



Contents lists available at ScienceDirect

Annals of Epidemiology

journal homepage: www.annalsofepidemiology.org

Review article

The Millennium Cohort Study: The first 20 years of research dedicated to understanding the long-term health of US Service Members and Veterans



Jennifer N. Belding, PhD^{a,b}, Sheila F. Castañeda, PhD^{a,b}, Isabel G. Jacobson, MPH^{a,b}, Cynthia A. LeardMann, MPH^{a,b}, Ben Porter, PhD^{a,b,c}, Teresa M. Powell, MS^{a,b}, Claire A. Kolaja, MPH^{a,b}, Amber D. Seelig, MPH^d, Rayna K. Matsuno, PhD^{a,b}, Felicia R. Carey, PhD^{a,b}, Anna C. Rivera, MPH^{a,b}, Daniel W. Trone, PhD^b, Beverly D. Sheppard^{a,b}, Jennifer L. Walstrom^{a,b}, Edward J. Boyko, MD, MPH^d, Rudolph P. Rull, PhD^{b,*}, for the Millennium Cohort Study Team

^a Leidos, San Diego, CA^b Naval Health Research Center, Deployment Health Research Department, San Diego, CA^c Mississippi State University, Starkville, MS^d VA Puget Sound Health Care System, Seattle, WA

ARTICLE INFO

Article history:

Received 3 September 2021

Revised 29 November 2021

Accepted 1 December 2021

Available online 11 December 2021

Keywords:

Millennium Cohort Study

Military

Veterans

Deployment

Risk factors

Protective factors

Physical health

Mental health

Health-related behaviors

Longitudinal cohort

ABSTRACT

Purpose: The Millennium Cohort Study, the US Department of Defense's largest and longest running study, was conceived in 1999 to investigate the effects of military service on service member health and well-being by prospectively following active duty, Reserve, and National Guard personnel from all branches during and following military service. In commemoration of the Study's 20th anniversary, this paper provides a summary of its methods, key findings, and future directions.

Methods: Recruitment and enrollment of the first 5 panels occurred between 2001 and 2021. After completing a baseline survey, participants are requested to complete follow-up surveys every 3–5 years.

Results: Study research projects are categorized into 3 core portfolio areas (psychological health, physical health, and health-related behaviors) and several cross-cutting areas and have culminated in more than 120 publications to date. For example, some key Study findings include that specific military service-related factors (e.g., experiencing combat, serving in certain occupational subgroups) were associated with adverse health-related outcomes and that unhealthy behaviors and mental health issues may increase following the transition from military service to veteran status.

Conclusions: The Study will continue to foster stakeholder relationships such that research findings inform and guide policy initiatives and health promotion efforts.

Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

Abbreviations: Army STARRS, Army Study to Assess Risk and Resilience in Servicemembers; DoD, Department of Defense; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; OND, Operation New Dawn; PTSD, posttraumatic stress disorder; VA, Department of Veterans Affairs.

Conflict of Interest Disclosures: None declared.

* Corresponding author. Rudolph P. Rull, PhD, Naval Health Research Center, Deployment Health Research Department, 140 Sylvester Rd, San Diego, CA 92106. Tel.: 619-553-9267

E-mail address: Rudolph.p.rull2.civ@mail.mil (R.P. Rull).

Introduction

The United States Armed Forces comprises over 2,000,000 service members charged with the defense of the nation [1]. Through the course of their service, military personnel may deploy, endure traumatic experiences, be exposed to toxic substances, sustain disabling injuries, and risk death, as well as develop leadership skills, obtain education, and gain technical training and certifications. Certain exposures, stressors, and experiences may influence

Table 1
Enrollment summary of the Millennium Cohort Study

Panel (group)	Enrollment dates	Y of service at enrollment*	Oversampled groups*	Roster size (date)	Total contacted	Total enrolled (%)
1	Jul 2001–Jun 2003	Unrestricted	Females Reserves and/or Guard Prior deployers	256,400 (Oct 2000)	214,388	77,019 (36%)
2	Jun 2004–Feb 2006	1–2	Females Marine Corps	150,000 (Oct 2003)	123,001	31,110 (25%)
3	Jun 2007–Dec 2008	1–3	Females Marine Corps	200,000 (Oct 2006)	154,270	43,439 (28%)
4	Apr 2011–Apr 2013	2–5	Females Married	250,000 (Oct 2010)	247,266	50,052 (20%)
5	Sept 2020–Aug 2021	1–5	Females Married	500,000 (Jun 2020) [†]	~500,000 [†]	~58,000 (11%) [†]

* Specific subgroups were oversampled in order to ensure robust numbers for comparisons among these subgroups. To augment Panel 1, Panels 2–5 had restrictions on years of service at enrollment to obtain a sample that was representative of the currently serving force.

[†] Final roster size, total contacted, and total enrolled will be determined once all data have been received and cleaned.

their well-being and physical health during and following military service. Historically, the ability to ascertain risk factors associated with military service has been a challenge. For example, numerous reports of unexplained health symptoms among veterans returning from the 1990–1991 Gulf War resulted in the prioritization of research on what became known as Gulf War illness, which, to this day, does not have a single clinical definition. This research was hindered by a lack of baseline health assessments necessary to detect longitudinal associations [2–4]. Consequently, the Institute of Medicine recommended a coordinated prospective study of the health of service members [5]. This recommendation was subsequently mandated by Congress in Section 743 of the National Defense Authorization Act for Fiscal Year 1999 (Public Law 105–261), which directed the Department of Defense (DoD) to establish “a longitudinal study to evaluate data on the health conditions of members of the Armed Forces upon their return from deployment on military operations for purposes of ensuring the rapid identification of any trends in diseases, illnesses, or injuries among such members as a result of such operations” [6].

The Millennium Cohort Study (henceforth referred to as Study) was subsequently launched in 2001 with the enrollment of the first panel of participants drawn from a random sample of service members. The Study has since become the largest and longest-running prospective study in the DoD and is the only study to follow active duty, Reserve, and National Guard personnel from all service branches during and after their military service. This occupational cohort study allows for in-depth and nuanced assessments of multiple aspects of military service that may be associated with adverse or beneficial outcomes.

Consistent with Congressional mandate, the overarching aim of the Study remains the same since its inception, which is to investigate the long-term effects of military service and experiences, including deployments, on the health and well-being of service members. Although initially expected to continue through 2022 to follow service members through their military careers, the Study was extended through 2068 to enable the study of the transition from military service, and the detection of outcomes across a lifetime. In addition, the Millennium Cohort Family Study (henceforth referred to as Family Study) was established in 2011 as a complementary effort to assess the effects of military experiences on the health and well-being of spouses of service members [7]. In recognition of the 20th anniversary of the Study, the purpose of this paper is twofold: (a) to present a brief summary of the Study methodology and findings from the past 20 years, and (b) to discuss the impacts of these key findings and future directions of the Study.

Study design and capabilities

The Study employs a multi-panel design (Figure 1) where potential participants are randomly selected from a sample of US military service members on active rosters maintained by the Defense Manpower Data Center, including individuals from all service

branches and components (Table 1) [8–10]. To ensure sufficient power to detect differences in smaller subsamples, specific groups (e.g., women, Marines) were targeted for oversampling. The first Panel of participants was enrolled from a probability-based sample of the entire military population on July 1, 2001. To augment Panel 1, Panels 2 through 4 in 2004, 2007, and 2011, respectively, were derived from probability-based samples of current service members with length of military service ranging between 1 and 5 years in order to obtain a sample that contained the currently serving force. Enrollments across these first four panels yielded a total of 201,619 participants. The recent enrollment of a fifth panel occurred between September 2020 and August 2021 (Table 1). Response rates for enrollment of Panels 1–4 ranged from 20%–36%. While numerous studies have noted the widely observed declines in survey participation [11–14], inherent challenges in obtaining survey responses from military personnel also include greater geographic mobility associated with moving on military orders, deployments to regions where contact is restricted or limited, and survey fatigue due to numerous required surveys for military personnel. Nonetheless, investigations of potential biases found Cohort participants to be representative of the Armed Forces population, with participants reporting reliable data, and no differential participation by health status (Table 2).

Invited service members who provided informed consent to enroll in the cohort and completed a baseline survey were subsequently invited to complete follow-up surveys even after separation from military service. Follow-up surveys are administered approximately every 3–5 years in order to allow for sufficient time to procure federal regulatory approvals for each planned survey, process survey responses (e.g., entering data from paper surveys, data cleaning), and minimize participant burden. These self-administered web-based or paper surveys include a variety of standardized assessments for mental and physical health, health-related behaviors, military exposures, and other experiences based on their direct relevance to stakeholder-identified topics of interest [8–10,15]. Detailed descriptions of the Study’s methodology have been published elsewhere and provide an overview of the Study’s design, sampling methodology, data collection instruments, survey reliability and validity, and linkages with enterprise databases (Table 2) [8,9,15,16].

