. Although loss to follow-up may result in bias, we have previously investigated this possibility using statistical techniques for missing data and have found that it did not bias risk estimates for several key outcomes of this study, including posttraumatic stress disorder (PTSD), depression, and eating disorders.^[39] We adjusted for multiple variables potentially associated with both the exposure and outcome. The potential remains though for residual confounding due to unmeasured variables or inaccurately measured variables meeting the criteria for confounding.

This study has multiple strengths, including a large sample size permitting subgroup analyses and detection of smaller associations with excellent power, and a longitudinal design that permits assessment of new-onset outcomes in relation to previously measured exposures. In addition, the study included a large proportion of National Guard/Reservists and followed subjects even after separation from the military, thereby providing an advantage over analyses based on electronic data for active-duty service members until the time of separation from the military. We assessed multiple relevant exposures, including combat deployment, and specifically combat-related head trauma and proximity to an explosive blast, smoking status, occupation requiring PPE, or exposures that involve routine contact with chemicals, among other factors.

In summary, these are the first analyses to our knowledge to define and quantify the substantial risk of new-onset hearing loss related to military combat-related exposures. We found that combat experience was associated with a 63% increased risk for hearing loss. In addition, we also identified that individuals who reported exposure to an explosive blast or had combat-related head trauma were much more likely to report hearing loss. This study also demonstrated the validity of self-reported hearing loss, when queried in the context of the Millennium Cohort Study, in defining this important health outcome. From a clinical perspective, the 6-fold increase in risk of hearing loss after combat-related head trauma deserves further attention. A multidisciplinary approach to treatment of patients with combat-related head trauma should take into account possible overlapping symptoms with blast-related comorbidities including PTSD, dizziness and imbalance, and speech and language problems, in order to identify and properly manage auditory system outcomes.^[27,48] This may facilitate overall recovery, improve cognitive deficits, and result in better quality of life. Preventive strategies should include early detection and monitoring of hearing loss, based on pre-deployment and post-deployment audiograms, to inform clinical practice guidelines, as well as development of improved and more acceptable hearing protection, protective head gear, and possible identification of effective otoprotectants.

Acknowledgments

In addition to the authors, the Millennium Cohort Study Team includes James Davies, PhD; Carrie Donoho, PhD; Melissa Frasco, PhD;

Dennis Hernando; Lauren Kipp, MPH; Cynthia LeardMann, MPH; William Lee; Gordon Lynch; Sheila Medina-Torne, MPH; Anna Nagel, MPH; Emma Schaller, MPH; Katherine Snell; Steven Speigle; Kari Sausedo, MA; Beverly Sheppard; Jennifer Walstrom; Martin White, MPH; and James Whitmer; from the Deployment Health Research Department, Naval Health Research Center, San Diego, California; Paul Amoroso, from MultiCare Health System Research Institute, Tacoma, Washington; Gary Gackstetter from Analytic Services, Inc., Arlington, Virginia; and Tyler C. Smith, MS, PhD, from National University, San Diego, California. We thank Scott L. Seggerman from the Management Information Division, Defense Manpower Data Center, Monterey, California, and Michelle LeWark, also from the Naval Health Research Center. We thank CDR Joel Bealer and all professionals who provided support for DOEHRs-HC data. We also thank the professionals from the U.S. Army Medical Research and Materiel Command, especially those from the Military Operational Medicine Research Program, Fort Detrick, Maryland. VA Puget Sound Health Care System supported Dr. Boyko's participation in this research. We are indebted to the Millennium Cohort Study participants, without whom these analyses would not be possible.

Address for correspondence:

Dr. Timothy S. Wells,
1839 Waverly Road, Holt, Michigan, USA.
E-mail: tmlbwells@wowway.com

