

## The Millennium Cohort Study

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- Background:** In the late 1990s, the US Department of Defense and Congress identified the need for coordinated epidemiological research to determine how military occupational exposures, including deployment-related exposures, affect long-term health. The Institute of Medicine more specifically defined the importance of a large, prospective study for evaluating exposures and a broad spectrum of important health outcomes. The Millennium Cohort Study was designed, in collaboration with all military services and the Department of Veterans Affairs, to meet these research challenges.
- Objective:** The primary study objective is to evaluate the impact of military service, including deployments and other occupational exposures, on long-term health. Important health outcomes include all objective diagnoses, as well as subjective measures of symptoms and functional health.
- Approach:** Launched in the summer of 2001, the Millennium Cohort Study began enrolling a representative sample of US military personnel, both active duty and Reserve/Guard members, who agreed to participate in follow-up well past their time in service, for up to 21 years. Currently, Panel 1 includes over 77,000 participants, Panel 2 includes an additional 31,100, Panel 3 includes 43,400 participants, and Panel 4 includes approximately 50,000 participants. All participants provide important information on exposures and health through and beyond their time in service. Information is maintained confidentially and securely. The Millennium Cohort Study will follow participants until at least 2022.
- Value:** Although the original designers of the Millennium Cohort Study could not foresee the post-2001 military conflicts, the project is perfectly positioned to address health outcomes related to these operations. More than 50% of Millennium Cohort participants have deployed in support of the Global War on Terrorism. Millennium Cohort investigators are able to evaluate, prospectively, detailed data from before, during, and long after these deployments.
- Collaboration:** Investigators include scientists from the Army, Navy, Air Force, Department of Veterans Affairs, and leading academic institutions. The Millennium Cohort External Advisory Board includes many distinguished external scientific researchers and subject matter experts from academia, the DoD, and Veterans Affairs as well as leading Veteran Service Organizations.
- Support:** The project is supported by the US Department of Defense, Military Operational Medicine Research Program. DMDC Reference #00-0019. RCS #DD-HA(AR)2106. OMB approval #0720-0029.
- Contacts:** The Principal Investigator of the Millennium Cohort Study is Mr. Martin White, and the primary performing site is the Deployment Health Research Department in San Diego, CA. The study team can be contacted (toll-free) at 1-888-942-5222 or email [milcohortinfo@med.navy.mil](mailto:milcohortinfo@med.navy.mil) More information is also available on the website, [www.millenniumcohort.org](http://www.millenniumcohort.org)

## **Millennium Cohort Study Products**

*The investigative team has shared more than 150 presentations at scientific conferences since 2001, and received multiple research awards. Below represents a chronologic list of publications in the medical literature. Many additional products are under development and review.*

Wells TS, Bagnell ME, Miller SC, Smith TC, Gackstetter GD and Boyko EJ for the Millennium Cohort Study Team. **US Naval and Marine Corps occupations, PTSD and depression risk and absenteeism.** Journal of Workplace Behavioral Health; In press.

*This study investigated whether military occupation was associated with PTSD or depression, and if PTSD or depression was associated with lost workdays among US Navy and US Marine personnel. Navy personnel in service and supply occupations were 85% more likely to screen positive for new-onset PTSD, while those serving in health care were 58% more likely to screen positive for new-onset depression compared to other occupations. In addition, those with new-onset and persistent PTSD were twice as likely to miss one or more days of work. This suggests that early identification and management of these conditions may improve force readiness.*

Crum-Cianflone N, Bagnell ME, Schaller E, Boyko EJ, Smith B, Maynard C, Ulmer CS, Vernalis M and Smith TC. **Impact of combat deployment and Posttraumatic Stress Disorder on newly reported coronary heart disease among US Active Duty and Reserve forces.** Circulation; In press.

*This study evaluated the association of combat deployments and posttraumatic stress disorder (PTSD) on coronary heart disease among a young cohort of US service members. Experiencing combat deployment was associated with an increased odds of coronary heart disease by both self-report and medical record diagnosis after adjustment for demographic, military, and mental health characteristics. Screening positive for PTSD was not associated with CHD after adjustment. This study demonstrates that intense and acute stressful life experiences may increase the risk for coronary heart disease over a relatively short period among young adults.*

Woodall KA, Jacobson IG, Crum-Cianflone NF. **Deployment experiences and motor vehicle crashes among U.S. service members.** American Journal of Preventive Medicine; In press.

*Findings indicate experiencing combat during deployment and multiple deployments are strong predictors for a motor vehicle crash (MVC) within the first six months of returning home from deployments in support of Iraq and Afghanistan among U.S. military members. These data provide critical information for targeting prevention strategies to decrease MVCs among personnel postdeployment.*

Owens BD, Wolf JM, Seelig AD, Jacobson IG, Boyko EJ, Smith B, Ryan MAK, Gackstetter GD, Smith TC. **Risk factors for lower extremity tendinopathies in military personnel.** The Orthopaedic Journal of Sports Medicine; In press.

*This study found that deployment was associated with the development of plantar fasciitis. Modifiable risk factors including being overweight or obese were associated with both Achilles tendinopathy and plantar fasciitis, with a marginal relationship between moderate alcohol use and Achilles tendinopathy. Identification of potential risk factors for musculoskeletal injuries among service members could serve as the focus for future prevention and intervention efforts.*

Hoge CW, LeardMann CA, Boyko EJ. **Suicides Among Military Personnel Reply.** Journal of the American Medical Association. 2013 Dec;310(23):2565-2566.

