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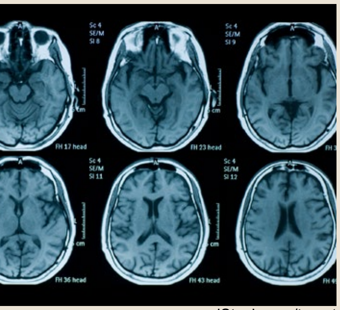

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Hearing Conservation Measures of Effectiveness Across the Department of Defense

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This article summarizes the findings from the first report of the new, standard Measures of Effectiveness developed by the Department of Defense (DoD) Hearing Conservation Program Working Group in 2018. When examining periodic hearing test results of DoD personnel, the overall risk of potential hearing injury/illness was stable from 2012 through 2018. The National Guard and Reserve components showed a higher potential risk of hearing loss, possibly related to lower compliance on follow-up tests when a shift in hearing occurred. Finally, the overall percentage of DoD personnel (who received periodic hearing tests) with hearing impairment decreased over the years presented.

WHAT ARE THE NEW FINDINGS?

DoD Hearing Conservation Program evaluation has historically been limited to service-specific metrics. This article presents the findings from the first review of data on the Measures of Effectiveness developed by the DoD Hearing Conservation Working Group.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Hazardous noise exposure is one of the most common occupational hazards within the DoD; such exposure can cause hearing loss or tinnitus that may directly affect a service member's ability to communicate effectively. The data presented here represent a means to evaluate the services' efforts at hearing conservation.

Starting in 1949 with the first U.S. Air Force (USAF) regulation on noise,[1] Hearing Conservation Programs (HCPs) have been implemented within the military and most commercial occupational settings where hazardous noise is present. These programs protect individuals who are exposed to hazardous noise from developing noise-induced hearing loss or tinnitus, which may result in permanent disability and negatively affect quality of life.[2] Basic components of an HCP to mitigate the negative effects of noise on the worker include noise exposure monitoring, engineering and administrative controls (e.g., reducing the noise at the source, limiting personnel work hours around a hazard), audiometric evaluation, use of hearing protection devices, education and motivation, record keeping, and program evaluation.[3]

The Occupational Safety and Health Administration (OSHA) directs that employers maintain an accurate record of all workers' noise exposures and audiometric testing information.[4] Maintaining accurate and complete records provide evidence of compliance with regulations and are used to evaluate the effectiveness of the program.[5] Due to the military's transient workforce, the Department of Defense (DoD) uses a system of records that allows for monitoring audiograms of service members and DoD civilian personnel at installations worldwide: the Defense Occupational and Environmental Health Readiness System - Hearing Conservation Data Repository (DOEHRS-HC DR). This system allows for capture, analysis, and storage of hearing test (audiograms) results worldwide for DoD HCPs.

Each DoD component establishes, maintains, and evaluates the effectiveness of its own HCP. At a minimum, hearing test results that document a significant threshold shift (STS) and a permanent threshold shift (PTS), as well as rates of compliance with requirements for hearing tests, are collected, reviewed by program managers, and reported to higher headquarters.[6] However, because each service varies in how the metrics are gathered and reported, STS and PTS rates are not always standardized and thus not always comparable. For example, in the Army and Marines Corps, all service members receive hearing tests on at least an annual basis due to the risk of noise-induced hearing loss secondary to exposures to weapon fire noise during required weapon qualification. Hearing ability is also considered an element of individual readiness due to the need to communicate effectively on the battlefield and its relationship to warfighter lethality and survivability. The Air Force and Navy hearing conservation programs take a risk-based approach in which only members who are exposed to routine hazardous noise are enrolled in an audiometric monitoring program and receive periodic hearing tests. To resolve discrepancies between services, the DoD Hearing Conservation Working Group (HCWG) agreed upon standard HCP Measures of Effectiveness (MOEs) in 2018. These MOEs were then prepared and codified by the U.S. Air Force School of Aerospace Medicine's Epidemiology Consult Service Division and the Armed Forces Health Surveillance Branch Air Force Satellite.

METHODS

DOEHRS-HC DR data were used to generate MOEs at the DoD level and for each individual service. Data were stratified by component (active component [AC], National Guard [NG], reserve component, and civilian) and presented as annual percentages among those who were tested. This report presents findings for calendar years 2012 through 2018. All statistical analyses were performed using SAS/STAT software, version 9.4 (2014, SAS Institute, Cary, NC).

It is important to note that, if an individual's reference or periodic hearing test reveals a hearing threshold exceeding 25 decibels hearing level (dBHL) in either ear, then that individual is considered to suffer from hearing impairment. A reference test is the initial hearing test received by an individual before exposure to hazardous noise duty. A periodic test is the monitoring hearing test done regularly to detect changes in hearing that may be associated with hearing injury/illness. When compared to the reference test, changes in hearing in the periodic test may initially be characterized as a significant threshold shift (STS). An STS is an average deterioration in hearing threshold of 10 dBHL or more at 2000, 3000, and 4000 Hz in either ear on the monitoring test, when compared to the individual's reference test. When an STS occurs, follow-up testing is required to confirm whether the shift is temporary or permanent.[7,8,9] If the STS has resolved at the time of the follow-up test, it is considered to have been a temporary threshold shift (TTS). Conversely, if an STS is confirmed on follow-up testing, or the member does not return for retesting within the specified timeframe, the STS is considered to represent a permanent threshold shift (PTS). The timeframe for follow-up testing varies from 30 to 90 days from the periodic test depending on service-specific regulations. Hearing is assessed at least annually for individuals and is compared to the most current reference test available. If an individual had more than one periodic or reference test series in a given calendar year, their most recent test series was used in the analysis. Aggregate data for 4 MOEs were compiled across all services and are described in this report.

MOE 1 examines potential hearing illnesses/injuries by calculating the percentages of tested individuals who had results of STS, TTS, and PTS. The percentages of threshold shifts were calculated by taking the number of unique individuals meeting each set of respective criteria on an annual (a type of periodic test) hearing test per calendar year and dividing by the total number of individuals who received an annual hearing test. For example, the number of individuals with a PTS is divided by the number of those who received an annual hearing test in a given timeframe and the result is expressed as a percentage.

MOE 2 measures compliance with the requirement for follow-up testing after an STS. This MOE is similar to the DoD Instruction 6055.12 definition of compliance rates, but instead of measuring annual compliance with hearing tests,[6] it measures non-compliance when follow-up is required. The rate of non-compliance is calculated by dividing the number of people with an STS who did not receive follow-up testing within the required timeframe by the total number of tests indicative of STS per year. The timeframe for follow-up testing is based on service-specific requirements.

MOE 3 is a measure of the frequency of hearing impairment (hearing thresholds above 25 dBHL) or the frequency of those with clinically normal hearing (hearing thresholds at 25 dBHL or below) in a population of interest. In this report, MOE 3 focuses on the proportion of hearing impairment counts among individuals who received testing per year. Percentages of hearing impaired were calculated by taking the number of individuals (including enlisted accessions as a separate population) with hearing impairment results on a periodic or reference hearing test per year and dividing by the total number of individuals who received a periodic or reference hearing test in the same year.

MOE 4 calculates the percentages of unique individuals who qualify for Veterans Affairs (VA) claims using counts and criteria as outlined in 38 CFR §3.385, Disability Due to Impaired Hearing.[10] Service members meeting these criteria are deemed audiometrically eligible for service-connected disability for hearing impairment; however, there are multiple, additional criteria required before a disability rating for hearing loss is awarded by the VA. The audiometric criteria for MOE 4 are as follows: 1) any threshold greater than or equal to 40 dBHL from 500 to 4000 Hz in either ear, or 2) an average of the 3 highest frequencies between 500 to 4000 Hz greater than 25 dBHL (pure-tone average). The percentage of individuals meeting the VA compensation criteria was defined as the number who met the VA criteria per year divided by the total number of individuals who received a periodic or reference hearing test in that same year.

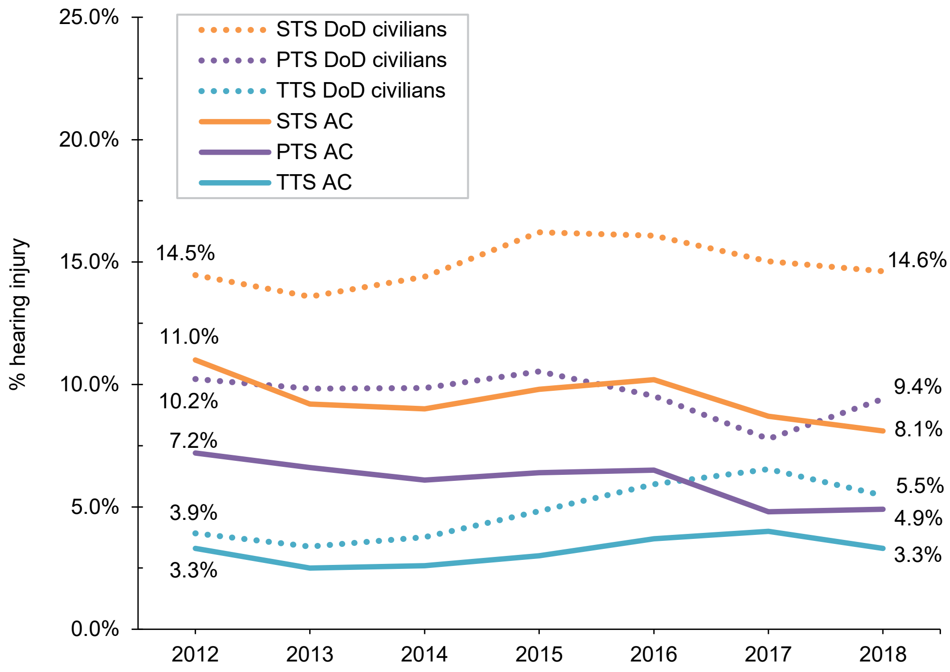
RESULTS

Service representation in the data used for this analysis was approximately 60% Army, 14% Navy, 14% Marines, and 12% Air Force.[11] Figures 1a and 1b show results for MOE 1. Overall, from 2012 through 2018, percentages of potential hearing injury/illness (MOE 1) exhibited a stable pattern or steady decline during the period for AC and civilians, and essentially a stable pattern for NG and reserve members after 2014. Annual percentages of STS and PTS were consistently higher in NG (STS range: 15.1 – 16.3%, PTS range: 12.8 – 14.9%) and reserve members (STS range: 13.7 – 18.4%, PTS range: 11.8 – 17.2%) when compared to AC members (STS range: 8.1 – 11.0%, PTS range: 4.8 – 7.2%). Over the course of the 7-year period, civilian percentages of STS (range: 13.6 – 16.2%) were broadly similar to that of reserve and NG members. Annual percentages of PTS in civilians (range: 9.4 – 10.5%) were higher than those among AC members, but lower than percentages among reserve and NG members **(Figures 1a, 1b)**.