References

1. Helfer TM, Canham-Chervak M, Canada S, Mitchener TA. Epidemiology of hearing impairment and noise-induced hearing injury among U.S. military personnel, 2003-2005. *Am J Prev Med* 2010;38:S71-7.
2. Trost RP, Shaw GB. Statistical analysis of hearing loss among navy personnel. *Mil Med* 2007;172:426-30.
3. Rovig GW, Bohnker BK, Page JC. Hearing health risk in a population of aircraft carrier flight deck personnel. *Mil Med* 2004;169:429-32.
4. Humes LE, Joellenbeck LM, Durch JS. Noise and Military Service. Implications for Hearing Loss and Tinnitus. Washington, DC: National Academies Press; 2005.
5. Saunders GH, Griest SE. Hearing loss in veterans and the need for hearing loss prevention programs. *Noise Health* 2009;11:14-21.
6. US Government Accountability Office. Hearing Loss Prevention: Improvements to DOD Hearing Conservation Programs Could Lead to Better Outcomes. Washington DC: US Government Accountability Office; 2011.
7. Ritenour AE, Wickley A, Ritenour JS, Kriete BR, Blackburne LH, Holcomb JB, *et al.* Tympanic membrane perforation and hearing loss from blast overpressure in Operation Enduring Freedom and Operation Iraqi Freedom wounded. *J Trauma* 2008;64:S174-8.
8. Geckle L, Lee R. Soldier perceptions of deployment environmental exposures. Paper presented at: Force Health Protection Conference; Albuquerque, NM; August, 2004.
9. Muhr P, Månsson B, Hellström PA. A study of hearing changes among military conscripts in the Swedish Army. *Int J Audiol* 2006;45:247-51.
10. Niebuhr DW, Li Y, Powers TE, Krauss MR, Chandler D, Helfer T. Attrition of U.S. military enlistees with waivers for hearing deficiency, 1995-2004. *Mil Med* 2007;172:63-9.
11. Helfer TM, Jordan NN, Lee RB. Postdeployment hearing loss in U.S. Army soldiers seen at audiology clinics from April 1, 2003, through March 31, 2004. *Am J Audiol* 2005;14:161-8.
12. Lew HL, Garvert DW, Pogoda TK, Hsu PT, Devine JM, White DK, *et al.* Auditory and visual impairments in patients with blast-related traumatic brain injury: Effect of dual sensory impairment on Functional Independence Measure. *J Rehabil Res Dev* 2009;46:819-26.