*Discusses the complexity of suicidal behaviors and some challenges related to this type of research, while highlighting the strengths of using data from the Millennium Cohort to study suicide.*

Bagnell ME, LeardMann CA, McMaster HS, Boyko EJ, Smith B, Granado, NS, and Smith TC. **The association of predeployment and deployment-related factors on dimensions of postdeployment wellness in US military service members.** The American Journal of Health Promotion. 2013 28:2, 56-66

*This study found that the majority of participants were well post-deployment, and military factors associated with post-deployment wellness included not experiencing combat and being trained as a combat specialist. Modifiable factors significantly associated with post-deployment wellness were also detected, including normal BMI, not smoking, and being physically active.*

LeardMann CA, Powell TM, Smith TC, Bell MR, Smith B, Boyko EJ, Hooper TI, Gackstetter GD, Ghamsary M, Hoge CW. **Risk factors associated with suicide in current and former US military personnel.** Journal of the American Medical Association. 2013;310(5):496-506.

*Based on data from over 150,000 current and former service members from all service branches, 83 suicide deaths occurred in 707,493 person-years from 2001 through 2008 (11.73/100,000 person-years). Suicide risk was independently associated with depression, manic-depressive disorder, alcohol-related problems, and male gender. None of the deployment or military-related factors were associated with an increased risk for suicide. Assessing service members' prior psychiatric history as well as screening for and treating mental and substance abuse disorders may provide the best potential for mitigating suicide risk.*

Boyko EJ, Seelig AD, Jacobson IG, Hooper TI, Smith B, Smith TC, Crum-Cianflone NF. **Sleep characteristics, mental health, and diabetes risk: a prospective study of U.S. military service members in the Millennium Cohort Study.** Diabetes Care. 2013 Oct;36(10):3154-61.

*We investigated whether poor sleep and mental health symptoms were independently related to diabetes risk. During 6 years of follow-up, the annual incidence rate for type 2 diabetes was 3.6/1,000 person years. After adjusting for covariates including mental health disorders like posttraumatic stress disorder and depression, both trouble sleeping and sleep apnea significantly predicted diabetes risk independent of these mental health conditions and other diabetes risk factors.*

Horton JL, Jacobson IJ, Littman AJ, Alcaraz JE, Smith B, and Crum-Cianflone NF. **The impact of deployment experience and prior healthcare utilization on enrollment in a large military cohort study.** BMC Medical Research Methodology. 2013 Jul 11;13:90

*This study compared the characteristics of invited subjects (responders and nonresponders) prior to the enrollment cycle. Military personnel who deployed in support of OIF/OEF and those who presented for routine outpatient care were significantly more likely to enroll in a longitudinal cohort study examining their health and military experiences, while those with baseline mental disorders or longer hospital stays were less likely to enroll. These findings, which controlled for demographic and other potential confounders, suggest differential enrollment by deployment experience and health status, and may help guide recruitment efforts in future studies.*

Gehrman P, Seelig AD, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, Ulmer CS, Smith TC. **Predeployment sleep duration and insomnia symptoms as risk factors for new-onset mental health disorders following military deployment.** Sleep. 2013 Jul 1;36(7):1009-1018.

*This study showed that combat-related trauma and predeployment insomnia symptoms were significantly associated with developing posttraumatic stress disorder, depression, and anxiety following deployment. Assessment of insomnia symptoms predeployment may help to better identify those at highest risk for subsequent adverse mental health outcomes.*

LeardMann CA, Pietrucha A, Magruder KM, Smith B, Murdoch M, Jacobson IG, Ryan MAK, Gackstetter G, Smith TC, for the Millennium Cohort Study Team. **Combat deployment is associated with sexual harassment or sexual assault in a large, female military cohort.** *Women's Health Issues.* 2013 Jul-Aug;23(4):e215-23.

*Among female service members, the 3-year cumulative incidence of sexual harassment was 9.4% and sexual assault was 2.1%. Significant risk factors for sexual trauma included prior deployment with combat experience, serving as a Marine, younger age, recent marital separation or divorce, positive screen for a prior mental health condition, moderate/severe life stress, and prior sexual trauma experiences. Understanding the factors associated with sexual harassment and assault can inform future policy and prevention efforts in order to eliminate sexual trauma.*

Crum-Cianflone N. **The Millennium Cohort Study: answering long-term health concerns of US military service members by integrating longitudinal survey data with military health system records.** In: Amara J, Hendricks A, eds. *Military Health Care From predeployment to post-separation.* 1<sup>st</sup> ed. New York, NY: Routledge;2013: 55-77.

*This textbook chapter provides a detailed summary of the first decade of the Millennium Cohort Study. The chapter includes an overview of the study methodology and key publications including a review of foundational papers and epidemiologic studies examining the associations of military service experiences with mental, behavioral, and physical health outcomes.*

Horton JL, Jacobson IG, Wong CA, Wells TS, Boyko EJ, Smith B, Ryan MAK, and Smith TC. **The impact of prior deployment experience on civilian employment after military service.** *Occupational and Environmental Medicine.* 2013; 70: 408-417.