Several aspects of the Study distinguish it from other perspective research on military personnel (e.g., the UK King’s Cohort (17); Army Study to Assess Risk and Resilience in Servicemembers [Army STARRS] [18,19]). Notably, the Study includes personnel from the Army, Navy, Marine Corps, Air Force, Coast Guard, and Space Force, and participation is not limited solely to those on active-duty service. Individuals serving as Reservists or in the National Guard, who collectively make up almost half of all currently serving military personnel and have deployed regularly since the 1990–1991 Gulf War, are also invited to participate. Furthermore, the Study remains the largest prospective effort to continuously follow service members after separation from service. Additionally, repeated self-reported survey data facilitate the follow-up of

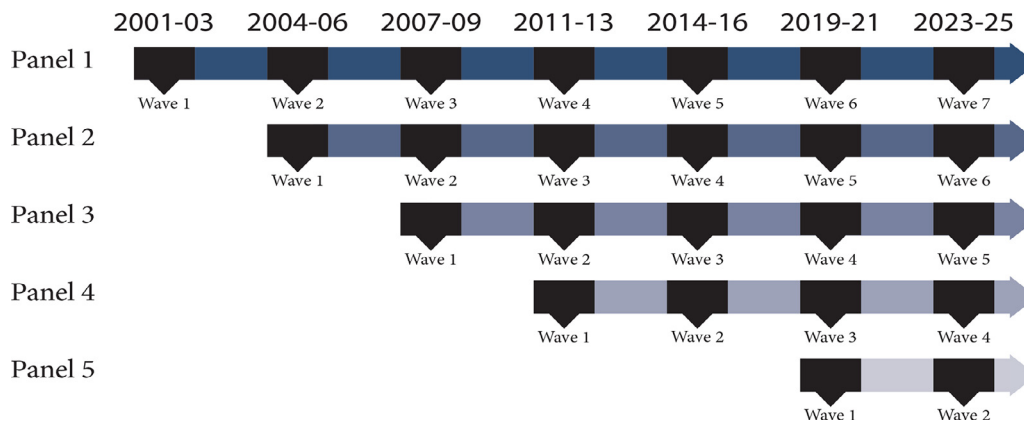


Figure 1. Depiction of the multiple panel design used in the Millennium Cohort Study.

participants in relation to important experiences, such as deployment, and the transitional period from military service to veteran status. This unique feature of the Study allows for ascertainment of health conditions and other post-service outcomes, such as employment status, potentially associated with military service that manifest later in life.

To complement the collection of survey data, the Study is linked with DoD, Department of Veterans Affairs (VA), and national databases (e.g., National Death Index). These data linkages provide a rich array of information that enhances the analytic capacity of the Study beyond self-reported data [15,16]. The DoD enterprise databases include administrative personnel files, deployment data, military inpatient and outpatient medical records, pharmaceutical transactions, vaccination records, traumatic injury registries, and mortality data, as well as other data sources, surveys, and studies (e.g., the DoD Birth and Infant Health Research Program, Deployment Health Assessments, and the Family Study) [16]. A recent Study innovation is the ability to further link with VA databases, including health and benefits records. The Study is thus the first large-scale prospective research with the ability to ascertain health outcomes reported in surveys in current and former military service members as well as those diagnosed and recorded in the DoD and VA healthcare systems. This comprehensive data linking ability has provided numerous opportunities to validate self-reported measures with objective data and assessment of other relevant psychometric properties ([20–30]; Table 2).

The Study’s conceptual model (Figure 2) illustrates the complex interrelationships between individual and community characteristics with military service experiences. In this ecological framework, these characteristics and experiences are hypothesized to influence a range of resiliency and vulnerability factors over the life course of a service member that subsequently affect health, well-being, and career outcomes. Building on this conceptual model, research from the Study is organized into three intersecting and overarching portfolio areas: psychological health, physical health, and health-related behaviors. These are complemented by multiple cross-cutting research portfolios that span several health domains (e.g., occupational and environmental health, injury and recovery, sexual trauma, veterans’ health, women’s health).

Summary of findings

Since 2002, the Study Team has published over 120 peer-reviewed publications. These include foundational papers describing the study design, methods, and capabilities, in addition to other methodological reports that provided baseline prevalence of a variety of health conditions, validated self-report measures with objective data, and examined a variety of psychometric proper-

ties (Table 2). The vast majority of the Study’s publications have reported findings from etiologic and hypothesis-driven analyses. Approximately two-thirds of the publications to date prospectively examined whether certain occupational exposures sustained during military service were associated with adverse outcomes (Table 3). The large-scale deployments in support of Operations Enduring Freedom (OEF), Iraqi Freedom (OIF), and New Dawn (OND) that followed the launch of the Study led to an extensive portfolio of publications that examined the relationship between deployment, including combat experience, and subsequent mental and physical health outcomes and health-related behaviors. For example, across nearly 50 publications, results have consistently shown that combat experience is associated with numerous adverse outcomes. Consistent with the Study’s conceptual model and overall purpose, the Study’s research can be broken down into three core areas (psychological health, physical health, and health-related behaviors) as well as multiple cross-cutting focus areas that organize an increasingly diverse portfolio. A summary of each of the core areas and research on sexual trauma as one example of a cross-cutting research area are provided in turn.

Psychological health overview

A large proportion of the Study’s research has focused on various aspects of mental health among service members during and after service. Early findings of baseline prevalence of mental health disorders among Study participants suggested that service members experienced fewer mental health disorders than the general population [31], though those with (vs. without) mental health conditions at subsequent assessments were more likely to be unemployed following separation from service [32]. Specific mental health conditions were frequently examined as outcomes, with posttraumatic stress disorder (PTSD) ($n = 27$) [31,33–58] and depression ($n = 15$) [31,33–37,40–44–48,58–60] most commonly reported in Study publications to date. Other conditions of interest examined as part of the psychological health portfolio include general mental health and overall health-related quality of life [34,35,42,43,45,61–64], comorbid PTSD and depression [65], disordered eating [66,67], stress [61], anxiety [35,40,43–45,58], anger [68], and suicide [27,64,69,70]. Findings for PTSD, depression, and suicide are described more thoroughly as follows.

PTSD

Among the most consistent findings of the Study is that combat experience increases risk of adverse mental health outcomes, with PTSD being the most commonly demonstrated outcome [37,43–45,48,49,51–55]. The Study observed a threefold increase in new-onset self-reported PTSD symptoms or diagnoses among those who

Table 2
Summary of foundational Millennium Cohort Study publications to date.

	Citation	Summary
Foundational papers and/or literature reviews and/or study design	[8]	Presents a general review of Millennium Cohort Study methodology.
	[9]	Provides a general summary of the Millennium Cohort Study.
	[10]	Presents a literature review of the first 10 years of the Millennium Cohort Study.
	[15]	Provides a brief summary of findings from the Millennium Cohort Study.
	[16]	Provides an overview of different Department of Defense databases that can be linked with Millennium Cohort Study data.
	[17]	Compares the Millennium Cohort Study with the UK's King's Cohort.
	[78]	Summarizes presentations at a 1-day American Thoracic Society workshop focused on effects of deployment on respiratory health, which included a Millennium Cohort Study presentation.
	[124]	Summarizes the effectiveness of different sources of mortality data to indicate deaths among members of the Cohort.
Enrollment and recruitment	[31]	Presents baseline prevalence of mental disorders in Millennium Cohort Study participants enrolled in Panel 1.
	[125]	Describes the use of postcards to encourage participation and cost-effective means to keep contact information updated over time for a highly mobile population.
	[126]	Summarizes the Millennium Cohort Study methodology and demographic characteristics of participants enrolled in Panel 1.
	[127]	Compares baseline health of Millennium Cohort participants with a general population of same age and sex.
	[128]	Compares health outcomes by whether participants completed the web-based versus paper-based survey.
	[129]	Examines whether prior healthcare utilization was associated with Millennium Cohort enrollment by comparing those who did and those who did not enroll in response to the recruitment invitation.
	[130]	Examines differences between those who respond early to the invitation to participate (including both consenters and refusers) and non-responders.
	[131]	Evaluates the potential for nonresponse bias in follow-up assessments among Panel 1 responders.
	[132]	Examines whether deployment status and prior healthcare utilization were associated with enrollment in Panels 2 and 3.
	Validation of self-reported measures	[20]
[21]		Describes agreement between self-reported medical diagnoses and those recorded in the medical record.
[22]		Describes the validity of self-reported and officially recorded military occupation for female Millennium Cohort participants.
[23]		Compares results of depression screens completed on the Millennium Cohort Study survey with those reported on the Post-Deployment Health Assessment.
[24]		Estimates the reliability and validity of self-reported smallpox vaccinations when compared with official documentation in the medical record.
[25]		Estimates the reliability and validity of self-reported anthrax vaccinations when compared with official documentation in the medical record.
[26]		Examines test-retest reliability of various measures, including demographic characteristics and standardized instruments for physical and mental health.
Examination of psychometric properties	[27]	Compares the effectiveness of the 9-item Patient Health Questionnaire (PHQ-9) with the PHQ-8.
	[28]	Presents confirmatory and exploratory factor analyses of a modified version of the Posttraumatic Growth Inventory-Short Form.
	[29]	Describes an exploratory factor analysis of self-reported physical and psychological symptoms.
	[30]	Reports on responses to an open-ended "health concern" item on the Millennium Cohort Study survey.
	[133]	Summarizes the efficiency and feasibility of multiple imputation to address missing data in longitudinal research.
	[71]	Responds to a critique of a paper by LeardMann et al. (2013) on suicide among military personnel.
Commentaries and responses	[134]	Responds to a critique of a paper by Jacobson et al. (2008) on the association between combat deployment and alcohol use.
	[135]	Responds to a critique of a paper by Smith et al. (2004) examining the effects of 9/11 on substance use.
	[136]	Responds to a critique of a paper by Donoho et al. (2017) examining trajectories of posttraumatic stress disorder symptomology.

deployed with combat compared with their nondeployed peers [38], though studies examining PTSD, and other mental health outcomes among specific sub-populations have been mixed. For example, individual augmentees (i.e., individuals deployed under a unit different from their current assignment; versus non-individual augmentee deployment) and Army Special Forces personnel (vs. Army General Purpose Forces infantrymen) were not at higher risk for PTSD [35,42], while Army veterinarians were more likely to experience mental disorders than Army physicians [64]. Furthermore, the association between combat experience and post-deployment PTSD was relatively consistent among all branches of

service [38] and did not differ by sex when adjusting for relevant confounding variables, including sexual assault [50]. However, the risk of post-deployment PTSD was elevated among those who had deployed more than once [57], experienced prior physical or sexual assault [55], sustained more (vs. less) severe combat injuries [37], or reported poor baseline mental health [41]. These findings suggest those with pre-existing vulnerabilities, such as a prior assault or poor pre-deployment mental health, appeared to have greater risk for PTSD, above and beyond the risk of experiencing combat.