The frequency of non-compliance with follow-up testing (MOE 2) demonstrated a downward trend from 2012 through 2017 among AC, NG, and civilians. Overall, non-compliance among reserve members trended upward during the 7-year study period. In general, non-compliance was substantially lower among AC members (range: 28.2 – 55.0%) and civilians (range: 27.6 – 54.9%) when compared to reserve (range: 78.5 – 93.9%) and NG members (range: 82.0 – 95.5%) **(Figure 2)**.

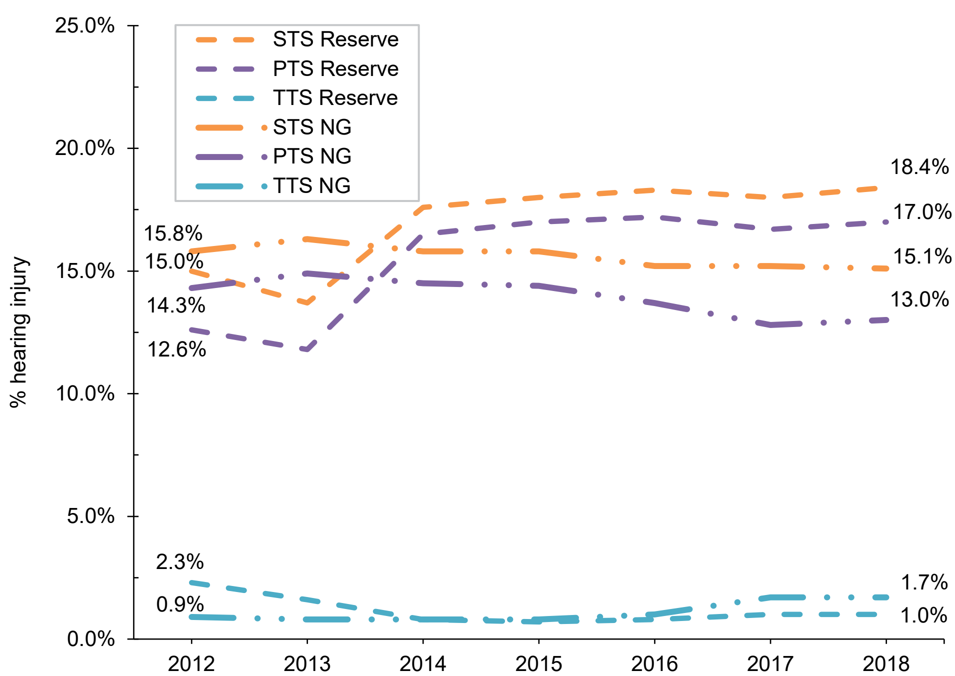
The percentages of those with hearing test results indicative of hearing impairment (MOE 3) decreased slightly but steadily from 2012 through 2018 for all service members and civilians **(Figure 3)**.

FIGURE 1a. MOE 1: Percentages of STS, TTS, and PTS, U.S. active component service members and DoD civilians, 2012–2018



MOE, Measure of Effectiveness; DoD, Department of Defense; STS, significant threshold shift; TTS, temporary threshold shift; PTS, permanent threshold shift; AC, active component; NG, National Guard.

FIGURE 1b. MOE 1: Percentages of STS, TTS, and PTS, reserve component, U.S. Armed Forces, 2012–2018



MOE, Measure of Effectiveness; STS, significant threshold shift; TTS, temporary threshold shift; PTS, permanent threshold shift; NG, National Guard.

A stable, but slightly downward trend was also noted for DoD enlisted accessions.

The percentages of those tested who met the VA compensation criteria (MOE 4) decreased steadily over the 7-year period for all components and the DoD overall **(Figure 4)**. This downward trend appeared to occur equally across all service components.

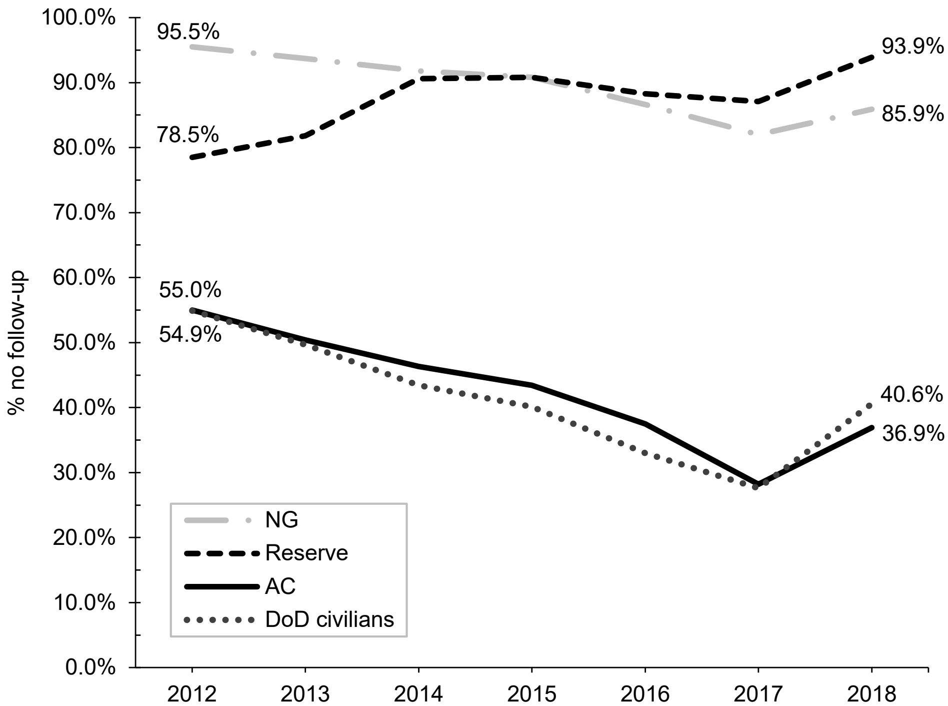
EDITORIAL COMMENT

MOE 1 results show that DoD civilian personnel have generally maintained a stable risk of hearing injury/illness from 2012 through 2018. The goal for this MOE was to detect potential hearing injuries/illnesses due to hazardous noise exposure; therefore, only the periodic annual tests were used to better reflect the personnel who are more routinely exposed. However, because only periodic annual tests were used in computing this measure, it is not recommended to compare MOE 1 STS, PTS, and/or TTS outcomes to similar metrics found in DOEHRS-HC DR aggregate reports, or in other surveillance or research projects. Additionally, not all services are evenly represented within the DOEHRS-HC DR since each branch has its own criteria for enrolling members onto the program as previously stated.

Examination of MOE 1 results across components revealed that AC members had the lowest STS and PTS percentages, and the highest TTS percentages compared to reserve, and NG members. This trend in reserve and NG members may be the result of high non-compliance on follow-up tests as evident in the pattern of MOE 2 results. When an individual does not comply with the required follow-up test to verify a shift in hearing on the periodic annual hearing test within the required timeframe, then a TTS automatically becomes a PTS in the DOERH-HC DR until the individual takes the next year's hearing test. Therefore, an accurate analysis of permanent hearing injury/illness in these 2 populations is not possible until the differences in the proportions of non-compliance are addressed.

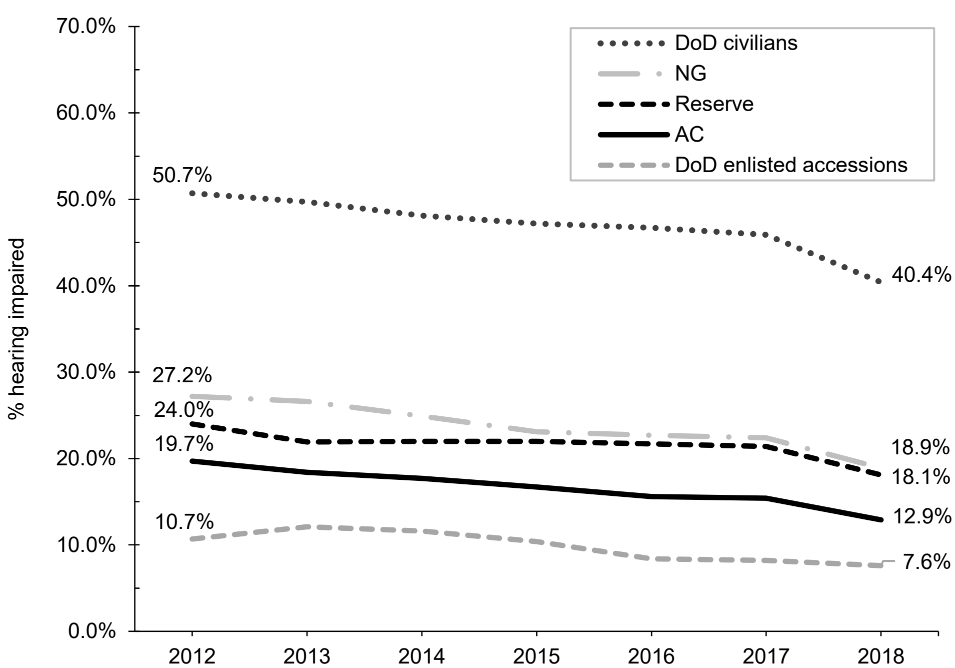
The explanation for the elevated proportions of STS, TTS, and PTS among DoD civilian personnel is unknown; however, the results for this population may

FIGURE 2. MOE 2: Percentages of non-compliance with follow-up testing, by service component and DoD civilians, 2012–2018



MOE, Measure of Effictiveness; DoD, Department of Defense; NG, National Guard; AC, active component.

FIGURE 3. MOE 3: Percentage hearing impaired by service component, DoD civilians, and enlisted accessions, 2012–2018

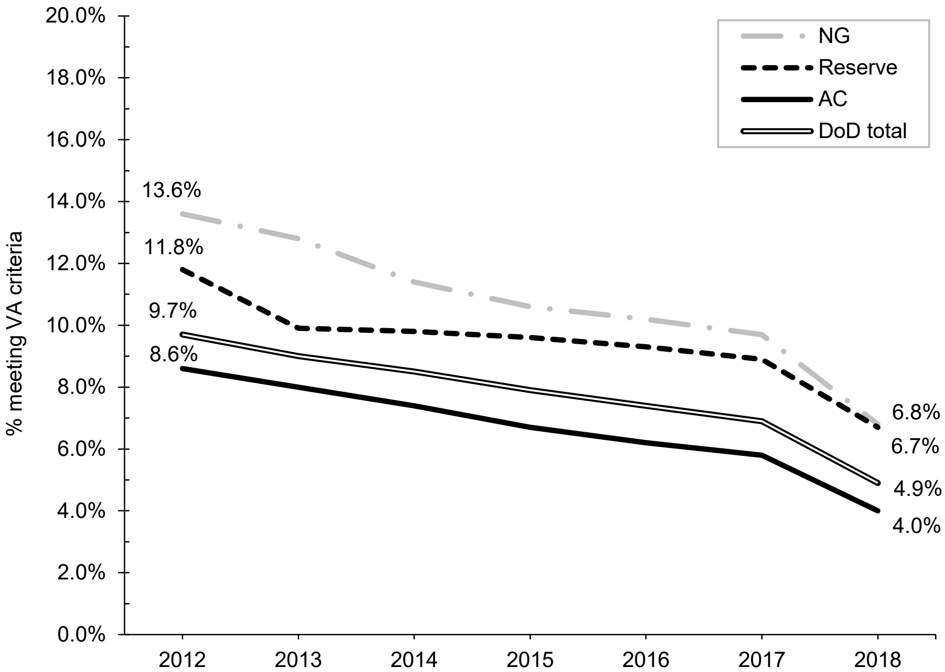


MOE, Measure of Effictiveness; DoD, Department of Defense; AC, active component; NG, National Guard.

reflect differences in age and/or years of noise exposure compared to service member populations (as the effects of noise on the auditory system are cumulative over time), as well as non-compliance with follow-up testing when an STS is captured. Overall, the comparisons between these 4 groups should be undertaken with care due to the differences in their contributions to the dataset (AC 63%; reserve 12%; NG 18%; DoD civilian personnel 7%). In other words, although AC accounts for the largest percentage of test results represented in the DOEHRS-HC DR data, the rules of surveillance are quite different between services and in comparison to reserve, NG or DoD civilian populations. In addition, there are significant age and sex differences between the DoD civilian population and the other populations. Furthermore, there may be additional exposures for the reserves and NG; for example a traditional guardsman only on orders 1 weekend a month could have a concurrent full-time civilian position with hazardous noise exposure.