*Employment after military service, in particular after stressful deployment experiences, is a concern for many veterans and policymakers. Among this large cohort of veterans, we found that prior deployment and PTSD were not significantly associated with job status post-service; in contrast, depression, panic/anxiety disorder, and poor physical health increased the risk of unemployment among certain groups. These findings may guide policy for veterans most in need of post-military employment support.*

Wells TS, Horton JL, LeardMann CA, Jacobson IG, and Boyko EJ. **A comparison of the PRIME-MD PHQ-9 and PHQ-8 in a large military prospective study, the Millennium Cohort Study.** *Journal of Affective Disorders.* May 2013; 148(1): 77-83.

*The PHQ-9 is a validated tool for depression screening, however recently an abbreviated version (PHQ-8) is increasingly being used in survey research that excludes the last and most sensitive item. This study compared the performance of the PHQ-8 with the PHQ-9 in a large, population-based sample of current and former military service members. Excellent agreement was detected between the two instruments, suggesting that the PHQ-8 performs well when screening for depression in similar populations.*

Littman AJ, Jacobson IG, Boyko EJ, Powell TM, Smith TC, for the Millennium Cohort Study Team. **Weight change following US Military service.** *International Journal of Obesity (Lond).* 2013 Feb;37(2):244-53.

*This study provides the first prospectively collected evidence for an increased rate of weight gain around the time of military discharge that may explain previously reported higher rates of obesity in veterans, and identifies characteristics of higher-risk groups. Discharge from military service presents a window of risk and opportunity to prevent unhealthy weight gain in military personnel and veterans.*

Nguyen S, LeardMann CA, Smith B, Conlin AMS, Slymen DJ, Hooper TI, Ryan MAK, Smith TC, for the Millennium Cohort Study Team. **Is Military Deployment a Risk Factor for Maternal Depression?** Journal of Women's Health. 2013 Jan; 22(1):9-18.

*This study found that military women who recently gave birth and then deployed with combat experience had an increased risk for depression. Combat experience primarily increased the risk for depression, rather than childbirth itself. In addition, deployment without combat experience was not significantly associated with maternal depression among women who recently gave birth.*

Jacobson IG, Horton JL, LeardMann CA, Ryan MAK, Boyko EJ, Wells TS, Smith B, Smith TC, for the Millennium Cohort Study Team. **Posttraumatic stress disorder and depression among US military health care professionals deployed in support of the operations in Iraq and Afghanistan.** Journal of Traumatic Stress. 2012 Dec;25(6):616-23.

*Among military personnel deployed with combat experience, health care professionals did not have increased odds for new-onset PTSD or depression over time compared to individuals in other occupations. Combat experience significantly increased the odds for new-onset PTSD or depression among deployed health care professionals, suggesting that combat experience, not features specific to being a health care professional, was the key exposure explaining development of these outcomes.*

Pinder RJ, Greenberg N, Boyko EJ, Gackstetter GD, Hooper TI, Murphy D, Ryan MA, Smith B, Smith TC, Wells TS, Wessely S, for the Millennium Cohort Study Team. **Profile of two cohorts: UK and US prospective studies of military health.** International Journal of Epidemiology; 2012 Oct;41(5):1272-82.

*Despite differences and limitations in methodologies, analyses of these two cohorts provide the prospect of driving improvement and innovation in military health and extending findings to other occupational populations.*

Seelig AD, Jacobson IG, Smith B, Hooper TI, Gackstetter GG, Ryan MAK, Wells TS, MacDermid Wadsworth S, Smith TC, for the Millennium Cohort Study Team. **Prospective evaluation of mental health and deployment experience among women in the US military.** American Journal of Epidemiology. 2012;176(2):135-45.

*Women with reported combat exposures were more likely to have mental health symptoms than women who deployed without combat associated exposures and women who never deployed.*

Jacobson IG, Horton JL, Smith B, Wells TS, Boyko EJ, Lieberman HR, Ryan MAK, Smith TC, for the Millennium Cohort Study Team. **Body building, energy, and weight loss supplements are associated with deployment and physical activity in U.S. Military personnel.** Annals of Epidemiology. 2012;22:318-330.

*Nearly half of the population studied reported use of energy, body building, or weight loss supplements, with energy supplements being the most highly endorsed (38%) supplement type. Deployment experience, physical activity, problem drinking, and suboptimal sleep emerged as important characteristics associated with supplement use, which may be of importance to medical planners and military policy makers in targeting adverse event monitoring and for future research determining how supplements affect performance and health over time.*



Powell TM, Smith TC, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, Phillips CJ, Smith B, for the Millennium Cohort Study Team. **Prospective assessment of chronic multisymptom illness reporting possibly associated with open-Air burn pit smoke exposure in Iraq.** Journal of Occupational and Environmental Medicine. 2012 June;54(6):682-688.