Furthermore, the Study Team has made great strides to understand the trajectories of PTSD over time. While combat experience

Table 3
Millennium Cohort Study publications reporting on physical health outcomes, psychological health outcomes, health-related behaviors, and risk factors*

Core research area	Military service characteristics Includes Gulf War era, pre-versus post-9/11, branch of service and/or pay grade, service component, military occupation, post-service characteristics	Deployment characteristics Includes general deployment, combat deployment, deployment frequency, burn pit exposure, land versus sea deployments, blast exposure	Health-related behaviors Includes general health-related behaviors, physical activity, alcohol use, prescription substance use, sleep disturbance, vaccinations	Physical health Includes general physical health, pain, head injury, childbirth	Mental health Includes general mental health, PTSD, depression, stress, trauma	
Physical health outcomes Includes general physical health, autoimmune diseases, chronic multisymptom illness, coronary heart disease, diabetes, hearing loss, hypertension, inflammatory bowel disease, low back pain, lower extremity tendinopathies, migraines and/or headaches, reproductive health, respiratory health, weight change	[35,36,61,62,66,72,88,95,96,98,127,138,139] 13	[61,62,66,72–74,80–87,92–96,115,127,138,140–145] 28	[25,89,90,92,95,97–99] 8	[36,86,98,143] 4	[33,34,84–86,91,92,94–96,115,116,145] 13	42
Psychological health outcomes Includes general mental health, anger, anxiety and/or panic, comorbid PTSD and depression, depression, health-related quality of life, PTSD, sexual harassment and/or sexual assault, stress, suicide	[31,35,37,38,46,47,52,56–58,61–65,68,127,146] 18	[37,38,42–57,59–62,65,68,69,117,127,146] 28	[39,40,44,45,51,53,56,68,69,98] 10	[36,37,41,51,56,60,65,98] 8	[33,34,37,40,41,50,55,56,65,68,69] 11	40
Health-related behaviors outcomes Includes alcohol use, complementary and alternative medicine use, disordered eating, motor vehicle crash, physical activity, sleep disturbance, prescription substance use, tobacco use	[31,35,58,64,100,102,104,106] 8	[43,48,87,100,102–106,147] 12	[40,89,100,101] 4	[36,148] 2	[33,40,67,106,109,118,149,150] 8	27
	31	64	19	12	30	92

* Study publications that did not present novel empirical data are not included, nor are two publications whose outcomes did not fit neatly into one of the three core research areas [32,137].
Bold and italicized number in each cell and at the end of each row and column represents the total number of publications for that category.
PTSD = posttraumatic stress disorder.

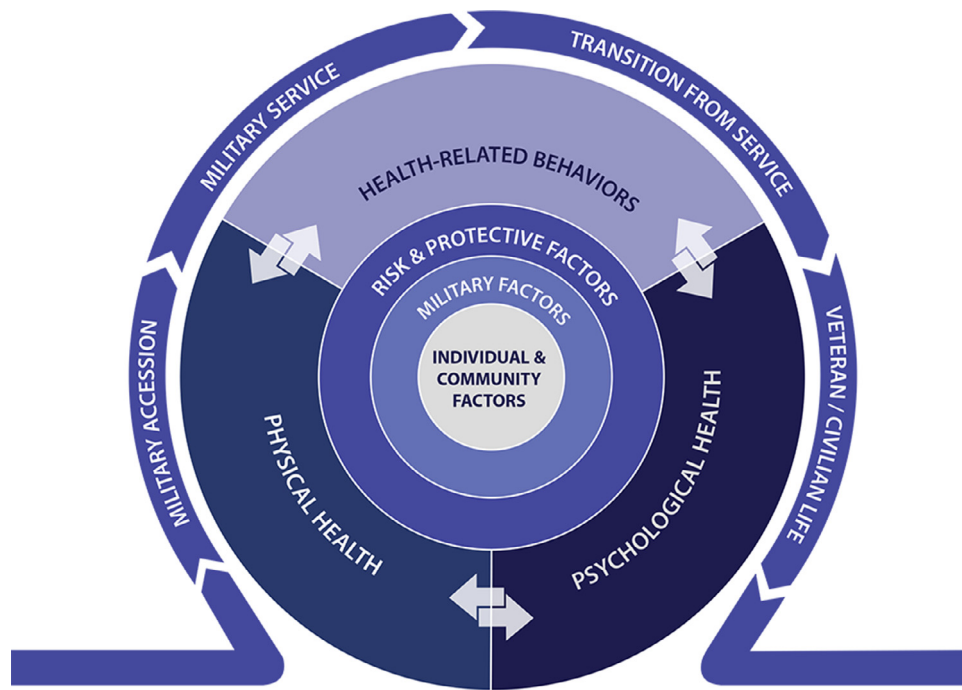


Figure 2. Conceptual model of the Millennium Cohort Study.

has been consistently associated with PTSD, multiple investigations using latent growth mixture models identified several trajectories of PTSD, the most common of which was resiliency [54,56,57,65]. Specifically, among those who deployed, nearly 90% without combat experience and 80% with combat experience maintained low levels of PTSD symptoms over several survey cycles following deployment [54]. Findings were generally consistent when accounting for single versus multiple deployments [57]. Taken together, these findings suggest that while military service may expose service members to combat experience, which can result in PTSD, the vast majority of service members are resilient and do not develop PTSD.

Depression

Study findings regarding depression were similar to those observed for PTSD. Specifically, several publications reported that those who experienced combat while deployed had an increased risk of depression compared with those who did not deploy or who deployed without combat experience [43–45,48,49,59]. While military healthcare workers endure the stress of being responsible for providing potentially lifesaving care to wounded or injured personnel, those exposed to combat had no greater risk for depression or PTSD compared with those working in other occupations who were also exposed to combat [49]. Additionally, other investigations reported that those with (vs. without) pre-deployment insomnia symptoms were more susceptible to depression following combat deployment [44]. Furthermore, the Study observed that servicewomen had a higher prevalence of depression than servicemen, a trend also noted among non-military populations, although risk factors were consistent for both men, and women [59]. Maternal depression may partially explain this difference between women and men, but these findings suggest that combat experience was the most important factor in predicting depression among servicewomen with young children [60].

Suicide

Developing strategies to prevent suicide among service members and veterans is a critically important priority for the DoD and

VA and requires a comprehensive understanding of the complex nature of suicidality. While a predominant theory emerged that the higher suicide rates among service members and veterans were directly associated with deployments in support of OEF and/or OIF and/or OND, a seminal prospective analysis of 150,000 service members and veterans was the first study to report no direct association between deployment and suicide risk [69,71]. Rather, depression, bipolar disorder, alcohol-related problems, and male sex were independently associated with suicide risk [69,71]. A more recent in-depth examination found that high combat severity and certain combat experiences, such as killing a non-combatant, were associated with suicide attempts, though these associations were mostly accounted for by mental health disorders (e.g., PTSD) [70].

Physical health overview

The second core research portfolio focuses on physical health (e.g., acute and chronic physical illnesses and injuries). Although physical and mental health outcomes were examined with relatively equal frequency, the specific outcomes studied within the physical health portfolio have been more varied, with most examined as a function of different facets of deployment. Other than findings that deployment, broadly defined, was associated with increased risk of plantar fasciitis [72] and newly reported respiratory symptoms [73,74], much of the Study’s findings were consistent with the “healthy warrior effect” that hypothesizes that those who are healthier are more likely to deploy and are thus at lower risk of adverse physical health outcomes than those who do not deploy [75–77]. While these findings suggest that deployment in and of itself is not inherently harmful to physical health and that deployers are generally healthier than non-deployers, certain events or exposures that are more likely to occur during deployment have been associated with adverse physical health outcomes. Here we review specific Study findings on respiratory health, autoimmune conditions, and cardiometabolic health in more detail.

Respiratory health

In response to public concerns regarding airborne hazards encountered during deployments, including open-air burn pits, dust storms, and high ambient levels of particulate matter, the Study has conducted multiple analyses examining respiratory health [78,79]. The Study was one of the first to report an increase in respiratory symptoms (e.g., shortness of breath) during deployment, though these increases are likely attributed to specific exposures, such as combat, compared with deployment itself [73,74]. Using survey data linked with records of OEF and/or OIF deployment locations within 2, 3, or 5 miles of a documented burn pit, no significant association was observed between burn pit proximity and chronic multisymptom illness [80], newly reported respiratory symptoms (i.e., persistent cough or shortness of breath), or respiratory diseases (i.e., asthma, chronic bronchitis, or emphysema) [81]. However, with ongoing follow-up of participants, the Study is conducting additional analyses that account for extended follow-up time to capture respiratory outcomes with longer latency (e.g., emphysema and chronic bronchitis) in relation to combat deployment and potential burn pit exposure.

Autoimmune conditions

Data from the Study have been leveraged to examine the effects of military service on the development of several autoimmune conditions such as lupus, rheumatoid arthritis, and inflammatory bowel disease. Deployment (both with and without combat) was not associated with increased risk of newly reported lupus, and deployers were less likely to report rheumatoid arthritis than their non-deployed counterparts [82]. Furthermore, proximity to burn pits during deployment was not associated with newly reported lupus or rheumatoid arthritis [81]. However, a recent study observed that PTSD was associated with the development of select autoimmune conditions, a finding suggestive of a common immune-mediated inflammatory mechanism [84]. Another study found that a greater number of life stressors and prior infectious gastroenteritis were associated with subsequent inflammatory bowel disease (e.g., Crohn's disease and ulcerative colitis) [85,86].