The trend seen in MOE 3 of fewer individuals presenting with a hearing impairment over the past 6 years could be the result of multiple factors, such as effective hearing conservation prevention efforts, employee turnover, a reduction in noise exposure due to an overall decrease in combat operations, and/or force reduction efforts (e.g., reduction in force by medical requirement enforcement, or decrease in waivers for hearing issues identified at accession). Additionally, the DoD civilian population had a higher percentage meeting the hearing impairment criteria. As with the MOE 1 results for civilians, this observation may have been due to differences in age and/or years of noise exposure for this population compared to service member populations. Alternatively, this trend could also have been the result of less comprehensive efforts in hearing conservation for non-military individuals within DoD. As the DoD continues to emphasize noise-induced hearing loss prevention and to monitor metrics like the MOEs, the downward trend of members meeting MOE 4 VA Criteria indicates fewer individuals are meeting audiometric hearing impairment criteria. There are additional criteria that need to be met before a final

FIGURE 4. MOE 4: Percentages meeting VA criteria by service component, 2012–2018



MOE, Measure of Effectiveness; VA, Veteran's Affairs; NG, National Guard; DoD, Department of Defense; AC, active component.

service-connected disability rating can be obtained for hearing loss such as speech recognition scores below a specified cut-off and medical professional concurrence.

A limitation of the DOEHRS-HC DR data, particularly for more recent years in this report, is the real-time nature of the system in which hearing tests are continuously being imported/exported, edited, and corrected at installations and service levels; decidedly, the data become more stable over time. Therefore, there is less confidence in some data trends until they are shown to be stable in subsequent years; MOE 3 and 4 results show recent shifts in their respective trends between 2017 and 2018, for example.

The MOEs methods and data sets will continually be reviewed by the DoD HCWG and adjusted as needed based on the ever changing mission sets and hazardous noise environments. Upon the request of the DoD HCWG, the Air Force Hearing Conservation Program Office at USAFSAM is evaluating early warning shifts (greater than or equal to 15dB shift at 1,000, 2,000, 3,000 or 4,000 Hz on periodic hearing tests compared to reference hearing test for an individual) for use as a more sensitive indicator for potential hearing injury/illness. These shifts are also flagged in the DOERHS-HC DR data and are very similar to the NIOSH recommended STS criteria.[12] Preliminary data show that early warning shifts have a high positive predictive value in identifying those service members who will present with an STS on their periodic hearing test. Additionally, for the last several years, the Army has taken the STS reporting a step further by creating a "new case of STS" metric, due to the STS's dependence on follow-up test compliance. This metric only counts a new STS; it does not count a repeat STS that was noted the year before. A repeat STS can happen when the member does not complete the required follow up during the year prior; therefore, the reference was never re-established and the member presents with another shift. This metric helps the Army better understand the incidence of hearing injury and STS within their members. The addition of these 2 metrics could give the individual services the ability to better evaluate the effectiveness of their programs and make real-time recommendations, making these metrics good candidates for inclusion as an MOE in the future.

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Alcohol-Related Emergency Department Visits, Hospitalizations, and Co-Occurring Injuries, Active Component, U.S. Armed Forces, 2009–2018

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The military has a high prevalence of alcohol misuse, which can lead to injuries and negative health outcomes. This report characterizes the rate of alcohol-related emergency department and inpatient encounters in the military and the percentage of encounters with co-occurring injury. Between January 2009 and December 2018, there were 75.3 alcohol-related encounters per 10,000 person-years, with a 14.0% decline over the study period. Rates were higher among men, those aged 21–25 years, non-Hispanic whites, Army service members, junior enlisted, and those in combat-specific occupations compared to their respective counterparts. An increase in the rate of encounters in 2010 and 2012 mirrored the surge of troops in Afghanistan. Moreover, 17.1% of alcohol-related encounters were associated with co-occurring injuries. Intentional injuries constituted the largest mechanism of injury, and the percentage of injuries attributable to intentional causes trended down over the study period. Policies and programs that discourage heavy drinking, especially among those exposed to combat, have the potential to decrease medical encounters and injuries related to alcohol misuse.

WHAT ARE THE NEW FINDINGS?

The crude overall incidence rate of alcohol-related encounters among U.S. active component service members during 2009–2018 was 75.3 per 10,000 person-years, with a 14.0% decline over the study period. The pattern of annual rates of alcohol-related injuries differed by deployment status, and 17.1% of encounters had a co-occurring injury diagnosis. Self-inflicted injuries and assaults each accounted for around 10% of the injuries, and both trended downward during the 10-year period.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

The U.S. Armed Forces invests considerable time, money, and resources in training and equipping service members. Alcohol-related incidents with and without injury affect individual readiness and unit mission preparedness and can prematurely end a service member's career. Understanding more about factors associated with alcohol misuse and injury patterns may help identify targets for future interventions.

The Centers for Disease Control and Prevention (CDC) defines binge drinking as 4 or more drinks on 1 occasion for a woman and 5 or more for a man. Heavy drinking is defined as 8 or more drinks per week for a woman or 15 or more drinks per week for a man. The CDC finds that binge drinking is the most common form of excessive alcohol use, and that most adults who binge drink are not alcohol dependent.[1]

Excessive use of alcohol can lead to a variety of both short- and long-term health effects and can result in emergency department (ED) visits and hospitalizations. Injuries such as those associated with motor vehicle crashes, falls, drownings, and burns have been shown to be correlated with preceding alcohol use.[2] In 2016, the CDC reported that alcohol consumption was associated with 10% of deaths among working-age adults in the U.S.[1] The World Health Organization reported that alcohol consumption accounted for 5.3% of all deaths worldwide in 2018.[3]

There was a substantial increase in the number and rate of alcohol-related ED visits between 2006 and 2014 in the U.S., with 45- to 54-year-olds having the highest overall rates of ED visits in 2014.[4] While men typically have been heavier and more frequent drinkers and have also experienced more alcohol-related injuries than women in the past, studies in the last 2 decades have shown a narrowing of the gap between men and women in the prevalence of binge drinking and alcohol-related injuries.[5,6]

Active duty service members are known to have a higher prevalence of alcohol use, heavy drinking, and binge drinking than the general population.[7] Those who drink and who binge drink by the end of high school have higher propensity to both express intent to join and actually join the military.[8,9] Additional research shows that while binge and heavy drinking are an accepted part of military culture, rates of binge and heavy drinking are also significantly higher among those with combat exposure.[10,11] The 2015 Department of Defense (DoD) Health Related Behaviors Survey showed that around 30% of service member respondents were current binge drinkers in 2014, compared to 24.7% of U.S. adults over the age of 18. Moreover, about 8% of service member respondents reported a negative consequence of drinking.[7] Quantifiable alcohol-related adverse events have been characterized in some military populations,[12,13] but not across the entire U.S. Armed Forces.

Emergency room visits and hospitalizations for alcohol-related disorders are increasingly costly in the civilian sector because of both healthcare costs and lost productivity.[14] Healthcare expenditures and lost productivity similarly impact military members. A study of TRICARE expenditures noted alcohol-related medical care to cost around $425 million a year in 2006,[15] which would be over $500 million in 2018, after adjusting for inflation. In addition, significant resources are required to address behavioral and performance issues associated with alcohol misuse in the military. Alcohol-related disorders result in arrests, fights, injuries, lost opportunities for promotion, and early discharge of service members whom the DoD has spent significant time and resources training.[16] These factors converge to negatively impact mission readiness and force lethality.

This investigation characterizes the rates of alcohol-related ED visits and hospitalizations in the active component during 2009–2018 as well as the percentage of those visits in which an injury was sustained. Trends in these data over time are also described.

METHODS

This study utilized a retrospective cohort design with a surveillance period from 1 January 2009 through 31 December 2018. The surveillance population included any member of the Army, Navy, Air Force, or Marine Corps who served in the active component at any point during the surveillance period. All data used to identify cases of alcohol-related visits with and without co-occurring injuries were derived from inpatient and outpatient records within the Defense Medical Surveillance System (DMSS), which is maintained by the Armed Forces Health Surveillance Branch. *Direct care* refers to care rendered within the Military Health System (MHS). *Network care* refers to care rendered by a civilian treatment facility and is captured via TRICARE claims. ED encounters and hospitalizations of active component members of the U.S. Armed Forces in both military and civilian (if reimbursed through the MHS) treatment facilities were included. Each individual was allowed a maximum of 1 ED visit per day. When an ED visit and hospitalization occurred on the same day, the hospitalization was prioritized over the ED visit.

ED visits were defined as those with Medical Expense Performance Reporting System codes BHI* or BIA* or containing Current Procedural Terminology (CPT) codes 99281–99285 in 1 of the first 4 diagnostic positions. ED visits and hospitalizations with an alcohol-related International Classification of Disease, 9th or 10th Revision (ICD-9 or ICD-10, respectively) diagnosis code in any of the first 3 diagnostic positions of the visit were considered to be alcohol-related encounters. Alcohol-related encounters were categorized into 1 of the following 4 groups: alcoholic psychosis, alcohol dependence, alcohol abuse and poisoning, and alcohol-associated organ system damage. ICD-9 and ICD-10 codes used to identify these events are listed in **Table 1**. Alcohol-related ICD-10 codes for which there were no ICD-9 equivalents, such as alcohol-induced pancreatitis, were omitted to avoid creation of an artificial increase in rates of alcohol-related events with the transition from ICD-9 to ICD-10 in 2015. Demographic and military covariates included sex, age group, race, ethnicity, education level, marital status, service branch, rank/grade, military occupation, and deployment to Operation Enduring Freedom, Operation Iraqi Freedom, or Operation New Dawn before any alcohol-related encounter. Deployment history was defined using Defense Manpower Data Center (DMDC) deployment data for Army and Air Force and post-deployment health assessment (PDHA) forms for the Navy and Marine Corps, given that at the time of the analysis the DMDC deployment data were not complete for the latter. Both DMDC and PDHA data are housed in the DMSS. An individual service member could have multiple qualifying alcohol-related ED visits or hospitalizations during the study period and could contribute person-time in different demographic categories as appropriate over time (age, rank, having a deployment, etc.). Statistical analyses were carried out using SAS/STAT software, version 9.4 (2014, SAS Institute, Cary, NC) and Stata IC, version 15.1 (2017, StataCorp LLC, College Station, TX).