*There was no increase in chronic multisymptom illness (CMI) symptom reporting in Army and Air Force personnel deployed within a 2-, 3-, or 5-mile radius of documented open-air burn pits located in Iraq at Joint Base Balad, Camp Taji, and Camp Speicher compared with other deployed personnel. This initial report on possible burn pit exposure associated with CMI at a population-level is reassuring, but future research evaluating the potential association of burn pit smoke and CMI should utilize individual exposure data when possible.*

Jones KA, Smith B, Granado NS, Boyko EJ, Gackstetter GD, Ryan MAK, Phillips CJ, Smith TC, for the Millennium Cohort Study Team. **Newly reported lupus and rheumatoid arthritis in relation to deployment within proximity to a documented open-air burn pit in Iraq.** Journal of Occupational and Environmental Medicine. 2012 June;54(6):698-707.

*This study examined the incidence lupus and rheumatoid arthritis in relation to Army and Air Force personnel deployed within a 3- and 5-mile radius of documented open-air burn pits located in Iraq at Joint Base Balad, Camp Speicher, and Camp Taji. Overall, the results indicate no elevated risk of newly reported lupus or rheumatoid arthritis in the combined three-camp analysis. However, possible exposure at Balad was individually associated with newly reported lupus, although only two cases were at this site. Additional studies, including individual exposure data, are needed to further investigate these associations.*

Smith B, Wong CA, Boyko EJ, Phillips CJ, Gackstetter GD, Ryan MAK, Smith TC, for the Millennium Cohort Study Team. **The effects of exposure to documented open-air burn pits on respiratory health among deployers of the Millennium Cohort Study.** Journal of Occupational and Environmental Medicine. 2012 June;54(6):708-716.

*Burn pit exposure within 3 or 5 miles was not associated with newly reported asthma, chronic bronchitis or emphysema, or self-reported respiratory symptoms. In general, these findings do not support an elevated risk for respiratory outcomes among personnel deployed within proximity of documented burn pits in Iraq. Increased symptom reporting, however, was observed among Air Force deployers located within 2 miles of Joint Base Balad, though this finding was marginally significant with no evidence of trend.*

Granado NS, Zimmermann L, Smith B, Jones KA, Wells TS, Ryan MAK, Slymen DL, Koffman RL, Smith TC, for the Millennium Cohort Study Team. **Individual augmentee deployment and newly reported mental health morbidity.** Journal of Occupational and Environmental Medicine. 2012 May;54(5):615-620.

*Individual augmentees (IAs), who presumably have lower social support or unit cohesion, were not at increased risk for PTSD or mental health symptoms following deployment compared with non-IA deployers. It is likely that social isolation was not highly influential among Navy IAs in this study.*

Hermes ED, Wells TS, Smith B, Boyko EJ, Gackstetter GD, Miller SC, Smith TC, for the Millennium Cohort Study Team. **Smokeless tobacco use related to military deployment, cigarettes, and mental health symptoms in a large, prospective cohort study among US service members.** *Addiction*. 2012 May;107(5):983-994.

*Chronic use of smokeless tobacco has been linked to poor military training performance, early discharge, and a host of medical problems from cancer to heart disease. Smokeless tobacco initiation occurred in 1.9% and persistent use in 8.9% of Millennium Cohort participants. The study showed that deployment, combat exposure, smoking, and symptoms of posttraumatic stress disorder increased the risk for smokeless tobacco initiation, while deployment and combat exposure increased the risk for persistent use.*

Bonanno GA, Mancini AD, Horton JL, Powell TM, LeardMann CA, Boyko EJ, Wells TS, Hooper TI, Gackstetter GD, Smith TC, for the Millennium Cohort Study Team. **Trajectories of trauma symptoms and resilience in deployed U.S. military service members: a prospective cohort study.** *British Journal of Psychiatry*. 2012 Apr;200(4):317-23.

*Symptoms of posttraumatic stress (PTS) were examined over time in relation to deployment. Four classes of PTS trajectories were identified for both single and multiple deployers, with over 80% of the deployers exhibiting a stable trajectory of low symptoms (i.e., resilience) pre- to post-deployment. Several factors predicting PTS trajectories were identified, which may direct future research aimed at decreasing the risk of posttraumatic stress disorder among deployers.*

Wells TS, Ryan MAK, Jones KA, Hooper TI, Boyko EJ, Jacobson IG, Smith TC, Gackstetter GD, for the Millennium Cohort Study Team. **A comparison of mental health outcomes in persons entering U.S. Military Service before and after September 11, 2001.** *Journal of Traumatic Stress*. 2012 Feb;25: 17–24.

*It is hypothesized that those who entered military service prior to September 11, 2001 might have had expectations of experiencing a regular operational tempo and less combat compared with those entering service after this date, therefore an increased risk for mental disorders. Although measuring the direct reason for entering the military was not possible for this study, the findings showed that those entering pre-September 11 did not have a higher odds of mental disorders, suggesting that mental disorders resulting from the experience of war are common across the pre- and post-September 11 accession eras.*

Proctor SP, Wells TS, Jones KA, Boyko EJ, Smith TC, for the Millennium Cohort Study Team. **Examination of post-service health-related quality of life among rural and urban military members of the Millennium Cohort Study.** *Journal of Rural Social Sciences*. 2011;26(3):32–56.

*In this large population-based sample of young US veterans recently separated from military service, health-related quality of life (HRQL) was not significantly different among rural and urban residents in the adjusted analyses and deployment experience did not alter the association between the outcome and rural or urban residence. These results suggest that rural status is not independently associated with HRQL among recent U.S. veterans.*

Jones KA, Granado NS, Smith B, Slymen DJ, Ryan MAK, Boyko EJ, Gackstetter GD, Phillips CJ, Smith TC, for the Millennium Cohort Study Team. **A prospective study of lupus and rheumatoid arthritis in relation to deployment in support of Iraq and Afghanistan: the Millennium Cohort Study.** *Autoimmune Diseases*. 2011 Nov;741267.