Cardiometabolic health

In addition to respiratory and autoimmune health, several investigations have examined the potential associations between military service and cardiometabolic conditions and its precursors, including obesity [33,36,66,87–91], hypertension [33,36,92,93], heart disease [36,94], and type 2 diabetes [33,36,95,96]. While service members tend to be healthier than their civilian counterparts overall, service members and veterans similarly gain weight over time [36]. Those who reported combat experience during deployment and those with PTSD were more likely to gain weight and become obese over time [66,91]. Additionally, separation from service was associated with subsequent weight gain [36,66], although practicing healthy behaviors (e.g., regular exercise, sufficient sleep) was identified as one potential avenue for obesity prevention [90]. Similarly, combat deployment, PTSD, being overweight, and poor sleep were associated with development of newly reported hypertension among study participants [92,93]. Combat deployment and PTSD were also found to be associated with diagnoses of new-onset coronary heart disease [94]. Furthermore, while combat deployment was not directly associated with development of type 2 diabetes, associations were observed with PTSD, trouble sleeping, and sleep apnea [95,96].

Health-related behaviors

The third core research portfolio area addresses health-related behaviors, including substance use (e.g., alcohol, tobacco), sleep,

and physical activity. These modifiable behaviors have been a key focus of the Study, given the potential to inform recommendations and interventions that may improve service member and veteran health. This particular research portfolio comprised about 30% of the Study's publications to date, with research investigating health-related behaviors as both consequences of military service as well as precursors (e.g., modifiable risk factors) for other outcomes of interest [25,39,40,44,45,51,53,56,68,69,89,90,92,95,97–101]. Generally, combat deployment has been associated with a variety of maladaptive health-related behaviors, including greater alcohol use [43,48,102–104], tobacco use [43,105–107], and sleep disturbance [108], though findings suggest that the associations between the number of deployments (i.e., single vs. multiple) and these health-related behaviors are mixed [102,105]. When examined as precursors, Study findings have noted that poor health-related behaviors are associated with increased risk of adverse mental and physical health outcomes [45,56,69]. A summary of findings on physical activity, substance abuse, and sleep are provided in further detail as follows.

Physical activity

Due to physical activity and fitness requirements inherent in military service, the Study has conducted several investigations of self-reported physical activity. For example, an investigation of Air Force participants observed high rates of self-reported physical activity levels that exceeded national recommendations and were ultimately associated with high levels of physical fitness based on objective assessments [89]. Engagement in more healthy behaviors, such as physical activity and adequate sleep, has conferred subsequent benefits, including decreased risk of mental and physical health problems among soldiers [35]. Another study observed decreased risk of new-onset and persistent PTSD among those engaged in physical activity, especially vigorous activity [39]. Among veterans, moderate to vigorous physical activity decreased among those who most recently separated from the military, indicating the importance of including health promotion efforts targeted for the transition period out of service [88,90].

Tobacco and alcohol use

Another topic that has received a great deal of attention by Study investigators is unhealthy substance use, including the initiation of and relapse to smoking and unhealthy alcohol use. Notably, the association between mental health issues and substance use are inherently bidirectional in nature [40]. Study findings have also repeatedly observed increases in heavy weekly drinking, binge drinking, alcohol-related problems, smoking initiation, and smoking relapse associated with combat deployment [43,48,102–106], and was one of the first to document significant unhealthy alcohol use in Reserve and/or Guard members post-deployment [103]. Additionally, prior mental health issues (e.g., PTSD) and major life stressors were all associated with initiation, persistence, and relapse of tobacco use [105,106]. Furthermore, Study findings have shown occupational differences in substance use [35,64] and that prior sexual assault was associated with relapse to smoking in men and relapse to unhealthy alcohol use in women [109].

Sleep

As with other health-related behaviors, sleep can be affected by military service and poor sleep is associated with numerous adverse outcomes. Deployment in particular was observed to hamper sleep quality and quantity, though these associations were mediated by a combination of combat experience, and mental health symptoms [108]. Poor sleep was also associated with adverse mental and physical health outcomes. For example, those with poor sleep prior to deployment were more likely to experience a variety of post-deployment mental health conditions, including PTSD,

depression, and anxiety [44,51]. Type 2 diabetes risk was also elevated among those with self-reported trouble sleeping and sleep apnea, compared to those without these sleep problems, even after adjustment for relevant mental health conditions [95]. Furthermore, the association between sleep, readiness, and other military career outcomes is of particular importance to the DoD. For example, the Study observed that service members with insomnia symptoms were less likely to deploy, more likely to report lower self-rated health, more lost workdays, and early discharge from service, and to have more health care visits, compared to those with no insomnia symptoms [97].

Sexual trauma

In addition to the psychological health, physical health, and health-related behaviors core portfolio areas, several other topics have emerged over time as research priorities that cut across the overarching portfolio areas, including sexual trauma. Sexual trauma, which includes sexual harassment and/or sexual assault, has been prioritized by the DoD, the VA, Congress, and the general public [110,111]. Although the absolute counts of US servicemen who experience sexual trauma are comparable to servicewomen, most of the previous research had focused on women. Research from the Study has corroborated and expanded upon the previous findings that documented some of the negative impacts of sexual trauma among service members and veterans [112–114].

Analyses of Study data revealed numerous associations between sexual trauma and adverse outcomes. Among male and female participants, sexual trauma was associated with poorer functional, physical, and mental health as well as difficulties in the workplace [34]. Furthermore, male survivors of sexual assault or harassment were more likely to experience smoking relapse, separation from the military, and post-service disability and/or unemployment [34,115]. In addition, sexual health was negatively affected by sexual assault in service men, which was mediated through PTSD [116]. Among women, sexual assault was associated with relapse to unhealthy alcohol use [109], and sexual harassment was associated with military demotion [115]. Combat experience during deployment was associated with elevated risk of sexual trauma among women [117]. Study findings have also observed that service men and women who experienced sexual assault were more likely to report higher levels of physical activity, potentially suggesting that survivors may use exercise as a means of coping [118].

Discussion

Over the past 20 years, the Study has provided a unique and extraordinary opportunity to efficiently study the effects of military service on service member and veteran health and well-being, including but not limited to the unanticipated deployments in support of OEF, OIF, and OND. Given the productivity of the Study to date and the promise of further discoveries with additional follow-up, the Study arguably represents a large return on investment. The Study has been prolific in identifying risk and protective factors for service member and veteran health and well-being. Indeed, from being one of the earliest large-scale prospective longitudinal studies to use internet-based data collection, the accumulation of linkages with multiple databases, and the ability to prospectively follow service members throughout their military careers and through transition out of service, the Study has been groundbreaking in multiple areas. In order to make research accessible to a diverse range of audiences and stakeholders, the Study's dissemination strategy includes identifying customers for targeted knowledge transition and developing formal agreements with DoD offices and other stakeholders, conducting stakeholder-informed re-

search, and producing reports tailored toward the translation from research to practice and policy.

Future directions

Although initially designed as a 21-year effort to track service member health throughout their military careers, the Study is now planned to continue through 2068 in order to follow service members throughout their lifetimes. This provides the unique ability to research health and life challenges during the period of transition out of military service and reintegration into civilian life, as well as long-term health and well-being outcomes of military service. Additionally, the Study will continue to present opportunities to increase collaboration across the DoD, VA, academia, government, and non-governmental organizations.

The Study remains responsive to ever-changing situations and environments (e.g., congressional mandates [119], emerging military conflicts, new research priorities) as well as major current events (e.g., 9/11, COVID-19 pandemic). Some of these new research priorities reflect the increasing proportion of participants who are now veterans, while others reflect recognition of novel risk factors for service member, and veteran health or responses to stakeholder concerns (e.g., women's health [119]). For example, the large proportion of Cohort members who have left military service since the Study's initiation prompted substantial growth of the veterans' health research area. Additionally, the survey instrument continues to evolve over time to remain responsive to stakeholder concerns. For example, following increased awareness of the incidence of traumatic brain injury during the recent conflicts [120,121], new items assessing history, severity, and mechanisms of brain injury were incorporated. Other additions to the survey over time included topics such as sexual orientation, gender identity, financial health, homelessness, bullying and/or discrimination, perceived social support, specific combat events, anger, resilience, e-cigarette and/or vaping use, childhood trauma, and insomnia. Since the survey revision process occurs several years prior to cycle launch in order to allow time for review and approval, it is challenging to quickly adapt to include items related to important current events (e.g., COVID-19). This highlights the importance of established data linkages already in place (e.g., with medical records from DoD and VA) which enable timely responses to stakeholder and public concerns. The study thus remains well-positioned to investigate current and emerging threats to service member health and well-being.

Two future directions warrant special note. Following a long-standing research collaboration with VA researchers, which began with planning the Study, the VA became a Study sponsor following an interagency agreement in 2013, and a subsequent data use agreement in 2018 enabled linkages with VA healthcare and benefits records. This unprecedented access facilitates examination of the continuity of care between the DoD and VA during the transition to veteran status, risk and protective factors during the transition phase, and enhances the long-term ascertainment of health outcomes (e.g., cancer, neurodegeneration) occurring long after separation from service. Veteran health and well-being represent an emerging priority for the Study. For example, future research will identify factors associated with retention of service members as well health and well-being of those during transitioning out of the military. This expansion will further advance the understanding of the implications of military service on chronic conditions, including those that may develop much later in life (e.g., dementia), and those that may not be identified based on survey data alone. Furthermore, because veterans are followed regardless of their utilization of VA services, the Study will be uniquely positioned to examine an important segment of the veteran population that often cannot be examined in research conducted by the VA.