To examine the second objective, service members' ED visits and inpatient hospitalizations qualifying as alcohol-related events collected for the first objective were analyzed. All events with an injury code listed in any diagnostic position were considered to be alcohol-related events with co-occurring injury. In addition to the alcohol-related code and injury code, when external cause of injury codes were included, events were categorized as follows: unintentional falls; strikes and crush injuries; drownings and near-drownings; motor vehicle accidents; hypothermia; cuts, pierces, gunshots, and other machinery accidents; intentional injuries; and all other. When a single ED visit or

TABLE 1. ICD-9 and ICD-10 codes for alcohol-related encounters

ICD-9[a]	ICD-10[a]
Alcoholic psychosis	
291.*	F10.121, F10.14, F10.15*, F10.18*, F10.19, F10.221, F10.231, F10.232, F10.239, F10.24, F10.25*, F10.26, F10.27, F10.28*, F10.29, F10.921, F10.94, F10.95*, F10.96, F10.97, F10.98*, F1099
Alcohol abuse and poisoning	
305.0* excluding 305.03, 790.3, 980.0, E860.0	F10.1, F10.10, F10.12, F10.120, F10.129, F10.9, F10.92, F10.920, F10.929, Y90.*, R780, T510.*
Alcohol dependence	
303.* excluding 303.93	F10.20, F10.22, F10.220, F10.229, F10.23, F10.230
Alcohol-associated organ system damage	
571.0-571.3, 357.5, 425.5, 535.5*	K70.0, K70.1*, K70.2, K70.3*, K704.*, K709, G62.1, I42.6, K29.2

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD, International Classification of Diseases.

TABLE 2. ICD-9 and ICD-10 codes for injuries

ICD-9[a]	ICD-10[a]
General injury codes	
800.*–995.*	S00.*–T79.*, DOD0101–DOD0105
External cause of injury codes	
Falls	
E880.*–E886.*, E888.*, E833.*, E834.*, E835.*, E843.*, E987.*	W00*–W19*, V00.111*, V00.121*, V00.131*, V00.141*, V00.151*, V00.181*, V00.211*, V00.221*, V00.281*, V00.311*, V00.321*, V00.381, V00.811*, V00.821*, V00.831*, V00.891*, V80.0*, V81.5*, V81.6*, V82.5*, V82.6*, V91.2*, Y30.*
Drownings/near-drownings	
E910.*, 994.1, E830.*, E832.*, E984.*	W65*, W67*, W69*, W73*, W74*, T75.1*
Strikes and crush injuries	
E916.*, E917.*, E928.3, E918.*, E919.*	W20.*, W21.*, W22.*, W23.*, W24.*, W50.*, W51.*, W52.*, V91.1*, V91.3*, Y29.*, Y31.*
Motor vehicle accidents	
E81.*, E820.*–E825.*	V20.*–V79.*, V86.*–V87.*, Y32.*, V98.*
Hypothermia	
E901.*	X31.*, W93.*
Cuts, pierces, gunshots, other machinery accidents	
E920.*–E923.*, E836.*–E837.*, E985.*, E986.*	W25.*–W40.*, W45.*–W46.*, Y22.*–Y25.*, Y28.*
Self-inflicted injuries	
E950.*–E959.*	X71.*–X83.*
Assaults	
E960.*–E969.*	X92.*–X99.*, Y00.*–Y09.*
Terrorism	
E979.*, E999.1	Y38.*
All others	
All other E codes not previously listed	All other V, W, X, and Y codes not previously listed

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD, International Classification of Diseases.

hospitalization had more than 1 external cause of injury code, a maximum of 1 code was accepted per category. For example, a single ED visit could be counted for both a fall and a strike injury, but not for 2 fall injuries. ICD-9 and ICD-10 codes used to identify injuries are listed in **Table 2**.

Using person-years (p-yrs) derived from individuals serving in the active component during each year of observation as the denominator, rates of alcohol-related events were stratified by year and by demographic and military covariates. Using the alcohol-related events as the denominator, the percentage of alcohol-related events in which injuries co-occurred was also stratified by year and by the above covariates. Descriptive statistics were used to characterize trends over the surveillance period and to make comparisons between subgroups.

RESULTS

During the 10-year study period, there were 101,554 alcohol-related encounters, including both ED visits and hospitalizations among active component service members, with an overall crude rate of 75.3 encounters per 10,000 p-yrs **(Table 3)**. Among these, 52.6% (n=53,368) of encounters were for alcohol abuse and poisoning, 35.0% (n=35,584) were for alcohol dependence disorders, 11.5% (n=11,640) were for alcoholic psychosis, and 0.9% (n=962) were for alcohol-related organ damage **(data not shown)**. ED visits and hospitalizations occurred at crude overall rates of 35.6 and 39.7 per 10,000 p-yrs, respectively **(Table 3)**. Crude annual rates of encounters rose between 2010 and 2012, peaked at 84.4 per 10,000 p-yrs in 2012, and declined thereafter **(Figure 1)**. Overall, there was a 14.0% decrease in the rate of encounters over the 10-year period, from 82.6 encounters per 10,000 p-yrs in 2009 to 71.0 encounters per 10,000 p-yrs in 2018.

Examination of overall rates of alcohol-related encounters by sex and age group indicated that men had a higher rate of alcohol-related encounters than women in every age group except among those under

TABLE 3. Numbers and rates of alcohol-related hospitalizations and ED visits, active component, U.S. Armed Forces, 2009–2018

Study population	No.	Rate[a]
Total	101,554	75.3
Encounter type		
Hospitalization	53,559	39.7
ED visit	47,995	35.6
Sex		
Male	88,419	77.3
Female	13,135	64.5
Age group (years)		
<21	10,759	64.0
21–25	47,815	111.9
26–30	20,841	70.4
31–35	10,797	54.8
36–40	6,803	47.6
41+	4,539	38.8
Sex by age group (years)		
Male		
<21	8,891	63.2
21–25	41,302	114.6
26–30	18,368	73.5
31–35	9,564	57.0
36–40	6,187	49.9
41+	4,107	40.4
Female		
<21	1,868	68.0
21–25	6,513	97.7
26–30	2,473	53.3
31–35	1,233	42.4
36–40	616	32.5
41+	432	28.5
Race/ethnicity group		
Non-Hispanic white	64,890	80.5
Non-Hispanic black	14,122	65.0
Hispanic	13,274	74.1
Asian/Pacific Islander	2,420	47.6
Other/unknown	6,848	71.8
Education level		
High school or less	84,081	93.6
Some college	8,704	57.3
Bachelor's or advanced degree	6,996	26.2
Other/unknown	1,773	56.8
Marital status		
Single, never married	52,043	95.1
Married	43,741	59.1
Other/Unknown	5,770	94.7
Service		
Army	50,198	97.8
Navy	18,923	59.0
Air Force	15,853	49.3
Marine Corps	16,580	86.2
Military rank/grade		
Junior enlisted (E1–E4)	65,862	111.6
Senior enlisted (E5–E9)	30,414	57.8
Junior officer (O1–O3; W01–W03)	3,601	25.1
Senior officer (O4–O10; W04–W05)	1,677	18.9
Military occupation		
Combat-specific[b]	21,708	110.4
Motor transport	4,180	104.8
Pilot/air crew	1,135	22.5
Repair/engineering	29,364	74.9
Communications/intelligence	20,789	70.8
Healthcare	8,290	70.4
Other/unknown	16,088	62.4
Deployment history		
Previous deployment to OEF/OIF/OND	41,640	75.1
No previous deployment to OEF/OIF/OND	59,914	75.5

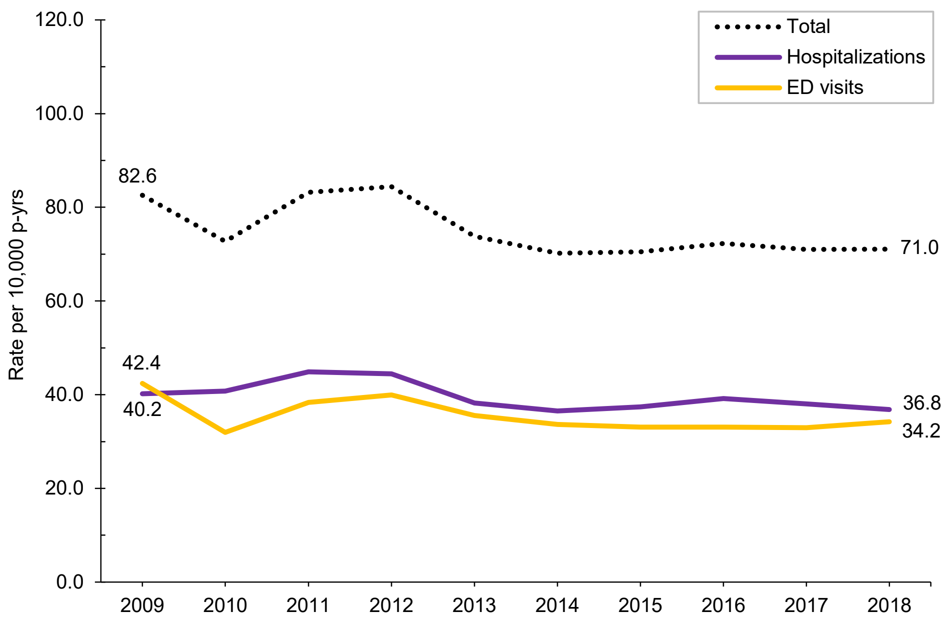
[a]Incidence rate per 10,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
ED, emergency department; No., number; OEF, Operation Enduring Freedom; OIF, Operation Iraqi Freedom; OND, Operation New Dawn.

21 years of age (women: 68.0 per 10,000 p-yrs; men: 63.2 per 10,000 p-yrs) **(Table 3)**. Those service members aged 21–25 years had the highest overall rate of alcohol-related encounters for both sexes **(Table 3)**. There was a marked decrease in the annual encounter rate in the youngest age group for both sexes over time, from 100.8 per 10,000 p-yrs in 2009 to 57.2 per 10,000 p-yrs in 2018. Rates for the 36–40-year-old age group and the 41 years and older age group, while generally lower than the rates for other age groups, increased slightly between 2009 and 2018 **(Figure 2)**.