*Newly reported lupus was not associated with military deployment in support of the current operations in Iraq and Afghanistan when compared with nondeployers. Our study did note a significantly decreased risk of newly reported rheumatoid arthritis among deployers with and without combat exposures when*

*compared with nondeployers; the reason for this finding is unknown, but may be due to a selection effect for deployment.*

Leleu TD, Jacobson IG, LeardMann CA, Smith B, Foltz PW, Amoroso PJ, Derr M, Ryan MAK, Smith TC, for the Millennium Cohort Study Team. **Application of latent semantic analysis for open-ended responses in a large, epidemiologic study.** BMC Medical Research Methodology. 2011 Oct;11:136.

*Using latent semantic analysis to analyze the final open-ended text field on the Millennium Cohort questionnaire helped identify important topic areas for future survey questions and also revealed the most common areas of concern for participants were illness and injuries, exposures, and exercise. Subjects with worse self-reported general health were more likely to provide a response in the open-ended text field than subjects with better general health.*

Smith TC, for the Millennium Cohort Study Team. **Linking exposures and health outcomes to a large population-based longitudinal study: the Millennium Cohort Study.** Military Medicine. 2011 Jul;176(7 Suppl):56-63.

*Linking Millennium Cohort prospective data to individual-level exposure data is critical for understanding and quantifying any long-term health outcomes potentially associated with unique military occupational exposures.*

Jankosky C, Hooper TI, Granado NS, Scher A, Gackstetter GD, Boyko EJ, Smith TC, for the Millennium Cohort Study Team. **Headache disorders in the Millennium Cohort: epidemiology and relations with combat deployment.** Headache. 2011 Jul-Aug;51(7):1098-1111.

*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 for development of headache provides support for targeted interventions.*

LeardMann CA, Kelton ML, Smith B, Littman AJ, Boyko EJ, Wells TS, Smith TC, for the Millennium Cohort Study Team. **Prospectively assessed posttraumatic stress disorder and associated physical activity.** Public Health Reports. 2011 May/Jun;126(3):371-83.

*Nearly 90% of the Cohort participate in some level of physical activity. Engagement in physical activity, specifically vigorous activity, was associated with decreased odds of PTSD symptoms. While further research is needed, a physical activity component may be valuable to treat and/or prevent PTSD among service members.*

Sandweiss DA, Slymen DJ, LeardMann CA, Smith B, White MR, Boyko EJ, Hooper TI, Gackstetter GD, Amoroso PJ, Smith TC, for the Millennium Cohort Study Team. **Preinjury psychiatric status, injury severity, and postdeployment posttraumatic stress disorder.** Archives of General Psychiatry. 2011 May;68(5):496-504.

*Physical injuries were significantly associated with postdeployment PTSD. Baseline psychiatric status was also significantly associated with postdeployment PTSD, irrespective of injury severity. Deployed service members who suffer from a predeployment psychiatric condition or injury while deployed may benefit from interventions targeted to prevent postdeployment PTSD or ensure early identification and treatment.*



White MR, Jacobson IG, Smith B, Wells TS, Gackstetter GD, Boyko EJ, Smith TC, for the Millennium Cohort Study Team. **Health care utilization among complementary and alternative medicine users in a large military cohort.** BMC Complementary and Alternative Medicine. 2011 Apr;11:27.

*Our findings provide evidence that CAM users are utilizing more physician-based medical services than users of conventional care. Those using CAM account for 45.1% of outpatient care and 44.8% of inpatient care, but make up only 39% of the study population. Whether CAM use is supplementing current conventional medical practice to meet the health care needs of these individuals is not fully understood.*

Smith TC, Jacobson IG, Hooper TI, LeardMann CA, Boyko EJ, Smith B, Gackstetter GD, Wells TS, Amoroso PJ, Gray GC, Riddle JR, Ryan MAK, for the Millennium Cohort Study Team. **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 Jan;11(1):69.

*This report summarizes findings from the Millennium Cohort Study through 2008 that have addressed health concerns related to military service. Conducting strategic studies aimed to identify, reduce, and prevent adverse health outcomes in military members have guided public health policy and will continue to affect policy for years to come.*

Seelig AD, Jacobson IG, Smith B, Hooper TI, Boyko EJ, Gackstetter GD, Gehrman PR, Macera CA, Smith TC, for the Millennium Cohort Study Team. **Sleep patterns before, during, and after deployment to Iraq and Afghanistan.** Sleep, 2010 Dec;33(12):1615-22.

*Participants reported having trouble sleeping and getting less sleep either during deployment or after returning home from deployment more than nondeployed participants. Self-reported combat exposures and mental health symptoms were independently associated with increased reporting of trouble sleeping.*

Kelton ML, LeardMann CA, Smith B, Boyko EJ, Hooper TI, Gackstetter GD, Bliese PD, Hoge CW, Smith TC, for the Millennium Cohort Study Team. **Exploratory factor analysis of self-reported symptoms in a large, population-based military cohort.** BMC Medical Research Methodology. 2010 Oct;10(1):94.