Second, in recognition of the integral role that families play in service member readiness and well-being, the Study expanded its scope to include spouses of service members in a complementary and parallel effort, the Family Study, which is the largest prospective longitudinal study of nearly 10,000 military spouses. The Family Study completed its first decade of follow-up and finished enrolling its second panel of participants in August 2021. The Family Study is uniquely able to study several subpopulations such as dual-military couples, male spouses, and, with the addition of the second panel, single-parent service members. Spouses enrolled in the Family Study also report on the health of their children, which further expands capabilities to understand the impact of military service on families. The Family Study also shares several characteristics in common with the Study, such as the ability to link data from a variety of administrative data sources. Specifically, the ability to link Family Study data with Millennium Cohort Study data allows for dyadic analyses of military couples and a unique way to examine the associations between military service and family well-being [122,123].

Conclusion

This paper presented a brief summary of the Study, its methodology, and its impact over its first 20 years. Although the impact the Study has made over these 20 years cannot be overstated, the continued growth of scientific knowledge and understanding of how military service (including but not limited to deployment) has the potential to affect service member and veteran health and well-being. The Study Team investigators will continue to collaborate with other research organizations to deliver high-quality and impactful knowledge products that inform scientific understanding, policy, clinical practice guidelines, and health promotion efforts to ultimately improve the health and well-being of service members, veterans, and families.

Author contributions

Jennifer N. Belding – Conceptualization, methodology, writing – original draft, writing – review and editing, visualization, project administration; *Edward J. Boyko* – Writing – review and editing; *Felicia R. Carey* – Writing – review and editing; *Sheila F. Castañeda* – Conceptualization, methodology, visualization, writing – review and editing; *Isabel Jacobson* – Conceptualization, methodology, writing – review and editing; *Claire A. Kolaja* – Writing – review and editing; *Cynthia LeardMann* – Conceptualization, methodology, visualization, writing – review and editing; *Rayna K. Matsuno* – Writing – review and editing; *Ben Porter* – Writing – review and editing; *Teresa Powell* – Conceptualization, writing – review and editing; *Anna C. Rivera* – Writing – review and editing; *Rudolph P. Rull* – Conceptualization, methodology, visualization, writing – review and editing, funding acquisition, supervision; *Amber Seelig* – Writing – review and editing; *Beverly Sheppard* – Writing – review and editing; *Daniel Trone* – Writing – review and editing; *Jennifer Walstrom* – Writing – review and editing.

Disclaimer

I am a military service member or employee of the U.S. Government. This work was prepared as part of my official duties. Title 17, U.S.C. §105 provides that copyright protection under this title is not available for any work of the U.S. Government. Title 17, U.S.C. §101 defines a U.S. Government work as work prepared by a military service member or employee of the U.S. Government as part of that person's official duties. Report No. 21–41 was supported by the Military Operational Medicine Research Program, Defense Health Program, and Department of Veterans Affairs under

work unit no. 60002. 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. The study protocol was approved by the Naval Health Research Center Institutional Review Board in compliance with all applicable Federal regulations governing the protection of human subjects. Research data were derived from an approved Naval Health Research Center Institutional Review Board protocol, number NHRC.2000.0007.

Funding/Support

This work was supported by Military Operational Medicine Research Program, Defense Health Program, and the Department of Veterans Affairs under work unit no. 60002. VA Puget Sound provided support for Dr. Boyko to participate in this research.

Acknowledgments

In addition to the authors, the Millennium Cohort Study Team includes Satbir Boparai, Ania Bukowinski, Toni Geronimo-Hara, Gia Gumbs, Clinton Hall, David Ignacio, William Lee, Steven Speigle, and Steven Warner. The authors also appreciate contributions from the Deployment Health Research Department, Millennium Cohort Family Study, and the Birth and Infant Health Research Team. We thank the Millennium Cohort Study participants.

References

- [1] Defense Manpower Data Center. Active duty military strength by service: strength summary 2021. Accessed from: <https://dwp.dmdc.osd.mil/dwp/app/dod-data-reports/workforce-reports> [Accessed 26 August 2021].
- [2] Sartin JS. Gulf War illnesses: causes and controversies. In: *Mayo Clinic Proceedings*, 75; 2000. p. 811–19.
- [3] Research Advisory Committee on Gulf War Veterans' Illnesses Gulf War illness and the health of Gulf War veterans: scientific findings and recommendations. Washington (DC): US: Government Printing Office; 2008.
- [4] Institute of Medicine Chronic multisymptom illness in Gulf War veterans: case definitions reexamined. Washington (DC): National Academies Press; 2014.
- [5] Institute of Medicine. Committee on Measuring the Health of Gulf War Veterans Gulf War veterans: measuring health. Washington (DC): National Academies Press; 1999.
- [6] Strom Thurmond National Defense Authorization Act for Fiscal Year 1999 Public Law 105–261, H.R. 3616, 105th Congress; 1997. Accessed from: <https://www.congress.gov/105/plaws/publ261/PLAW-105publ261.pdf> [Accessed 26 August 2021].
- [7] Crum-Cianflone NF, Fairbank JA, Marmar CR, Schlenger W. The Millennium Cohort Family Study: a prospective evaluation of the health and well-being of military service members and their families. *Int J Methods Psychiatr Res* 2014;23(3):320–30.
- [8] Chesbrough KB, Ryan MAK, Amoroso P, Boyko EJ, Gackstetter GD, Hooper TI, et al. The Millennium Cohort Study: a 21-year prospective cohort study of 140,000 military personnel. *Mil Med* 2002;167(6):483–8.
- [9] Smith TC, for the Millennium Cohort Study Team. The US Department of Defense Millennium Cohort Study: career span and beyond longitudinal follow-up. *J Occup Environ Med* 2009;51(10):1193–201.
- [10] 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(1):69.
- [11] Draugalis JR, Coons SJ, Plaza CM. Best practices for survey research reports: a synopsis for authors and reviewers. *Am J Pharm Educ* 2008;72(1):1–6.
- [12] Fincham JE. Response rates and responsiveness for surveys, standards, and the Journal. *Am J Pharm Educ* 2008;72(2):1–3.
- [13] Lacey JV Jr, Savage KE. Response rates: half-empty, or half-full? *Cancer Causes Control* 2016;27(6):805–8.
- [14] National Research Council Nonresponse in social science surveys: a research agenda. Washington, DC: The National Academies Press; 2013. doi:10.17226/18293.
- [15] Crum-Cianflone Nancy F, Amara J, Hendricks A. 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: *Military health care from predeployment to post-separation*. New York: Routledge; 2013. p. 55–77.
- [16] Smith TC. Linking exposures and health outcomes to a large population longitudinal study: the Millennium Cohort Study. *Mil Med* 2011;176(Suppl 7):56–63.