Across the services, overall alcohol-related encounter rates were highest among Army members (97.8 per 10,000 p-yrs) and lowest among Air Force members (49.3 per 10,000 p-yrs) **(Table 3)**. Throughout the surveillance period, the pattern of rates among members of the Army and the Marine Corps were broadly similar, with the greatest decreases between 2012 and 2018. Rates among Navy and Air Force members increased slightly over the course of the 10-year period **(Figure 3)**. The rates of alcohol-related encounters for those without a deployment remained relatively stable over the study period, while the rates for those with a deployment peaked in 2012 and decreased steadily thereafter **(Figure 4)**. Combat-specific and motor transport occupations had the highest rates among occupation types, and pilots and air crew the lowest **(Table 3)**.

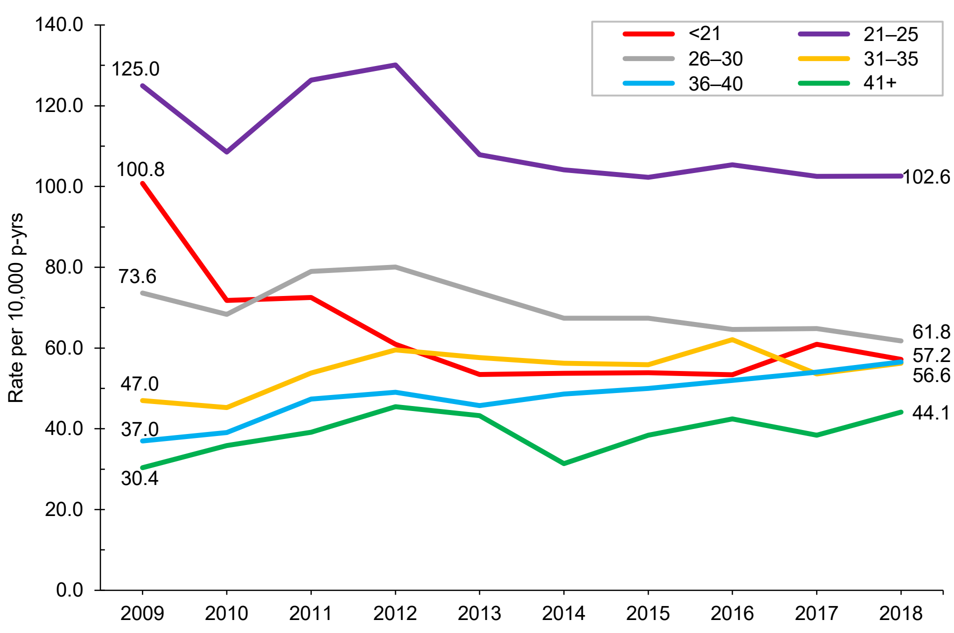
A total of 17,324 alcohol-related encounters (17.1%) had a co-occurring injury, with males, Marines, the 2 youngest age groups, junior enlisted, and junior officers experiencing higher percentages of injuries than their counterparts **(data not shown)**. Among alcohol-related encounters with co-occurring injury, a total of 10,120 external cause codes were recorded; slightly more than half (56.1%; n=9,714) of encounters were associated with 1 or more external cause codes **(Table 4)**. External cause codes in the "other" category accounted for the largest proportion of injuries (15.6%), followed by falls (11.7%), assaults (10.6%), and self-inflicted injuries (10.3%). Over time, the proportion of alcohol-related encounters with co-occurring injury stayed relatively stable **(data not shown)**, while the percentage of those encounters attributable

FIGURE 1. Annual incidence rates of alcohol-related hospitalizations and ED visits, by encounter type, active component, U.S. Armed Forces, 2009–2018



ED, emergency department; p-yrs, person-years.

FIGURE 2. Annual incidence rates of alcohol-related hospitalizations and ED visits, by age group (years), active component, U.S. Armed Forces, 2009–2018



ED, emergency department; p-yrs, person-years.

to self-inflicted injuries and assaults decreased substantially **(Figure 5)**.

Army service members experienced the highest percentage of alcohol-related self-inflicted injuries, while Marines experienced the highest percentage of assaults **(data not shown)**. When intentional injuries were characterized by sex, self-inflicted injuries accounted for a higher percentage of all alcohol-related injuries in women (20.0%; n=397) than in men (9.0%; n=1,390), while assaults accounted for a higher percentage of injuries in men (11.4%; n=1,756) compared to women (3.6%; n=72). Self-inflicted injuries accounted for a higher percentage of alcohol-associated injuries in women than in men across all age categories **(data not shown)**.

A total of 15,629 individuals had more than 1 encounter during the time period. For those service members with multiple alcohol-related encounters, the mean number of encounters was 2.3 (standard deviation:1.8; range: 2–31). While the Army accounted for 38.0% of the total p-yrs in the study, more than half (53.7%) of encounters attributable to repeat offenders occurred within that service branch. Of the 22,714 alcohol-related encounters among this group, a larger portion of them were hospitalizations as opposed to ED visits (62.4%; n=14,183) than in the study group as a whole. Otherwise, Army service members to whom these encounters were attributable were demographically similar to the rest of the study population: they were more predominantly male (88.9%; n=20,190), in the 21–25-year-old age group (36.4%; n=8,260) or the 26–30-year-old age group (24.0%; n=5,455), and more frequently had an education level of "high school or less" (77.0%; n=17,469). Combat-specific occupations were the most common occupation type (31.7%; n=7,192) **(data not shown)**.

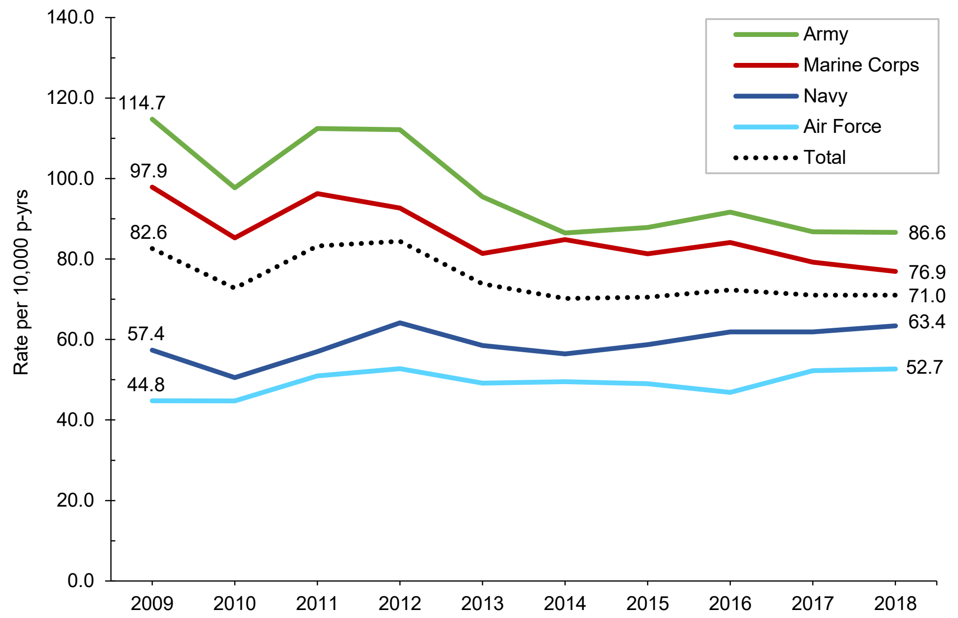
EDITORIAL COMMENT

This analysis is the first to characterize alcohol-related medical encounters and injuries across the entire active component. While direct comparisons are difficult, the estimated rate of alcohol-related ED visits and hospitalizations among active component service members is substantially lower than those reported in the civilian sector.[4] While published estimates suggest that service members misuse alcohol at higher rates than their civilian counterparts,[4,7] factors such as service members' concerns for potential negative career impact, alcohol and drug prevention programs and trainings implemented by each of the services, mandated buddy systems where service members share responsibility for each other's drinking and behavior, base restrictions on the use of alcohol, and alcohol and drug screening programs may work to limit the number of individuals who reach the level of requiring emergency medical attention.

This analysis demonstrated an overall decrease in alcohol-related encounters from 2009 through 2018. Interestingly, an increase in the rates of alcohol-related encounters in 2011 and 2012 and a subsequent decline were seen, both overall and among previous deployers. The timing of this increase in the rate of alcohol-related encounters mirrors the surge and subsequent drawdown of forces in Afghanistan. Military conflict has been shown to increase alcohol drinking behaviors,[10,17] at least for finite periods of time.[18] While it is not possible to causally relate the increase in the rates of alcohol-related encounters in 2011 and 2012 to the conflict in Afghanistan, it is reasonable to anticipate increases in the rates of such encounters in future potential military conflicts. The reason for the pattern of change in the rates of alcohol-related ED encounters during 2009–2012 while the rates of alcohol-related hospitalizations remained relatively stable is unclear. This could be related to a downtrend that began in years before the study period, or it may be an issue of data capture, as many EDs in the MHS transitioned from paper to electronic records around that time.

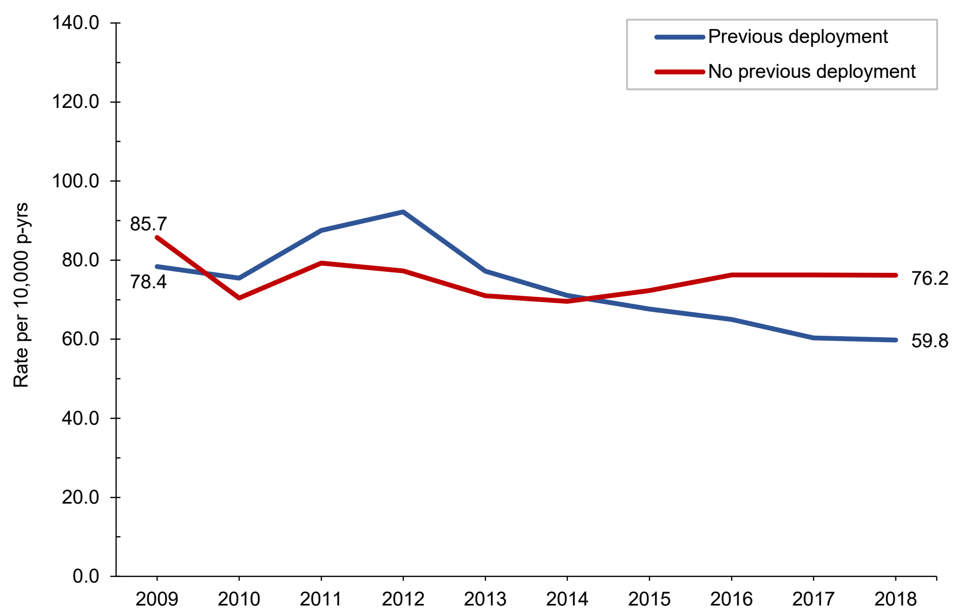
The older age groups in this study had lower rates of alcohol-related encounters in general; however, rates among those groups increased during the study period while the rates in other age categories remained steady or decreased. The increased rates are of concern and may be linked to the trend of increasing alcohol-related ED visits seen in the civilian sector among individuals aged 45 years and older. Whether this trend represents a cohort effect of heavy drinkers maintaining drinking behaviors over time, an increase in care-seeking behavior as individuals age, an impact associated with multiple deployments, or the effect of some other military or environmental exposure is unknown. Further investigation into these and other potentially contributing factors may be warranted.