*Using exploratory factor analysis, this study examined mental and physical health symptom covariance structure. A 14-factor model accounted for 60% of the variance indicating a reasonable amount of construct overlap and that the number and type of questions appropriately assess a spectrum of heterogeneous symptoms.*

Littman AJ, Boyko EJ, Jacobson IG, Horton JL, Gackstetter GD, Smith B, Hooper TI, Amoroso PJ, Smith TC, for the Millennium Cohort Study Team. **Assessing nonresponse bias at follow-up in a large prospective cohort of relatively young and mobile military service members.** BMC Medical Research Methodology. 2010 Oct;10(1):99.

*In this study population, nonresponse to the follow-up questionnaire did not result in appreciable bias as reflected by comparing measures of association for selected outcomes using complete case and inverse probability weighted methods.*

Boyko EJ, Jacobson IJ, Smith B, Ryan MAK, Hooper TI, Amoroso PJ, Gackstetter GD, Barrett-Connor E, Smith TC, for the Millennium Cohort Study Team. **Risk of diabetes in US military service members in relation to combat deployment and mental health.** Diabetes Care. 2010 Aug;33(8):1771-7.

*Higher risk of new onset self-reported diabetes mellitus among cohort members was observed over three years of follow-up in persons with PTSD symptoms at baseline. This association was independent of age, gender, overall body adiposity, and the presence of other mental health conditions. There was no independent association of new onset diabetes with deployment in support of OEF/OIF.*

Hooper TI, Gackstetter GD, LeardMann CA, Boyko EJ, Pearse LA, Smith B, Amoroso PA, Smith TC, for the Millennium Cohort Study Team. **Early mortality experience in a large military cohort and a comparison of data sources used for mortality ascertainment.** Population Health Metrics. 2010 May;8(1):15.

*This study assessed the ability of four different mortality data sources to document the early mortality experience of the Cohort. The strengths and limitations of each data source are described and support continued use of multiple sources for future mortality assessment.*

Wells TS, LeardMann CA, Fortuna SO, Smith B, Smith TC, Ryan MAK, Boyko EJ, Blazer D, for the Millennium Cohort Study Team. **A prospective study of depression following combat deployment in support of the wars in Iraq and Afghanistan.** American Journal of Public Health. 2010 Jan;100(1):90-9.

*Findings emphasize that exposure to combat, rather than deployment itself, among men and women significantly increase the risk of new-onset depression.*

Smith B, Wong CA, Smith TC, Boyko EJ, Gackstetter GD, Ryan MAK, for the Millennium Cohort Study Team. **Newly reported respiratory symptoms and conditions among military personnel deployed to Iraq and Afghanistan: a prospective population-based study.** American Journal of Epidemiology. 2009 Dec;170(11):1433-42.

*Elevated risk for self-reported respiratory symptoms was found among Army and Marine Corps personnel deployed in support of operations in Iraq and Afghanistan. No increased risk for self-reported asthma, bronchitis, or emphysema was found.*

Granado NS, Smith TC, Swanson GM, Harris RB, Shahar E, Smith B, Boyko EJ, Wells TS, Ryan MAK, for the Millennium Cohort Study Team. **Newly reported hypertension after military combat deployment in a large population-based study.** Hypertension. 2009 Nov;54(5):966-73.

*Findings suggest that deployers who report multiple combat exposures, especially those who personally witnessed a death due to war or disaster, are at higher risk for newly-reported hypertension, possibly indicating a stress-induced hypertensive effect.*

Smith TS, for the Millennium Cohort Study Team. **The US Department of Defense Millennium Cohort Study: career span and beyond longitudinal follow-up.** Journal of Occupational and Environmental Medicine. 2009 Oct;51(10):1193-1201.

*Describes the Millennium Cohort Study, a large longitudinal occupational health study designed and initiated prior to the combat deployments in Iraq and Afghanistan specifically to assess any short or long-term health outcomes during and after military service and career.*

Jacobson IG, White MR, Smith TC, Smith B, Wells TS, Gackstetter GD, Boyko EJ, for the Millennium Cohort Study Team. **Self-reported health symptoms and conditions among complementary and alternative medicine users in a large military cohort.** Annals of Epidemiology. 2009 Sep;19(9):613-22.

*Findings illustrate that a relatively young adult occupational cohort of military personnel using CAM therapies also report multiple comorbidities which may indicate chronic illness management and poorer overall health.*

LeardMann CA, Smith TC, Smith B, Wells TS, Ryan MAK, for the Millennium Cohort Study Team. **Baseline self-reported functional health predicts vulnerability to posttraumatic stress disorder following combat deployment: prospective US military cohort study.** British Medical Journal. 2009 Apr;338:b1273.

*Military service members who screen in the lowest 15% of health prior to combat exposure are more vulnerable to developing postdeployment PTSD.*

Welch KE, LeardMann CA, Jacobson IG, Speigle SJ, Smith B, Smith TC, Ryan MAK, for the Millennium Cohort Study Team. **Postcards encourage participant updates.** Epidemiology. 2009 Mar;20(2):313-4.