- [17] Pinder RJ, Greenberg N, Boyko EJ, Gackstetter GD, Hooper TI, Murphy D, et al. Profile of two cohorts: UK and US prospective studies of military health. *Int J Epidemiol* 2012;41(5):1272–82.
- [18] Ursano RJ, Colpe LJ, Heeringa SG, Kessler RC, Schoenbaum M, Stein MB. The Army Study to Assess Risk and Resilience in Servicemembers (Army STARRS). *Psychiatry* 2014;77(2):107–19.
- [19] Kessler RC, Colpe LJ, Fullerton CS, Gebler N, Naifex JA, Nock MK, et al. Design of the Army Study to Assess Risk and Resilience in Service members (Army STARRS). *Int J Methods Psychiatr Res* 2013;22(4):267–75.
- [20] Smith B, Wingard DL, Ryan MAK, 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(12):976–82.
- [21] Smith B, Chu LK, Smith TC, Amoroso PJ, Boyko EJ, Hooper TI, et al. Challenges of self-reported medical conditions and electronic medical records among members of a large military cohort. *BMC Med Res Methodol* 2008;8(1):37.
- [22] 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. *Int J Environ Health Res* 2007;17(4):271–84.
- [23] Welsh MM, Federinko SP, Burnett DG, Gackstetter GD, Boyko EJ, Seelig AD, et al. Deployment-related depression screening, 2001–2008: comparing clinical versus research surveys. *Am J Prev Med* 2014;47(5):531–40.
- [24] LeardMann CA, Smith B, Smith TC, Wells TS, Ryan MAK. Smallpox vaccination: comparison of self-reported and electronic vaccine records in the Millennium Cohort Study. *Hum Vaccin* 2007;3(6):245–51.
- [25] Smith B, Leard CA, Smith TC, Reed RJ, Ryan MAK. Anthrax vaccination in the Millennium Cohort: validation and measures of health. *Am J Prev Med* 2007;32(4):347–53.
- [26] Smith TC, Smith B, Jacobson IG, Corbeil TE, Ryan MAK. Reliability of standard health assessment instruments in a large, population-based cohort study. *Ann Epidemiol* 2007;17(7):525–32.
- [27] Wells TS, Horton JL, LeardMann CA, Jacobson IG, Boyko EJ. A comparison of the PRIME-MD PHQ-9 and PHQ-8 in a large military prospective study, the Millennium Cohort Study. *J Affect Disord* 2013;148(1):77–83.
- [28] Kaur N, Porter B, LeardMann CA, Tobin LE, Lemus H, Luxton DD, et al. Evaluation of a modified version of the Posttraumatic Growth Inventory-Short Form. *BMC Med Res Methodol* 2017;17(1):69.
- [29] Kelton ML, LeardMann CA, Smith B, Boyko EJ, Hooper TI, Gackstetter GD, et al. Exploratory factor analysis of self-reported symptoms in a large, population-based military cohort. *BMC Med Res Methodol* 2010;10(1):94.
- [30] Leleu TD, Jacobson IG, LeardMann CA, Smith B, Foltz PW, Amoroso PJ, et al. Application of latent semantic analysis for open-ended responses in a large, epidemiologic study. *BMC Med Res Methodol* 2011;11(1):136.
- [31] Riddle JR, Smith TC, Smith B, Corbeil TE, Engel CC, Wells TS, et al. Millennium Cohort: the 2001–2003 baseline prevalence of mental disorders in the US military. *J Clin Epidemiol* 2007;60(2):192–201.
- [32] Horton JL, Jacobson IG, Wong CA, Wells TS, Boyko EJ, Smith B, et al. The impact of prior deployment experience on civilian employment after military service. *Occup Environ Med* 2013;70(6):408–17.
- [33] Wang L, Seelig A, Wadsworth SM, McMaster H, Alcaraz JE, Crum-Cianflone NF. Associations of military divorce with mental, behavioral, and physical health outcomes. *BMC Psychiatry* 2015;15(1):128.
- [34] Millegan J, Wang L, LeardMann CA, Miletich D, Street AE. Sexual trauma and adverse health and occupational outcomes among men serving in the U.S. military. *J Trauma Stress* 2016;29(2):132–40.
- [35] Cooper AD, Warner SG, Rivera AC, Rull RP, Adler AB, Faix DJ, et al. Mental health, physical health, and health-related behaviors of U.S. Army Special Forces. *PLoS ONE* 2020;15(6):e0233560.
- [36] Rush T, LeardMann CA, Crum-Cianflone NF. Obesity and associated adverse health outcomes among US military members and veterans: findings from the Millennium Cohort Study. *Obesity* 2016;24(7):1582–9.
- [37] Sandweiss DA, Slymen DJ, LeardMann CA, Smith B, White MR, Boyko EJ, et al. Preinjury psychiatric status, injury severity, and postdeployment post-traumatic stress disorder. *Arch. Gen. Psychiatry* 2011;68(5):496–504.
- [38] Smith TC, Ryan MAK, Wingard DL, Slymen DJ, Sallis JF, Kritiz-Silverstein D. New onset and persistent symptoms of post-traumatic stress disorder self reported after deployment and combat exposures: prospective population based US Military Cohort Study. *BMJ* 2008;336(7640):366.
- [39] LeardMann CA, Kelton ML, Smith B, Littman AJ, Boyko EJ, Wells TS, et al. Prospectively assessed posttraumatic stress disorder and associated physical activity. *Public Health Rep* 2011;126(3):371–83.
- [40] Smith TC, LeardMann CA, Smith B, Jacobson IG, Miller SC, Wells TS, et al. Longitudinal assessment of mental disorders, smoking, and hazardous drinking among a population-based cohort of US service members. *J Addict Med* 2014;8(4):271–81.
- [41] LeardMann CA, Smith TC, Smith B, Wells TS, Ryan MAK. Baseline self reported functional health and vulnerability to post-traumatic stress disorder after combat deployment: prospective US military cohort study. *BMJ* 2009;338:b1273.
- [42] Granado NS, Zimmermann L, Smith B, Jones KA, Wells TS, Ryan MAK, et al. Individual augmentee deployment and newly reported mental health morbidity. *J Occup Environ Med* 2012;54(5):615–20.
- [43] Crum-Cianflone NF, Powell TM, LeardMann CA, Russell DW, Boyko EJ. Mental health and comorbidities in U.S. military members. *Mil Med* 2016;181(6):537–45.
- [44] Gehrman P, Seelig AD, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, et al. Postdeployment sleep duration and insomnia symptoms as risk factors for new-onset mental health disorders following military deployment. *Sleep* 2013;36(7):1009–18.
- [45] Seelig AD, Jacobson IG, Smith B, Hooper TI, Gackstetter GD, Ryan MAK, et al. Prospective evaluation of mental health and deployment experience among women in the US military. *Am. J. Epidemiol.* 2012;176(2):135–45.
- [46] Schaller EK, Woodall KA, Lemus H, Proctor SP, Russell DW, Crum-Cianflone NF. A longitudinal comparison of posttraumatic stress disorder and depression among military service components. *Military Psychology* 2014;26(2):77–87.
- [47] Wells TS, Bagnell ME, Miller SC, Smith TC, Gackstetter GD, Boyko EJ. U.S. naval and Marine Corps occupations, posttraumatic stress disorder, depression risk, and absenteeism. *J Workplace Behav Health* 2014;29(2):91–112.
- [48] Porter B, Hoge CW, Tobin LE, Donoho CJ, Castro CA, Luxton DD, et al. Measuring aggregated and specific combat exposures: associations between combat exposure measures and posttraumatic stress disorder, depression, and alcohol-related problems. *J Trauma Stress* 2018;31(2):296–306.
- [49] Jacobson IG, Horton JL, LeardMann CA, Ryan MAK, Boyko EJ, Wells TS, et al. Posttraumatic stress disorder and depression among U.S. military health care professionals deployed in support of operations in Iraq and Afghanistan. *J Trauma Stress* 2012;25(6):616–23.
- [50] Jacobson IG, Donoho CJ, Crum-Cianflone NF, Maguen S. Longitudinal assessment of gender differences in the development of PTSD among US military personnel deployed in support of the operations in Iraq and Afghanistan. *J Psychiatr Res* 2015;68:30–6.
- [51] Armenta RF, Rush T, LeardMann CA, Millegan J, Cooper A, Hoge CW, et al. Factors associated with persistent posttraumatic stress disorder among U.S. military service members and veterans. *BMC Psychiatry* 2018;18(1):48.
- [52] Smith TC, Wingard DL, Ryan MAK, Kritiz-Silverstein D, Slymen DJ, Sallis JF. PTSD Prevalence, associated exposures, and functional health outcomes in a large, population-based military cohort. *Public Health Rep* 2009;124(1):90–102.
- [53] Crum-Cianflone NF, Frasco MA, Armenta RF, Phillips CJ, Horton J, Ryan MAK, et al. Prescription stimulants and PTSD among U.S. military service members. *J Trauma Stress* 2015;28(6):585–9.
- [54] Donoho CJ, Bonanno GA, Porter B, Kearney L, Powell TM. A decade of war: prospective trajectories of posttraumatic stress disorder symptoms among deployed US military personnel and the influence of combat exposure. *Am. J. Epidemiol* 2017;186(12):1310–18.
- [55] Smith TC, Wingard DL, Ryan MAK, Kritiz-Silverstein D, Slymen DJ, Sallis JF. Prior assault and posttraumatic stress disorder after combat deployment. *Epidemiology* 2008;19(3):505–12.
- [56] Porter B, Bonanno GA, Frasco MA, Dursa EK, Boyko EJ. Prospective post-traumatic stress disorder symptom trajectories in active duty and separated military personnel. *J Psychiatr Res* 2017;89:55–64.
- [57] Bonanno GA, Mancini AD, Horton JL, Powell TM, LeardMann CA, Boyko EJ, et al. Trajectories of trauma symptoms and resilience in deployed US military service members: prospective cohort study. *Br J Psychiatry* 2012;200(4):317–23.
- [58] Wells TS, Ryan MAK, Jones KA, Hooper TI, Boyko EJ, Jacobson IG, et al. A comparison of mental health outcomes in persons entering U.S. military service before and after September 11, 2001. *J Trauma Stress* 2012;25(1):17–24.
- [59] Wells TS, LeardMann CA, Fortuna SO, Smith B, Smith TC, Ryan MAK, et al. A prospective study of depression following combat deployment in support of the wars in Iraq and Afghanistan. *Am J Public Health* 2010;100(1):90–9.
- [60] Nguyen S, LeardMann CA, Smith B, Conlin AMS, Slymen DJ, Hooper TI, et al. Is military deployment a risk factor for maternal depression? *J Womens Health* 2012;22(1):9–18.
- [61] Bagnell ME, LeardMann CA, McMaster HS, Boyko EJ, Smith B, Granado NS, et al. The association of predeployment and deployment-related factors on dimensions of postdeployment wellness in U.S. military service members. *Am J Health Promot* 2013;28(2):e56–66.
- [62] Porter B, Long K, Rull RP, Dursa EK, for the Millennium Cohort Study Team. Health status of Gulf War and era veterans serving in the US military in 2000. *J Occup Environ Med* 2018;60(5):e261–7.
- [63] Smith TC, Smith B, Corbeil TE, Riddle JR, 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. *J Occup Environ Med* 2004;46(8):775–82.
- [64] Rivera AC, Geronimo-Hara TR, LeardMann CA, Penix EA, Phillips CJ, Faix DJ, et al. Health of Army Veterinarians and Veterinary Technicians in the Millennium Cohort Study. *J. Am. Vet. Med. Assoc* 2021;258(7):767–75.
- [65] Armenta RF, Walter KH, Geronimo-Hara TR, Porter B, Stander VA, LeardMann CA, et al. Longitudinal trajectories of comorbid PTSD and depression symptoms among U.S. service members and veterans. *BMC Psychiatry* 2019;19(1):396.
- [66] Littman AJ, Jacobson IG, Boyko EJ, Powell TM, Smith TC for the Millennium Cohort Study Team. Weight change following US military service. *Int J Obes* 2013;37(2):244–53.
- [67] Mitchell KS, Porter B, Boyko EJ, Field AE. Longitudinal associations among posttraumatic stress disorder, disordered eating, and weight gain in military men and women. *Am. J. Epidemiol* 2016;184(1):33–47.
- [68] Adler A, LeardMann CA, Roenfeldt K, Jacobson I, Forbes D. Magnitude of problematic anger and its predictors in the Millennium Cohort. *BMC Public Health* 2020;20:1168.