FIGURE 3. Annual incidence rates of alcohol-related hospitalizations and ED visits, by service, active component, U.S. Armed Forces, 2009–2018



ED, emergency department; p-yrs, person-years.

FIGURE 4. Annual incidence rates of alcohol-related hospitalizations and ED visits, by deployment history, active component, U.S. Armed Forces, 2009–2018



ED, emergency department; p-yrs, person-years.

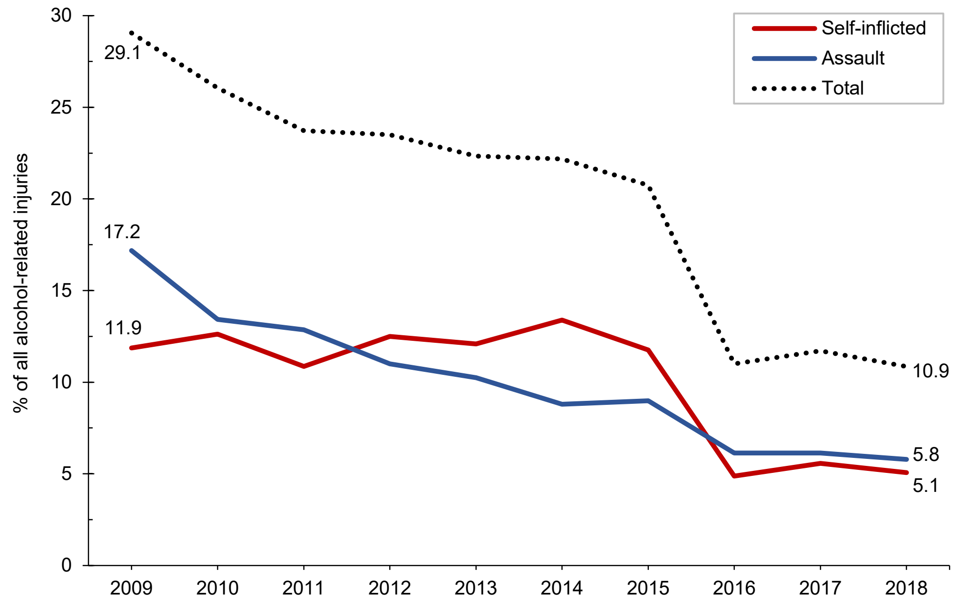
Though decreasing, the trend of self-inflicted injuries in women is also concerning. It must be noted that the crude number of alcohol-related injuries in women overall and the number of those injuries that were self-inflicted were low, which makes explanation of this pattern challenging. This may be related to a larger, nonalcohol-related trend, or it could be that women are simply less likely to injure themselves in accidental ways while drinking. Certainly this is another area that deserves further investigation.

TABLE 4. External cause of injury diagnoses among alcohol-related hospitalizations and ED visits with co-occurring injury, active component, U.S. Armed Forces, 2009–2018

Injury type	No. diagnoses	% of all injuries coded with external cause[a]
All other	2,696	15.6
Falls	2,027	11.7
Assault	1,828	10.6
Self-inflicted	1,787	10.3
Motor vehicle accidents	738	4.3
Strikes	647	3.7
Cut, pierce, unintentional gunshot	360	2.1
Hypothermia	25	0.1
Drowning	12	0.1

[a]Because some encounters had more than 1 external cause code and others had none, percentages do not add to 100% or reflect the percentages of encounters with external cause codes.
ED, emergency department; No., number.

FIGURE 5. Percentages of total alcohol-related injuries, by injury type classification, active component, U.S. Armed Forces, 2009–2018



Lost productivity due to alcohol-related ED visits and hospitalizations, both in routine and mission-related duties, is difficult to quantify but concerning nonetheless. A 2007 RAND report estimated the cost to the government of 1 military p-yr to be between $58,000 and $175,000, depending on occupation, specialty pays, and other specific entitlements.[19] Using the lowest estimated yearly value of $58,000 and accounting for inflation to 2014 (roughly the middle of the study period), 1 military p-yr can be estimated to cost the government just over $70,000. Under the assumption that each of the 101,554 ED encounters or inpatient hospitalizations in the last decade resulted in only 1 lost day of productivity, a little more than 278 p-yrs of time would have been lost, at a very conservative total cost estimate of around $19.5 million over the time frame. Lost duty days provide a poor estimate of impact, however, as the DoD generally does not pay for replacement staff when an active component member is absent from work, and a cost estimate does not account for the myriad of other readiness-related factors involved.

The overrepresentation of Army service members among those with repeat alcohol-related visits is likely related to the higher rate of alcohol-related encounters attributable to the Army in general. However, it may also suggest higher tolerance of these episodes and stronger efforts to rehabilitate soldiers and salvage careers than in the other service branches.

Some strengths and limitations of this study should be considered. The DMSS is a robust data source that allows capture of care anywhere it was rendered as long as the care is covered by TRICARE and also allows analysis of multiple demographic variables and exposures of interest. The number of active component service members who receive care in the civilian sector and use other insurance or pay out of pocket is likely low. However, it is still possible to have missed a significant number of alcohol-related encounters. The transition from ICD-9 to ICD-10 coding in 2015 creates challenges in maintaining consistent case definitions across the time frame of the study. In order to avoid capturing non-alcohol-related events or creating a false elevation in the trend of alcohol-related ED visits and hospitalizations at the time of the coding transition, some codes were intentionally omitted from the data query, which would have resulted in at least a small amount of undercounting. Moreover, there may be hesitancy on the part of clinicians treating active component members to use alcohol-related diagnosis codes because of concern of impact to the service member's career, which would have also resulted in cases not being captured. For more than 40% of the injuries, there were no external cause codes, which is a limitation that may also be at least partly explained by clinician hesitancy to code the circumstances surrounding the injury. For the deployment history variable, there may have been undercapture of deployments among Navy service members, as this information was dependent primarily on electronic completion of the PDHA for these individuals. Additionally, given the differences in demographics and drinking patterns, this study lacks generalizability to the civilian U.S. population. Finally, while actual costs can be calculated to some degree, the difficulty in truly quantifying the impact to the DoD in terms of readiness and mission preparedness is a limitation.

Alcohol misuse contributes to significant harms among military service members and substantial costs to the U.S. Armed Forces. It also decreases readiness and force lethality. A variety of programs and policies are in place to reduce alcohol misuse in the military, including educational campaigns, required annual training, sobriety checks on military bases, and buddy systems. Still, there is room for improvement, especially as it pertains to cultural factors that promote heavy drinking and stressors related to deployment and combat exposure. Though decreasing in frequency, intentional injuries account for a concerning proportion of injuries seen here. Additional exploration into military-specific as well as socioenvironmental drivers is warranted, as are interventions aimed at further reducing this trend. Similarly, efforts to identify and capitalize on protective factors may serve to further reduce alcohol-related encounters in the military and improve preparedness of the warfighter.

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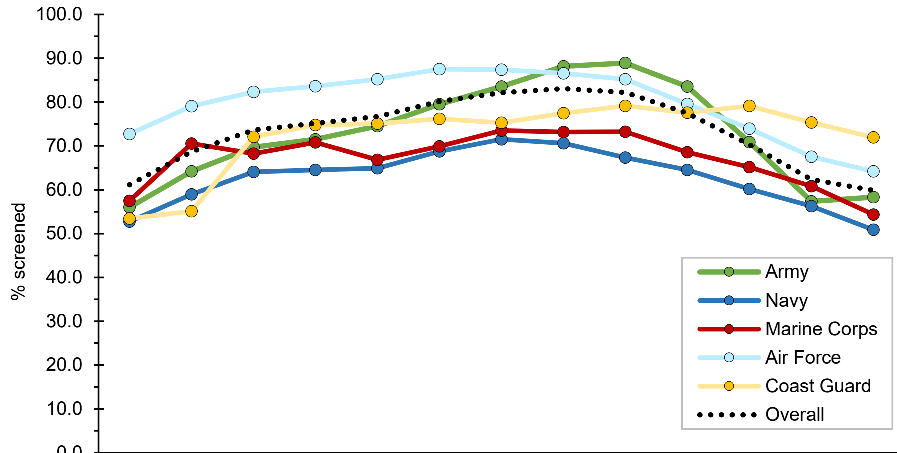
Surveillance Snapshot: Cervical Cancer Screening Among U.S. Military Service Women in the Millennium Cohort Study, 2003–2015

Rayna K. Matsuno, PhD, MPH; Ben Porter, PhD; Steven Warner, MPH; Natalie Wells, MD, MPH (CAPT, USN)

FIGURE. Cervical screening rates among service women, by branch of service, U.S. Armed Forces, 2003–2015



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Army	56.0	64.2	69.7	71.5	74.5	79.5	83.5	88.2	88.9	83.6	70.9	57.4	58.3
Navy	52.7	58.9	64.0	64.5	64.9	68.8	71.5	70.6	67.3	64.5	60.2	56.2	50.9
Marine Corps	57.5	70.5	68.2	70.8	66.8	69.9	73.5	73.2	73.2	68.5	65.2	60.8	54.4
Air Force	72.7	79.1	82.3	83.6	85.2	87.5	87.4	86.6	85.2	79.6	74.0	67.5	64.2
Coast Guard	53.4	55.1	72.1	74.8	75.1	76.2	75.3	77.5	79.2	77.6	79.1	75.3	71.9
Overall	61.2	68.7	73.6	75.2	76.7	80.1	82.1	83.1	82.2	77.5	70.3	62.3	59.8

The Millennium Cohort Study is a prospective study that was initiated in 2001 and includes over 200,000 current and prior U.S. military service members.[1] Questionnaires are sent to participants approximately every 3 years to collect information on service-related experiences as well as mental, physical, and behavioral health. Compliance with contemporary cervical cancer screening recommendations was determined among service women enrolled in the Millennium Cohort Study during 2003–2015. Current cervical cancer screening recommendations call for a Pap smear alone every 3 years in women aged 21–65 years or for a human papillomavirus (HPV) DNA test with or without a Pap test every 5 years for women aged 30–65 years.[2] Women were considered eligible for screening in a given year if they were aged 21–62 years on the last day of the year, had served in the active component (i.e., at least 9 months in active component pay and strength rosters) for the concurrent year and 2 years before, had not had a hysterectomy, and had not separated from the military. Women were considered compliant with screening recommendations between 2003–2015 if they had a medical report of a Pap smear in the year of assessment or prior 2 calendar years. Women were also considered compliant with screening recommendations in 2013–2015 if they had HPV DNA testing completed within the previous 5 years.

Overall, among U.S. service women in the Millennium Cohort Study, the compliance rate increased from 61.2% in 2003 to a peak of 83.1% in 2010 then declined to a low of 59.8% in 2015 **(Figure)**. During the first 7 years of the study period, compliance was highest among Air Force personnel. Between 2013 and 2015, compliance was highest among Coast Guard personnel. Compliance was lowest among Navy personnel in all but 1 year (2004) of the 13-year period. Compliance was also consistently higher for service women who had initiated the HPV vaccine than for women who had not (on average 6.3% higher). No differences in compliance were observed by cigarette smoking status, which was used as a surrogate measure of other health behaviors.