*The results of this study quantify and confirm that semiannual appreciatory contact is an effective way to maintain communication with a highly mobile participant population while prompting updates of contact information.*

Jacobson IG, Smith TC, Smith B, Keel PK, Amoroso PJ, Wells TS, Bathalon GP, Boyko EJ, Ryan MAK for the Millennium Cohort Study Team. **Disordered eating and weight changes after deployment: longitudinal assessment of a large US military cohort.** American Journal of Epidemiology. 2009 Feb;169(4):415-27.

*Deployed women who reported combat exposures represent a subgroup at higher risk for developing eating problems and weight loss postdeployment compared with deployed women who did not report combat exposures.*

Smith TC, Wingard DL, Ryan MAK, Kritz-Silverstein D, Slymen DJ, Sallis JF, for the Millennium Cohort Study Team. **PTSD prevalence, associated exposures, and functional health outcomes in a large, population-based military cohort.** Public Health Report. 2009 Jan;124:90-102.

*Findings suggest a 2% prevalence of current PTSD symptoms in the US Military that are associated with increased reporting of exposures and decrements in functional health.*

Smith B, Ryan MAK, Wingard DL, Patterson TL, Slymen DJ, Macera CA, for the Millennium Cohort Study Team. **Cigarette smoking and military deployment: a prospective evaluation.** American Journal of Preventive Medicine. 2008 Dec;35(6):539-46.

*Findings suggest an increase in smoking initiation and recidivism among deployers and highlight the importance of prevention strategies pre, during, and post deployment.*

Jacobson IG, Smith TC, Bell NS. **Military combat deployment and alcohol use reply.** Journal of the American Medical Association. 2008 Dec;300(22):2607.

*Highlights the utility of CAGE screening questions for use as controlling factors for those with potential problems using alcohol at baseline.*

Jacobson IG, Ryan MAK, Hooper TI, Smith TC, Amoroso PJ, Boyko EJ, Gackstetter GD, Wells TS, Bell NS, for the Millennium Cohort Study Team. **Alcohol use and alcohol-related problems before and after military combat deployment.** Journal of the American Medical Association. 2008 Aug;300(6):663-75.

*Findings suggest that Reserve and National Guard personnel and younger service members who deploy with reported combat exposures are at increased risk of new-onset heavy weekly drinking, binge drinking, and other alcohol-related problems.*

Smith B, Chu LK, Smith TC, Amoroso PJ, Boyko EJ, Hooper TI, Gackstetter GD, Ryan MAK, for the Millennium Cohort Study Team. **Challenges of self-reported medical conditions and electronic medical records among members of a large military cohort.** BMC Medical Research Methodology. 2008 Jun;8:37.

*This report highlights the importance of assessing medical conditions from multiple electronic and self-reported sources.*

Smith TC, Wingard DL, Ryan MAK, Kritz-Silverstein D, Slymen DJ, Sallis JF, for the Millennium Cohort Study Team. **Prior assault and posttraumatic stress disorder after combat deployment.** Epidemiology. 2008 May;19(3):505-12.

*In contrast to hypotheses that survival from trauma represents or confers resilience, these findings suggest vulnerability to combat stress and PTSD among survivors of prior assault.*

Wells TS, LeardMann CA, Smith TC, Smith B, Jacobson IG, Reed RJ, Ryan MAK, for the Millennium Cohort Study Team. **Self-reported adverse health events following smallpox vaccination in a large prospective study of US military service members.** Human Vaccines. 2008 Mar/Apr;4(2):127-33.

*Smallpox vaccination was not associated with any adverse self-reported health outcomes, including mental and physical functioning. These findings may be reassuring to health care providers and those who receive the smallpox vaccination.*

Wells TS, Jacobson IG, Smith TC, Spooner CN, Smith B, Reed RJ, Amoroso PJ, Ryan MAK, for the Millennium Cohort Study Team. **Prior health care utilization as a determinant to enrollment in a 22-year prospective study, the Millennium Cohort Study.** European Journal of Epidemiology. 2008 Feb;23(2):79-87

*Few health differences between Millennium Cohort responders and non-responders were found when comparing healthcare utilization in the 12 months preceding study invitation.*

Smith TC, Ryan MAK, Wingard DL, Slymen DJ, Sallis JF, Kritz-Silverstein D, for the Millennium Cohort Study Team. **New onset and persistent symptoms of posttraumatic stress disorder self-reported after deployment and combat exposures: prospective population-based US military cohort study.** British Medical Journal. 2008 Feb;336(7640):366-71.

*Findings define the importance of PTSD in this population and emphasize that specific combat exposures, rather than deployment itself, significantly affect the onset of PTSD symptoms postdeployment.*

Smith B, Wingard DL, Ryan MAK, Macera CA, Patterson TL, Slymen DJ, for the Millennium Cohort Study Team. **US military deployment during 2001-2006: comparison of subjective and objective data sources in a large prospective health study.** Annals of Epidemiology. 2007 Dec;17(12):976-82.

*Defining military deployments using multiple data sources is examined. Deployment timing and duration metrics, critical for epidemiological studies, are valid in the Millennium Cohort Study.*

LeardMann CA, Smith B, Smith TC, Wells TS, Ryan MAK, for the Millennium Cohort Study Team. **Smallpox vaccination: comparison of self-reported and electronic vaccine records in the Millennium Cohort Study.** Human Vaccines. 2007 Nov/Dec;3(6):245-51.