13. Gray GC, Chesbrough KB, Ryan MA, Amoroso P, Boyko EJ, Gackstetter GD, *et al.* The millennium Cohort Study: A 21-year prospective cohort study of 140,000 military personnel. *Mil Med* 2002;167:483-8.
14. Ryan MA, Smith TC, Smith B, Amoroso P, Boyko EJ, Gray GC, *et al.* Millennium Cohort: Enrollment begins a 21-year contribution to understanding the impact of military service. *J Clin Epidemiol* 2007;60:181-91.
15. Smith TC, Jacobson IG, Hooper TI, Leardmann CA, Boyko EJ, Smith B, *et al.* Health impact of US military service in a large population-based military cohort: Findings of the Millennium Cohort Study, 2001-2008. *BMC Public Health* 2011;11:69.
16. McIlwain DS, Gates K, Ciliax D. Heritage of army audiology and the road ahead: The Army Hearing Program. *Am J Public Health* 2008;98:2167-72.
17. Cohen JA. A coefficient of agreement for nominal scales. *Educ Psychol Meas* 1960;20:37-46.
18. Landis JR, Koch GG. The measurement of observer agreement for categorical data. *Biometrics* 1977;33:159-74.
19. Starck J, Toppila E, Pyykkö I. Impulse noise and risk criteria. *Noise Health* 2003;5:63-73.
20. Pääkkönen R, Lehtomäki K. Protection efficiency of hearing protectors against military noise from handheld weapons and vehicles. *Noise Health* 2005;7:11-20.
21. Murphy WJ, Flamme GA, Meinke DK, Sondergaard J, Finan DS, Lankford JE, *et al.* Measurement of impulse peak insertion loss for four hearing protection devices in field conditions. *Int J Audiol* 2012;51 Suppl 1:S31-42.
22. Henderson D, Hamernik RP. Impulse noise: Critical review. *J Acoust Soc Am* 1986;80:569-84.
23. Voigt P, Godenhielm B, Ostlund E. Impulse noise-measurement and assessment of the risk of noise induced hearing loss. *Scand Audiol Suppl* 1980;319-25.
24. Abel SM. Barriers to hearing conservation programs in combat arms occupations. *Aviat Space Environ Med* 2008;79:591-8.
25. Casali JG, Ahroon WA, Lancaster JA. A field investigation of hearing protection and hearing enhancement in one device: For soldiers whose ears and lives depend upon it. *Noise Health* 2009;11:69-90.
26. Lew HL, Jerger JF, Guillory SB, Henry JA. Auditory dysfunction in traumatic brain injury. *J Rehabil Res Dev* 2007;44:921-8.
27. Helfer TM, Jordan NN, Lee RB, Pietrusiak P, Cave K, Schairer K. Noise-induced hearing injury and comorbidities among postdeployment U.S. Army soldiers: April 2003-June 2009. *Am J Audiol* 2011;20:33-41.
28. Lin FR, Maas P, Chien W, Carey JP, Ferrucci L, Thorpe R. Association of skin color, race/ethnicity, and hearing loss among adults in the USA. *J Assoc Res Otolaryngol* 2012;13:109-17.
29. Mahboubi H, Zardouz S, Oliaei S, Pan D, Bazargan M, Djalilian HR. Noise-induced hearing threshold shift among US adults and implications for noise-induced hearing loss: National Health and Nutrition Examination Surveys. *Eur Arch Otorhinolaryngol* 2013;270:461-7.
30. Vyskocil A, Truchon G, Leroux T, Lemay F, Gendron M, Gagnon F, *et al.* A weight of evidence approach for the assessment of the ototoxic potential of industrial chemicals. *Toxicol Ind Health* 2012;28:796-819.
31. Crawford JM, Hoppin JA, Alavanja MC, Blair A, Sandler DP, Kamel F. Hearing loss among licensed pesticide applicators in the agricultural health study. *J Occup Environ Med* 2008;50:817-26.
32. Lee DJ, Gómez-Marín O, Lee HM. Sociodemographic correlates of hearing loss and hearing aid use in Hispanic adults. *Epidemiology* 1996;7:443-6.
33. Centers for Disease Control and Prevention (CDC). Severe hearing impairment among military veterans — United States, 2010. *MMWR Morb Mortal Wkly Rep* 2011;60:955-8.
34. Nondahl DM, Cruickshanks KJ, Wiley TL, Tweed TS, Klein R, Klein BE. Accuracy of self-reported hearing loss. *Audiology* 1998;37:295-301.
35. Sindhusake D, Mitchell P, Smith W, Golding M, Newall P, Hartley D, *et al.* Validation of self-reported hearing loss. The Blue Mountains Hearing Study. *Int J Epidemiol* 2001;30:1371-8.
36. Ferrite S, Santana VS, Marshall SW. Validity of self-reported hearing loss in adults: Performance of three single questions. *Rev Saude Publica* 2011;45:824-30.
37. Hong O, Ronis DL, Antonakos CL. Validity of self-rated hearing compared with audiometric measurement among construction workers. *Nurs Res* 2011;60:326-32.
38. Smith TC, Smith B, Jacobson IG, Corbeil TE, Ryan MA, Millennium Cohort Study Team. Reliability of standard health assessment instruments in a large, population-based cohort study. *Ann Epidemiol* 2007;17:525-32.
39. Littman AJ, Boyko EJ, Jacobson IG, Horton J, Gackstetter GD, Smith B, *et al.* Assessing nonresponse bias at follow-up in a large prospective cohort of relatively young and mobile military service members. *BMC Med Res Methodol* 2010;10:99.
40. Wells TS, Jacobson IG, Smith TC, Spooner CN, Smith B, Reed RJ, *et al.* Prior health care utilization as a potential determinant of enrollment in a 21-year prospective study, the Millennium Cohort Study. *Eur J Epidemiol* 2008;23:79-87.
41. Smith TC, Jacobson IG, Smith B, Hooper TI, Ryan MA, Millennium Cohort Study Team. The occupational role of women in military service: Validation of occupation and prevalence of exposures in the Millennium Cohort Study. *Int J Environ Health Res* 2007;17:271-84.
42. Smith B, Leard CA, Smith TC, Reed RJ, Ryan MA, Millennium Cohort Study Team. Anthrax vaccination in the Millennium Cohort: Validation and measures of health. *Am J Prev Med* 2007;32:347-53.
43. Smith B, Smith TC, Gray GC, Ryan MA, Millennium Cohort Study Team. When epidemiology meets the Internet: Web-based surveys in the Millennium Cohort Study. *Am J Epidemiol* 2007;166:1345-54.
44. Smith B, Wingard DL, Ryan MA, Macera CA, Patterson TL, Slymen DJ. U.S. military deployment during 2001-2006: Comparison of subjective and objective data sources in a large prospective health study. *Ann Epidemiol* 2007;17:976-82.
45. LeardMann CA, Smith B, Smith TC, Wells TS, Ryan MA, Millennium Cohort Study Team. Smallpox vaccination: Comparison of self-reported and electronic vaccine records in the millennium cohort study. *Hum Vaccin* 2007;3:245-51.
46. Agrawal Y, Platz EA, Niparko JK. Risk factors for hearing loss in US adults: Data from the National Health and Nutrition Examination Survey, 1999 to 2002. *Otol Neurotol* 2009;30:139-45.
47. Boyko EJ, Jacobson IG, Smith B, Ryan MA, Hooper TI, Amoroso PJ, *et al.* Risk of diabetes in U.S. military service members in relation to combat deployment and mental health. *Diabetes Care* 2010;33:1771-7.
48. Fausti SA, Wilmington DJ, Gallun FJ, Myers PJ, Henry JA. Auditory and vestibular dysfunction associated with blast-related traumatic brain injury. *J Rehabil Res Dev* 2009;46:797-810.