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Epidemiology of Functional Neurological Disorder, Active Component, U.S. Armed Forces, 2000–2018

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Functional neurological disorder (FND) is a complex neuropsychiatric disorder characterized by abnormal or atypical sensorimotor, gait, dissociative, or special sensory symptoms in the absence of structural nervous system lesions to explain the symptoms. Several factors are thought to be associated with FND, including comorbid mental health conditions; exposure to physical, emotional, or sexual trauma; young age, and low socioeconomic status. U.S. military service members may be at increased risk for FND because of the prevalence of some of these factors. The current study evaluated the incidence of FND in the U.S. Armed Forces between 2000 and 2018. The overall incidence rate was 29.5 per 100,000 person-years (p-yrs), with the highest rates among women and individuals less than 20 years old. The overall median annual prevalence rate was 37.2 per 100,000 persons. In addition, there were 162 medical evacuations out of the Central Command (CENTCOM) area of responsibility for FND during the study period. Most medical evacuations occurred among men and those with no history of depression or post-traumatic stress disorder (PTSD).

WHAT ARE THE NEW FINDINGS?

The crude overall incidence rate of FND diagnoses among U.S. active component service members during 2000–2018 was 29.5 per 100,000 p-yrs, which is approximately 2.5–7.4 times higher than estimates reported for the general U.S. population. The overall rates of FND among service members with a history of depression or a history of PTSD were more than 10 times the rates among individuals without such a history.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

There was a total of 162 medical evacuations out of CENTCOM for FND during the study period. Additional data exploring the impact of FND diagnosis on readiness and force health protection are warranted.

Functional neurological disorder (FND) is a complex neuropsychiatric disorder characterized by abnormal or atypical sensorimotor, gait, dissociative, or special sensory symptoms in the absence of structural nervous system lesions to explain the symptoms. As such, the symptoms of FND are inconsistent with currently understood central nervous system pathophysiology.[1] Other terms like "hysteria," "functional neurologic symptom disorder," "psychogenic disorder," and "conversion disorder" have historically been used in the diagnosis of FND, highlighting both the methodological heterogeneity and etiologic uncertainty that are characteristic of this disorder.[2] Methodological and clinical barriers have been recognized as limitations to the study of FND and are likely leading contributors to the underdiagnosis of the condition.[3] However, recent increasing awareness of this disorder has led to advances in the understanding of the epidemiology and pathophysiology of this complex condition.[4]

The estimated incidence rate of FND in the general population is 0.4–1.2 per 10,000 person-years (p-yrs),[1,3,5] and 1.1–2.2 per 10,000 p-yrs in psychiatric settings.[6] FND can present in all age groups, including children.[7–9] The diagnosis is most common among women and more common among patients with a history of childhood abuse of any kind, including emotional, physical, and sexual abuse.[3] There is also evidence that the prevalence of FND may be higher among individuals with lower educational achievement, lower socioeconomic status, and in underdeveloped countries.[10,11] Race is not thought to be a significant independent contributing factor in the diagnosis of FND.[11]

Comorbid psychiatric illness has been widely recognized as a major risk factor for FND. Studies have consistently found that patients with FND are diagnosed more frequently with depression and have higher levels of depressive symptoms.[12] The same has been observed with anxiety.[3] A recent study comparing the association of depression and anxiety symptoms found that depression may be more predictive of functional symptoms, regardless of the severity of anxiety.[13] Notwithstanding, whether functional symptoms are a consequence of or risk factor for depression or anxiety remains unclear. Functional neurological symptoms have been observed in other nonpsychiatric clinical populations as well, including inpatient, outpatient, and obstetric settings.[11,14]

Exposure to trauma, particularly combat trauma from military conflict, has been associated with the development of FND throughout history.[15,16] Review of individual cases from the American Civil War suggests that FND was probably highly prevalent among soldiers, particularly among those diagnosed with epilepsy or paralysis.[17] Historical data from the U.S. Army reported an estimated incidence of FND of 15.3 per 10,000 p-yrs at the end of World War I.[18] The occurrence of the condition among

British, French, and German forces was also written about extensively after World War I.[19] Academic interest in FND waned after World War II, but the condition was believed to be less common during this period than during World War I. There was a continual decline in incidence estimates following World War II, with increases again during the Korea and Vietnam conflicts. The incidence of FND in the Korea–Vietnam era reached a peak in 1975 at 9.5 cases per 10,000 p-yrs and has been slowly declining since that time based on 1991 estimates.[15]

Conditions associated with FND, including depression and post-traumatic stress disorder (PTSD), are prevalent among current members of the U.S. Armed Forces.[20] However, because of the potential adverse occupational, financial, and emotional impacts of this condition,[11] it remains a potentially important unexplored area of study. The current study assessed the epidemiology of FND among active component service members by first describing the incidence and prevalence of FND between 2000 and 2018 as well as the time between FND diagnosis and medical separation. To quantify the impact of FND on operational deployments, the number of FND-related medical evacuations out of the Central Command (CENTCOM) area of responsibility (AOR) was also described.

METHODS

The surveillance period was 1 January 2000 through 31 December 2018. The surveillance population consisted of all active component service members of the U.S. Army, Navy, Air Force, or Marine Corps who served at any time during the period. All data used for the analysis were ascertained from the Defense Medical Surveillance System. Diagnoses were ascertained from 1) administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System or in civilian facilities in the purchased care system and 2) in-theater medical records contained in the Theater Medical Data Store. Records of all medical evacuations conducted by the U.S. Transportation Command (TRANSCOM) and maintained in the TRANSCOM Regulating and Command and Control Evacuation System were used as the source of evacuation data. Deployment data were ascertained from the Defense Manpower Data Center Contingency Tracking System deployment roster. However, at the time of this analysis, deployment data were unavailable for the Navy and Marine Corps; therefore, deployment data for members of these services were supplemented with information collected using the post-deployment health assessment form (DD2796).

An incident case of FND was defined by records having 1) an inpatient encounter with a qualifying diagnosis **(Table 1)** in any diagnostic position, 2) an outpatient encounter with a qualifying diagnosis in any diagnostic position made in a neurology or mental health clinic (Medical Expense and Performance Reporting System code beginning with BAK or BF, respectively), or 3) at least 2 outpatient or in-theater medical encounters within 90 days of each other, with the qualifying diagnosis in any diagnostic position. The incidence date was defined as the date of the first case-defining encounter. Inpatient encounters were prioritized over outpatient and in-theater medical encounters if multiple encounters occurred on the same incident date. An individual could count as an incident case once per lifetime. Prevalent cases (i.e., cases occurring before the start of the surveillance period) and their corresponding person-time were excluded from the incidence rate calculations. Incidence rates were calculated per 100,000 p-yrs. In addition, the number of incident cases that occurred within 1 year before military separation were identified.

A prevalent case of FND in any given year was defined as someone who met criteria for becoming an incident case any time on or before the end of the surveillance period and had an inpatient, outpatient, or in-theater medical encounter with a qualifying diagnosis in any diagnostic position during the given calendar year. The encounter also had to occur on or after the incident case diagnosis date. For prevalence calculations, the denominator was the number of service members who were in service during June of the given calendar year.

Medical evacuations for FND were also identified. Medical evacuations were included in the analysis if the evacuated service member was evacuated from the CENTCOM AOR to a medical treatment facility outside the CENTCOM AOR and if the service member had at least 1 outpatient or inpatient medical encounter with a diagnosis of FND in the first or second diagnostic position during the time period from 5 days before to 10 days after the reported evacuation date.

Covariates used in the analysis included age, sex, race/ethnicity group, service branch, marital status, education level, grade, occupation, deployment history, history of depression, and history of PTSD. Deployment history was defined by having ever deployed in support of Operation Enduring Freedom (OEF), Operation Iraqi Freedom (OIF), or Operation New Dawn

TABLE 1. ICD-9 and ICD-10 diagnostic codes used for identification of FND cases

Condition	ICD-9	ICD-10[a]
FND	300.11, 298.2, 300.16, 300.10, 300.15	F44.4, F44.5, F44.6, F44.7, F44.8, F44.89, F44.9
Depressive disorder	296.2, 296.21, 296.22, 296.23, 296.24, 296.25, 296.26, 296.20, 311, 296.3, 296.30, 2963.1, 296.32, 296.33, 296.35, 296.36, 296.99, 300.4, 296.90, 296.9	F32.*, F33.*, F34, F34.1, F34.8, F34.9, F39, F34.81, F34.89
PTSD	309.81	F43.1, F43.10, F43.11, F43.12

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD, International Classification of Diseases; FND, functional neurologic disorder; PTSD, post-traumatic stress disorder.

TABLE 2. Incidence of FND, active component, U.S. Armed Forces, 2000–2018

	Total	
	No.	Rate[a]
Total	7,644	29.5
Source of incident case		
Inpatient	1,794	6.9
Outpatient	5,772	22.3
TMDS	78	0.3
Sex		
Male	5,443	24.7
Female	2,201	57.1
Age group (years)		
<20	917	48.8
20–24	2,785	32.9
25–29	1,605	27.6
30–34	894	22.8
35–39	724	23.0
40–49	652	26.6
50+	67	28.5
Race/ethnicity group		
Non-Hispanic white	4,684	29.7
Non-Hispanic black	1,471	33.3
Hispanic	800	26.1
Asian/Pacific Islander	225	23.3
Other/unknown	464	27.4
Education level		
High school or lower	5,891	32.9
Some college	738	28.7
Bachelor's or higher	828	17.2
Other/unknown	187	30.8
Marital status		
Single, never married	3,299	30.7
Married	3,984	28.3
Other/unknown	361	33.2
Service		
Army	3,735	39.0
Navy	1,575	24.5
Air Force	1,266	19.9
Marine Corps	1,068	30.3
Military grade		
Enlisted	7,041	32.6
Officer	603	13.9
Military occupation		
Combat-related[b]	1,179	32.8
Motor transport	355	44.3
Pilot/air crew	87	8.8
Repair/engineering	1,950	25.6
Communications/intelligence	1,800	31.0
Healthcare	739	33.5
Other/unknown	1,534	31.2
Ever deployed to OEF/OIF/OND		
Yes	2,336	26.1
No	5,308	31.3
History of depression		
Yes	2,711	203.4
No	4,933	20.1
History of PTSD		
Yes	1,359	318.8
No	6,285	24.7

[a]Rate per 100,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
FND, functional neurologic disorder; No., number; TMDS, Theater Medical Data Store; OEF, Operation Enduring Freedom, OIF, Operation Iraqi Freedom, OND, Operation New Dawn; PTSD, post-traumatic stress disorder.