*Self-report of smallpox vaccination is very reliable. Results may be valuable in supporting global response to bioterrorism threats.*

Smith TC, Zamorski M, Smith B, Riddle JR, LeardMann CA, Wells TS, Engel CC, Hoge CW, Adkins J, Blazer D, for the Millennium Cohort Study Team. **The physical and mental health of a large military cohort: baseline functional health status of the Millennium Cohort.** BMC Public Health. 2007 Nov;7(147):340.

*The functional health of service members in this 22-year longitudinal study compares favorably at baseline with other civilian and military populations.*

Smith B, Smith TC, Gray GC, Ryan MAK, for the Millennium Cohort Study Team. **When epidemiology meets the Internet: Web-based surveys in the Millennium Cohort Study.** American Journal of Epidemiology. 2007 Nov;166(11):1345-54.

*Optimal use of the Internet - with minimal response bias, maximum cost-savings, and improved data - is highlighted.*

Smith TC, Jacobson IG, Smith B, Hooper TI, Ryan MAK, for the Millennium Cohort Study Team. **The occupational role of women in military service: validation of occupation and prevalence of exposures in the Millennium Cohort Study.** International Journal of Environmental Health Research. 2007 Aug;17(4):271-84.

*Data on women's occupations are reliable, and occupational codes can be well correlated with exposures of concern. This was an award-winning presentation at a Navy conference in 2006.*

Smith TC, Smith B, Jacobson IG, Corbeil TE, Ryan MAK, for the Millennium Cohort Study Team. **Reliability of standard health assessment instruments in a large, population-based cohort study.** Annals of Epidemiology. 2007 Jul;17(7):525-32.

*Reliability metrics, by test-retest concordance and internal consistency, are extremely strong in Millennium Cohort Study data.*

Smith B, Leard CA, Smith TC, Reed RJ, Ryan MAK, for the Millennium Cohort Study Team. **Anthrax vaccination in the Millennium Cohort: validation and measures of health.** American Journal of Preventive Medicine. 2007 Apr;32(4):347-53.

*The largest ever evaluation of this topic revealed strong validity of self-reported vaccination, as well as unique health features of the small subset who may misreport vaccination. This work won awards at two research conferences in 2006.*

Ryan MA, Smith TC, Smith B, Amoroso P, Boyko EJ, Gray GC, Gackstetter GD, Riddle JR, Wells TS, Gumbs G, Corbeil TE, Hooper TI, for the Millennium Cohort Study Team. **Millennium Cohort: enrollment begins a 21-year contribution to understanding the impact of military service.** Journal of Clinical Epidemiology. 2007 Feb;60(2):181-91.

*A foundation report, this describes original enrollment methods and challenges of the Millennium Cohort Study. Characteristics of the first 77,047 participants are detailed and shown to strongly represent the population-based sample of the US military from which they were drawn.*

Riddle JR, Smith TC, Smith B, Corbeil TE, Engel CC, Wells TS, Hoge CW, Adkins J, Zamorski M, Blazer D, for the Millennium Cohort Study Team. **Millennium Cohort: the 2001-2003 baseline prevalence of mental disorders in the US military.** Journal of Clinical Epidemiology. 2007 Feb;60(2):192-201.

*The baseline prevalence of mental disorders in this 22-year longitudinal study compares favorably with other civilian and military populations.*



Chretien JP, Chu LK, Smith TC, Smith B, Ryan MAK, for the Millennium Cohort Study Team. **Demographic and occupational predictors of early response to a mailed invitation to enroll in a longitudinal health study.** Biomed Central Medical Research Methodology. 2007 Jan;7:6.

*Those who respond first to study invitations, whether to participate or decline, have distinct characteristics within the study population. This information can help structure recruitment efforts.*

Smith TC, Smith B, Corbeil TE, Ryan MAK, Riddle JR, for the Millennium Cohort Study Team. **Impact of terrorism on caffeine and tobacco use** [letter in response to "Self-reported mental health among US military personnel, prior and subsequent to the terrorist attacks of September 11, 2001"]. Journal of Occupational and Environmental Medicine. 2004 Dec;46(12):1194-5.

*Authors of a previously highlighted article respond to important suggestions on future analyses.*

Smith TC, Smith B, Corbeil TE, Riddle JR, and Ryan MAK, for the Millennium Cohort Study Team. **Self-reported mental health among US military personnel, prior and subsequent to the terrorist attacks of September 11, 2001.** Journal of Occupational and Environmental Medicine. 2004 Aug;46(8):775-82.

*Accepted without revision and featured by journal editors, this early analysis leveraged Millennium Cohort data to conclude that military members displayed stronger mental health characteristics soon after the terrorist attacks of September 11, 2001. The authors suggest this may be attributed to resilience and/or an outpouring of support for the US military mission.*

Gray GC, Chesbrough KB, Ryan MAK, Amoroso P, Boyko EJ, Gackstetter GD, Hooper TI, Riddle JR, for the Millennium Cohort Study Group. **The Millennium Cohort Study: A 21-year prospective cohort study of 140,000 military personnel.** Military Medicine. 2002 Jun;167(6):483-8.

*The origins and development of the Millennium Cohort Study are described. The largest prospective study in military history was established to answer the most difficult questions about long-term health after military service.*