- [69] LeardMann CA, Powell TM, Smith TC, Bell MR, Smith B, Boyko EJ, et al. Risk factors associated with suicide in current and former US military personnel. *JAMA* 2013;310(5):496–506.
- [70] LeardMann CA, Matsuno RK, Boyko EJ, Powell TM, Reger MA, Hoge CW, et al. Association of combat experiences with suicide attempts among active-duty US service members. *JAMA Network Open* 2021;4(2):e2036065.
- [71] Hoge CW, LeardMann CA, Boyko EJ. Suicides among military personnel—Reply. *JAMA* 2013;310(23):2565–6.
- [72] Owens BD, Wolf JM, Seelig AD, Jacobson IG, Boyko EJ, Smith B, et al. Risk factors for lower extremity tendinopathies in military personnel. *Orthop J Sports Med* 2013;1(1):2325967113492707.
- [73] Rivera AC, Powell TM, Boyko EJ, Lee RU, Faix DJ, Luxton DD, et al. New-onset asthma and combat deployment: findings from the Millennium Cohort Study. *Am. J. Epidemiol.* 2018;187(10):2136–44.
- [74] Smith B, Wong CA, Smith TC, Boyko EJ, Gackstetter GD, Ryan MAK, et al. Newly reported respiratory symptoms and conditions among military personnel deployed to Iraq and Afghanistan: a prospective population-based study. *Am. J. Epidemiol* 2009;170(11):1433–42.
- [75] McLaughlin R, Nielsen L, Waller M. An evaluation of the effect of military service on mortality: quantifying the healthy soldier effect. *Ann Epidemiol* 2008;18(12):928–36.
- [76] Larson GE, Highfill-McRoy RM, Booth-Kewley S. Psychiatric diagnoses in historic and contemporary military cohorts: combat deployment and the healthy warrior effect. *Am. J. Epidemiol* 2008;167(11):1269–76.
- [77] Toomey R. Invited commentary: how healthy if the “healthy warrior”? *Am. J. Epidemiol* 2008;167(11):1277–80.
- [78] Garshick E, Abraham JH, Baird CP, Ciminera P, Downey GP, Falvo MJ, et al. An official American Thoracic Society workshop report. *Ann Am Thorac Soc* 2019;16(8):e1–16.
- [79] . Respiratory health effects of airborne hazards exposures in the southwest asia theater of military operations. WashingtonDC: National Academies Press; 2020. p. 2020.
- [80] Powell TM, Smith TC, Jacobson IG, Boyko EJ, Hooper TI, Gackstetter GD, et al. Prospective assessment of chronic multisymptom illness reporting possible associated with open-air burn pit smoke exposure in Iraq. *J Occup Environ Med* 2012;54(6):682–8.
- [81] Smith B, Wong CA, Boyko EJ, Phillips CJ, Gackstetter GD, Ryan MAK, et al. The effects of exposure to documented open-air burn pits on respiratory health among deployers of the Millennium Cohort Study. *J Occup Environ Med* 2012;54(6):708–16.
- [82] Jones KA, Granado NS, Smith B, Slymen DJ, Ryan MAK, Boyko EJ, et al. A prospective study of lupus and rheumatoid arthritis in relation to deployment in support of Iraq and Afghanistan: the Millennium Cohort Study. *Autoimmune Dis* 2011;2011:741267.
- [83] Jones KA, Smith B, Granado NS, Boyko EJ, Gackstetter GD, Ryan MAK, et al. Newly reported lupus and rheumatoid arthritis in relation to deployment within proximity to a documented open-air burn pit in Iraq. *J Occup Environ Med* 2012;54(6):698–707.
- [84] Bookwalter DB, Roenfeldt KA, LeardMann CA, Kong SY, Riddle MS, Rull RP. Posttraumatic stress disorder and risk of selected autoimmune diseases among US military personnel. *BMC Psychiatry* 2020;20(1):23.
- [85] Porter CK, Welsh M, Riddle MS, Nieh C, Boyko EJ, Gackstetter G, et al. Epidemiology of inflammatory bowel disease among participants of the Millennium Cohort: incidence, deployment-related risk factors, and antecedent episodes of infectious gastroenteritis. *Aliment. Pharmacol. Ther.* 2017;45(8):1115–27.
- [86] Riddle MS, Welsh M, Porter CK, Nieh C, Boyko EJ, Gackstetter G, et al. The Epidemiology of irritable bowel syndrome in the US military: findings from the Millennium Cohort Study. *Am J Gastroenterol* 2016;111(1):93–104.
- [87] Jacobson IG, Smith TC, Smith B, Keel PK, Amoroso PJ, Wells TS, et al. Disordered eating and weight changes after deployment: longitudinal assessment of a large US military cohort. *Am. J. Epidemiol* 2009;169(4):415–27.
- [88] Littman AJ, Jacobson IG, Boyko EJ, Smith TC. Changes in meeting physical activity guidelines after discharge from the military. *J Phys Act Health* 2015;12(5):666–74.
- [89] de la Motte SJ, Welsh MM, Castle V, Burnett D, Gackstetter GD, Littman AJ, et al. Comparing self-reported physical activity and sedentary time to objective fitness measures in a military cohort. *J Sci Med Sport* 2019;22(1):59–64.
- [90] Bookwalter DB, Porter B, Jacobson IG, Kong SY, Littman AJ, Rull RP, et al. Healthy behaviors and incidence of overweight and obesity in military veterans. *Ann Epidemiol* 2019;39:26–32.e1.
- [91] LeardMann CA, Woodall KA, Littman AJ, Jacobson IG, Boyko EJ, Smith B, et al. Post-traumatic stress disorder predicts future weight change in the Millennium Cohort Study. *Obesity* 2015;23(4):886–92.
- [92] Howard JT, Stewart JJ, Kolaja CA, Sosnov JA, Rull RP, Torres I, et al. Hypertension in military veterans is associated with combat exposure and combat injury. *J. Hypertens* 2020;38(7):1293–301.
- [93] Granado NS, Smith TC, Swanson GM, Harris RB, Shahar E, Smith B, et al. Newly reported hypertension after military combat deployment in a large population-based study. *Hypertension* 2009;54(5):966–73.
- [94] Crum-Cianflone NF, Bagnell ME, Schaller E, Boyko EJ, Smith B, Maynard C, et al. Impact of combat deployment and posttraumatic stress disorder on newly reported coronary heart disease among US active duty and reserve forces. *Circulation* 2014;129(18):1813–20.
- [95] Boyko EJ, Seelig AD, Jacobson IG, Hooper TI, Smith B, Smith TC, et al. Sleep characteristics, mental health, and diabetes risk. *Diabetes Care* 2013;36(10):3154.
- [96] Boyko EJ, Jacobson IG, Smith B, Ryan MAK, 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(8):1771–7.
- [97] Seelig AD, Jacobson IG, Donoho CJ, Trone DW, Crum-Cianflone NF, Balkin TJ. Sleep and health resilience metrics in a large military cohort. *Sleep* 2016;39(5):1111–20.
- [98] White MR, Jacobson IG, Smith B, Wells TS, Gackstetter GD, Boyko EJ, et al. Health care utilization among complementary and alternative medicine users in a large military cohort. *BMC Complement Altern Med* 2011;11(1):27.
- [99] Wells TS, LeardMann CA, Smith TC, Smith B, Jacobson IG, Reed RJ, et al. Self-reported adverse health events following smallpox vaccination in a large prospective study of US military service members. *Hum Vaccin* 2008;4(2):127–33.
- [100] Jacobson IG, Horton JL, Smith B, Wells TS, Boyko EJ, Lieberman HR, et al. Bodybuilding, energy, and weight loss supplements are associated with deployment and physical activity in U.S. military personnel. *Ann Epidemiol* 2012;22(5):318–30.
- [101] Matsuno RK, Porter B, Warner S, Wells N. Surveillance snapshot: cervical cancer screening among U.S. military service women in the Millennium Cohort Study, 2003–2015. *MSMR* 2020;27(07):15.
- [102] Williams EC, Frasco MA, Jacobson IG, Maynard C, Littman AJ, Seelig AD, et al. Risk factors for relapse to problem drinking among current and former US military personnel: a prospective study of the Millennium Cohort. *Drug Alcohol Depend* 2015;148:93–101.
- [103] Jacobson IG, Ryan MAK, Hooper TI, Smith TC, Amoroso PJ, Boyko EJ, et al. Alcohol use and alcohol-related problems before and after military combat deployment. *JAMA* 2008;300(6):663–75.
- [104] Jacobson IG, Williams EC, Seelig AD, Littman AJ, Maynard CC, Bricker JB, et al. Longitudinal investigation of military-specific factors associated with continued unhealthy alcohol use among a large US military cohort. *J Addict Med* 2020;14(4):e53–63.
- [105] Hermes EDA, Wells TS, Smith B, Boyko EJ, Gackstetter GG, Miller SC, et al. Smokeless tobacco use related to military deployment, cigarettes and mental health symptoms in a large, prospective cohort study among US service members. *Addiction* 2012;107(5):983–94.
- [106] Boyko EJ, Trone DW, Peterson AV, Jacobson IG, Littman AJ, Maynard C, et al. Longitudinal investigation of smoking initiation and relapse among younger and older US military personnel. *Am J Public Health* 2015;105(6):1220–9.
- [107] Smith B, Ryan MAK, Wingard DL, Patterson TL, Slymen DJ, Macera CA. Cigarette smoking and military deployment: a prospective evaluation. *Am J Prev Med* 2008;35(6):539–46.
- [108] Seelig AD, Jacobson IG, Smith B, Hooper TI, Boyko EJ, Gackstetter GD, et al. Sleep patterns before, during, and after deployment to Iraq and Afghanistan. *Sleep* 2010;33(12):1615–22.
- [109] Seelig AD, Rivera AC, Powell TM, Williams EC, Peterson AV, Littman AJ, et al. Patterns of smoking and unhealthy alcohol use following sexual trauma among U.S. service members. *J Trauma Stress* 2017;30(5):502–11.
- [110] Stander VA, Thomsen CJ. Sexual harassment and assault in the U.S. military: a review of policy and research trends. *Mil Med* 2016;181(Suppl 1):20–7.
- [111] Kimerling R, Gima K, Smith MW, Street A, Frayne S. The Veterans Health Administration and military sexual trauma. *Am J Public Health* 2007;97(12):2160–6.
- [112] Suris A, Lind L. Military sexual trauma: a review of prevalence and associated health consequences in veterans. *Trauma, Violence, & Abuse* 2008;9(4):250–69.
- [113] Yuan NP, Koss M, Stone M. The psychological consequences of sexual trauma 2006 Accessed from: https://vawnet.org/sites/default/files/materials/files/2016-09/AR_PsychConsequences.pdf. [Accessed 26 August 2021].
- [114] Lang AJ, Rodgers CS, Laffaye C, Satz LE, Dresselhaus TR, Stein MB. Sexual trauma, posttraumatic stress disorder, and health behavior. *Behavioral Medicine* 2003;28(4):150–8.
- [115] Milligan J, Milburn EK, LeardMann CA, Street AE, Williams D, Trone DW, et al. Recent sexual trauma and adverse health and occupational outcomes among U.S. service women. *J Trauma Stress* 2015;28(4):298–306.
- [116] Kolaja CA, Roenfeldt K, Armenta RF, Schuyler AC, Orman JA, Stander VA, et al. Sexual health problems among service men: the influence of posttraumatic stress disorder. *J Sex Res* 2021:1–13.
- [117] LeardMann CA, Pietrucha A, Magruder KM, Smith B, Murdoch M, Jacobson IG, et al. Combat deployment is associated with sexual harassment or sexual assault in a large, female military cohort. *Women's Health Issues* 2013;23(4):e215–23.
- [118] Thomas CL, Nieh C, Hooper TI, Gackstetter GD, LeardMann CA, Porter B, et al. Sexual harassment, sexual assault, and physical activity among U.S. military service members in the Millennium Cohort Study. *J Interpers Violence* 2019;0886260519832904.
- [119] . Report to the Committees on Armed Services of the Senate and the House of Representatives: response to Section 748 of the National Defense Authorization Act for Fiscal Year 2020 (Public law 116-92): initial report on Millennium Cohort Study relating to women of the Armed Forces [Internet]. Washington, DC: Under Secretary of Defense for Personnel and Readiness; 2020. p. 16. Accessed at: May 10, 2021 Accessed from:.
- [120] Okie S. Traumatic brain injury in the war zone. *N Engl J Med* 2005;352(20):2043–7.