How to cite this article: Wells TS, Seelig AD, Ryan MA, Jones JM, Hooper TI, Jacobson IG, *et al.* Hearing loss associated with US military combat deployment. *Noise Health* 2015;17:34-42.

Source of Support: This research represents Naval Health Research Center report 13-59, supported by the Department of Defense, under work unit no. 60002. The Millennium Cohort Study is funded through the Military Operational Medicine Research Program of the US Army Medical Research and Materiel Command, Fort Detrick, Maryland.

Conflict of Interest: None declared.

Copyright of Noise & Health is the property of Medknow Publications & Media Pvt. Ltd. and its content may not be copied or emailed to multiple sites or posted to a listserv without the copyright holder's express written permission. However, users may print, download, or email articles for individual use.

REPORT DOCUMENTATION PAGE

The public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing the burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB Control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

| | | |
|--|--|--|
| 1. REPORT DATE (DD MM YY) 07 10 13 | 2. REPORT TYPE Journal article | 3. DATES COVERED (from – to) 2004–2008 |
|--|--|--|

| | |
|--|--|
| 4. TITLE Hearing Loss Associated With Military Combat Deployment | 5a. Contract Number: 5b. Grant Number: 5c. Program Element Number: 5d. Project Number: 5e. Task Number: 5f. Work Unit Number: 60002 |
|--|--|

| | |
|--|--|
| 6. AUTHORS Wells, Timothy S., Amber Seelig, Margaret A. K. Ryan, Jason M. Jones, Tomoko I. Hooper, Isabel G. Jacobson, & Edward J. Boyko | |
|--|--|

| | |
|---|--|
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Commanding Officer Naval Health Research Center 140 Sylvester Rd San Diego, CA 92106-3521 | 8. PERFORMING ORGANIZATION REPORT NUMBER 13-59 |
|---|--|

| | |
|--|---|
| 9. SPONSORING/MONITORING AGENCY NAMES(S) AND ADDRESS(ES) Commanding Officer Naval Medical Research Center 503 Robert Grant Ave Silver Spring, MD 20910-7500 | Chief, Bureau of Medicine and Surgery 7700 Arlington Blvd Falls Church, VA 22042 |
| 10. SPONSOR/MONITOR'S ACRONYM(S) BUMED/NMRC | |
| 11. SPONSOR/MONITOR'S REPORT NUMBER(S) | |

| |
|---|
| 12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution is unlimited. |
|---|

| |
|---|
| 13. SUPPLEMENTARY NOTES Noise & Health, 2015, <u>17</u> (74), 34-42 |
|---|

| |
|---|
| 14. ABSTRACT To define the risk of hearing loss among military members in relation to their deployment experiences, data were drawn from the Millennium Cohort Study. Self-reported data and objective military service data were used to assess exposures and outcomes. Among all 48,540 participants, 7.5% self-reported new-onset hearing loss. Self-reported hearing loss showed moderate to substantial agreement ($k = 0.57-0.69$) with objective audiometric measures. New-onset hearing loss was associated with combat deployment (adjusted odds ratio [AOR] = 1.63, 95% confidence interval [CI] = 1.49–1.77). Among deployers, new-onset hearing loss was also associated with proximity to improvised explosive devices (AOR = 2.10, 95% CI = 1.62–2.73), and with experiencing a combat-related head injury (AOR = 6.88, 95% CI = 3.77–12.54). These findings have implications for health care and disability planning, as well as for prevention programs. |
|---|

| |
|---|
| 15. SUBJECT TERMS Hearing loss, military service; Millennium Cohort Study; VA |
|---|

| | | | | | |
|--|----------------------------|-----------------------------|---|----------------------------------|--|
| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT UNCL | 18. NUMBER OF PAGES 11 | 18a. NAME OF RESPONSIBLE PERSON Commanding Officer |
| a. REPORT UNCL | b. ABSTRACT UNCL | c. THIS PAGE UNCL | | | 18b. TELEPHONE NUMBER (INCLUDING AREA CODE) COMM/DSN: (619) 553-8429 |

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39-18