- [121] Warden D. Military TBI during the Iraq and Afghanistan wars. *J Head Trauma Rehabil* 2006;21(5):398–402.
- [122] Porter B, Rodriguez LM, Woodall KA, Pflieger JC, Stander VA. Alcohol misuse and separation from military service: a dyadic perspective. *Addict Behav* 2020;110:106512.
- [123] Pflieger JC, Porter B, Carballo CE, Stander VA, Corry NH for the Millennium Cohort Family Study Team. Patterns of strengths in U.S. military couples. *J Child Fam Stud* 2020;29(5):1249–63.
- [124] Hooper TI, Gackstetter GD, LeardMann CA, Boyko EJ, Pearse LA, Smith B, et al. Early mortality experience in a large military cohort and a comparison of mortality data sources. *Popul Health Metr* 2010;8(1):15.
- [125] Welch KE, LeardMann CA, Jacobson IG, Speigle SJ, Smith B, Smith TC, et al. Postcards encourage participant updates. *Epidemiology* 2009;20(2):313–14.
- [126] Ryan MAK, 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(2):181–91.
- [127] Smith TC, Zamorski M, Smith B, Riddle JR, LeardMann CA, Wells TS, et al. The physical and mental health of a large military cohort: baseline functional health status of the Millennium Cohort. *BMC Public Health* 2007;7(1):340.
- [128] 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. *Am. J. Epidemiol.* 2007;166(11):1345–54.
- [129] 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(2):79–87.
- [130] Chretien J-P, Chu LK, Smith TC, Smith B, Ryan MAK the Millennium Cohort Study Team. Demographic and occupational predictors of early response to a mailed invitation to enroll in a longitudinal health study. *BMC Med Res Methodol* 2007;7(1):6.
- [131] 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(1):99.
- [132] Horton JL, Jacobson IG, Littman AJ, Alcaraz JE, Smith B, Crum-Cianflone NF. The impact of deployment experience and prior healthcare utilization on enrollment in a large military cohort study. *BMC Med Res Methodol* 2013;13(1):90.
- [133] Kolaja CA, Porter B, Powell TM, Rull RP, Armenta R, Boparai S, et al. Multiple imputation validation study: addressing unmeasured survey data in a longitudinal design. *BMC Med Res Methodol* 2021;21(1):5.
- [134] Jacobson IG, Smith TC, Bell NS. Military combat deployment and alcohol use—Reply. *JAMA* 2008;300(22):2606–7.
- [135] Smith TC, Smith B, Corbeil TE, Ryan MAK, Riddle JR for the Millennium Cohort Study Team. Impact of terrorism on caffeine and tobacco use. [Response to P. Lohiya letter in response to Smith TC et al. “Self-reported mental health among US military personnel, prior and subsequent to the terrorist attacks of September 11, 2001”]. *J Occup Environ Med* 2004;46(12):1194–5.
- [136] Donoho CJ, Bonanno GA, Porter B, Powell TM. A decade of war: prospective trajectories of posttraumatic stress disorder symptoms among deployed US military personnel and the influence of combat exposure. *Am. J. Epidemiol.* 2018;187(7):1570–5.
- [137] Ackerman A, Porter B, Sullivan R. The effect of combat exposure on veteran homelessness. *J Hous Econ* 2020;49:101711.
- [138] Granado NS, Pietrucha A, Ryan M, Boyko EJ, Hooper TI, Smith B, et al. Longitudinal assessment of self-reported recent back pain and combat deployment in the Millennium Cohort Study. *Spine* 2016;41(22):1754–63.
- [139] Porter B, Long K, Rull RP, Dursa EK for the Millennium Cohort Study Team. Prevalence of chronic multisymptom illness/Gulf War illness over time among Millennium Cohort participants, 2001 to 2016. *J Occup Environ Med* 2020;62(1):4–10.
- [140] McCutchan PK, Liu X, LeardMann CA, Smith TC, Boyko EJ, Gore KL, et al. Deployment, combat, and risk of multiple physical symptoms in the US military: a prospective cohort study. *Ann Epidemiol* 2016;26(2):122–8.
- [141] Porter B, Bonanno GA, Bliese PD, Phillips CJ, Proctor SP. Combat and trajectories of physical health functioning in U.S. service members. *Am J Prev Med* 2019;57(5):637–44.
- [142] Smith TC, Powell TM, Jacobson IG, Smith B, Hooper TI, Boyko EJ, et al. Chronic multisymptom illness: a comparison of Iraq and Afghanistan deployers with veterans of the 1991 Gulf War. *Am. J. Epidemiol.* 2014;180(12):1176–87.
- [143] Wells TS, Seelig AD, Ryan MAK, Jones JM, Hooper TI, Jacobson IG, et al. Hearing loss associated with US military combat deployment. *Noise Health* 2015;17(74):34–42.
- [144] Jankosky CJ, Hooper TI, Granado NS, Scher A, Gackstetter GD, Boyko EJ, et al. Headache disorders in the Millennium Cohort: epidemiology and relations with combat deployment. *Headache* 2011;51(7):1098–111.
- [145] Ippolito AC, Seelig AD, Powell TM, Conlin AMS, Crum-Cianflone NF, Lemus H, et al. Risk factors associated with miscarriage and impaired fecundity among United States servicewomen during the recent conflicts in Iraq and Afghanistan. *Women's Health Issues* 2017;27(3):356–65.
- [146] Proctor SP, Wells TS, Jones KA, Boyco EJ, Smith TC. Examination of post-service health-related quality of life among rural and urban military members of the Millennium Cohort Study. *J Rural Soc Sci* 2011;26(3):32–56.
- [147] Woodall KA, Jacobson IG, Crum-Cianflone NF. Deployment experiences and motor vehicle crashes among U.S. service members. *Am J Prev Med* 2014;46(4):350–8.
- [148] Jacobson IG, White MR, Smith TC, Smith B, Wells TS, Gackstetter GD, et al. Self-reported health symptoms and conditions among complementary and alternative medicine users in a large military cohort. *Ann Epidemiol* 2009;19(9):613–22.
- [149] Bensley KM, Seelig AD, Armenta RF, Rivera AC, Peterson AV, Jacobson IG, et al. Posttraumatic stress disorder symptom association with subsequent risky and problem drinking initiation. *J Addict Med* 2018;12(5):353–62.
- [150] Seelig AD, Bensley KM, Williams EC, Armenta RF, Rivera AC, Peterson AV, et al. Longitudinal examination of the influence of individual posttraumatic stress disorder symptoms and clusters of symptoms on the initiation of cigarette smoking. *J Addict Med* 2018;12(5):363–72.