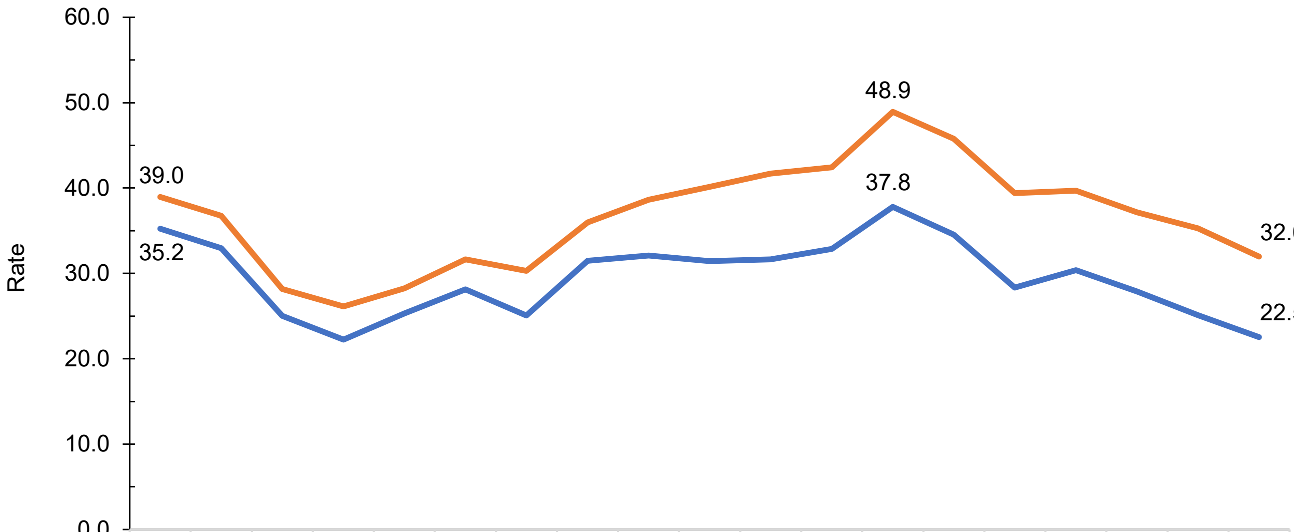
(OND). History of depression and history of PTSD were defined by ever having been diagnosed as an incident case of depression or PTSD. This meant having an inpatient encounter with a qualifying diagnosis **(Table 1)** in the first or second diagnostic position, an outpatient encounter with a qualifying diagnosis in the first or second diagnostic position made in a mental health specialty clinic, or at least 2 outpatient or in-theater medical encounters within 180 days of each other with a qualifying diagnosis in the first or second diagnostic position, occurring before the FND diagnosis.

RESULTS

Incidence

During 2000–2018, there were 7,644 incident cases of FND among active component service members, with a crude overall incidence rate of 29.5 cases per 100,000 p-yrs **(Table 2)**. The crude annual incidence rate of FND diagnoses was highest in 2012 (37.8 per 100,000 p-yrs) and lowest in 2003 (22.2 per 100,000 p-yrs) **(Figure 1)**. The overall incidence rate among females was 2.3 times that of males (57.1 and 24.7 per 100,000 p-yrs, respectively) **(Table 2)**. Overall rates of incident FND diagnoses were highest among individuals younger than 20 years of age (48.8 per 100,000 p-yrs) and lowest among individuals 30–34 years of age (22.8 per 100,000 p-yrs). Overall rates were highest among non-Hispanic blacks (33.3 per 100,000 p-yrs) and lowest among Asian/Pacific Islanders (23.3 per 100,000 p-yrs). Rates were highest among those with other/unknown marital status (which includes divorced and widowed) and lowest among married individuals (33.2 vs 28.3 per 100,000 p-yrs, respectively). Incidence rates of FND diagnoses were highest among individuals with lower levels of education (high school or lower) and lowest among individuals with a bachelor's degree or higher education (32.9 vs 17.2 per 100,000 p-yrs, respectively). The overall rate among service members with a history of depression was 10.1 times that of those without such a history (203.4 vs 20.1 per 100,000 p-yrs, respectively). Similarly, the overall rate among individuals with

FIGURE. Crude annual incidence and prevalence rates of FND diagnoses, active component, U.S. Armed Forces, 2000–2018



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Incidence rate[a]	35.2	32.9	25.0	22.2	25.3	28.1	25.0	31.5	32.1	31.5	31.6	32.9	37.8	34.5	28.3	30.4	27.9	25.1	22.5
Prevalence rate[b]	39.0	36.7	28.2	26.1	28.3	31.6	30.3	36.0	38.6	40.1	41.7	42.4	48.9	45.8	39.4	39.7	37.2	35.3	32.0

[a]Incidence rate per 100,000 person-years.
[b]Prevalence rate per 100,000 persons.
FND, functional neurologic disorder.

a history of PTSD was 12.9 times that of those without such a history (318.8 vs 24.7 per 100,000 p-yrs, respectively).

Among the service branches, overall rates of incident FND diagnoses were highest among those in the Army (39.0 per 100,000 p-yrs) and lowest among those in the Air Force (19.9 per 100,000 p-yrs) **(Table 2)**. The rate among enlisted individuals was 2.3 times the rate among officers (32.6 vs 13.9 per 100,000 p-yrs, respectively). Overall ates were highest among motor transport crew and lowest among pilot/air crew (44.3 vs 8.8 per 100,000 p-yrs, respectively). Finally, rates were higher among those who never deployed to OEF/OIF/OND compared to those who had deployed (31.3 vs 26.1 per 100,000 p-yrs, respectively).

Prevalence

The overall median annual prevalence rate of FND diagnoses during the study period was 37.2 cases per 100,000 persons **(Table 3)**. The annual trend in prevalence rates generally mirrored that of the annual trend in incidence rates **(Figure 1)**. In addition, patterns of prevalence followed similar demographic distributions as the patterns of incidence **(Table 3)**. Overall prevalence rates of FND diagnoses were higher among women compared to men (76.0 vs 30.1 per 100,000 persons, respectively). In addition, prevalence rates were highest among non-Hispanic black individuals, those with other/unknown marital status, enlisted service members, those with lower levels of education, Army members, and those working in motor transport. A notable exception to the incidence rate trends was age; the highest prevalence was among individuals age 50 and older (51.5 per 100,000 persons). Finally, prevalence rates were again higher among those who had no deployment history to OEF/OIF/OND compared to those who did (39.2 vs 33.5 per 100,000 persons), those with a history of depression compared to those without (298.3 vs 22.7 per 100,000 persons), and those with a history of PTSD compared to those without (560.5 vs 28.2 per 100,000 persons).

Military separation

A total of 3,162 cases of FND were diagnosed within 1 year before military separation, accounting for 41.4% of total FND cases **(Table 4)**. Only 4.6% (n=351) of cases were diagnosed within 30 days or fewer before separation. The majority (4,482; 58.6%) of active component service members diagnosed with FND remained on active duty for longer than 365 days after their incident diagnoses.

Medical evacuation

There were 162 medical evacuations out of CENTCOM for FND during the study period **(Table 5)**. A majority of medical evacuees for FND were male (84.6%) and 24 years old or younger (57.4%). Most medical evacuations occurred among non-Hispanic white service members (69.1%), Army service members (78.4%), those with a lower level of education (88.3%), those with a combat-related occupational specialty (34.6%), and those with an enlisted military grade (96.9%) compared to their respective counterparts. Slightly more than half of those evacuated for FND were married (51.9%), and greater majorities had no history of depression (75.9%) or PTSD (92.6%) **(Table 5)**.

TABLE 3. Median annual prevalence of FND, active component, U.S. Armed Forces, 2000–2018

	Median no.	Median rate[a]
Total	501	37.2
Source of incident case		
Inpatient	113	8.5
Outpatient	395	28.8
TMDS	2	0.2
Sex		
Male	348	30.1
Female	155	76.0
Age group (years)		
<20	42	35.9
20–24	179	39.3
25–29	103	35.7
30–34	59	29.5
35–39	52	31.7
40–49	41	37.3
50+	4	51.5
Race/ethnicity group		
Non-Hispanic white	313	36.8
Non-Hispanic black	100	42.9
Hispanic	54	33.8
Asian/Pacific Islander	15	28.8
Other/unknown	32	34.0
Education level		
High school or lower	378	42.8
Some college	53	36.6
Bachelor's or higher	55	23.2
Other/unknown	10	30.7
Marital status		
Single, never married	197	35.6
Married	270	35.6
Other/unknown	27	44.6
Service		
Army	218	46.4
Navy	97	29.3
Air Force	81	23.7
Marine Corps	64	34.7
Military grade		
Enlisted	462	41.8
Officer	40	17.9
Military occupation		
Combat-related[b]	68	39.6
Motor transport	24	55.8
Pilot/air crew	5	9.7
Repair/engineering	132	33.3
Communications/intelligence	121	41.1
Healthcare	49	44.7
Other/unknown	99	39.7
Ever deployed to OEF/OIF/OND		
Yes	164	33.5
No	317	39.2
History of depression		
Yes	197	298.3
No	277	22.7
History of PTSD		
Yes	124	560.5
No	373	28.2

[a]Rate per 100,000 persons.
[b]Infantry/artillery/combat engineering/armor.
FND, functional neurologic disorder; No., number; TMDS, Theater Medical Data Store; OEF, Operation Enduring Freedom, OIF, Operation Iraqi Freedom, OND, Operation New Dawn; PTSD, post-traumatic stress disorder.

EDITORIAL COMMENT

This study found a crude overall rate of incident FND diagnoses of 29.5 per 100,000 p-yrs, which is approximately 2.5–7.4 times higher than estimates reported for the general population.[1,3,5] Similar to other studies, incidence rates were highest among women, younger age groups, and individuals with lower levels of education. Interestingly, incidence of FND was lowest among the 30–34 year old age group with a gradual increase thereafter, suggestive of a bimodal distribution of incidence rates. Prevalence rates were highest among service members aged 50 years or older; however, during this period, there were generally very few prevalent cases of FND in this age group (median of prevalent cases per year=4).

The finding that the overall incidence of FND diagnoses was highest among those with the lowest educational attainment supports previous observations.[10,11] However, this association is likely confounded by age since FND incidence was also highest among the youngest service members. Similar to other studies, there were no clear differences in FND incidence rates among the various race/ethnicity groups.[11] Finally, rates among divorced and widowed individuals were higher compared to married individuals, though this difference was small.

Several previous studies have observed an association of FND with comorbid psychiatric conditions, including depressive disorders and PTSD.[3] Findings from the current study support this widely observed finding, noting that the overall incidence rates among individuals with a history of depression or PTSD were more than 10 times the rates of those without histories of these conditions and approximately 13 times higher among individuals with a history of PTSD compared to those without. It is unknown whether FND represents an adverse outcome of these conditions or a risk factor for them. Future studies may help to better characterize this relationship.

The overall incidence and prevalence rates of FND diagnoses were highest among individuals in the motor transport primary occupational specialty. A previous study conducted among U.S. Armed Forces found that incidence rates of traumatic

TABLE 4. Incident diagnoses of FND made within 12 months before separation from the military, 2000–2018

	No.	% of total FND cases (n=7,644)
Total	3,162	41.4
Time to separation		
≤30 days	351	4.6
31–90 days	526	6.9
91–180 days	786	10.3
181–365 days	1,499	19.6

FND, functional neurologic disorder; No., number.

TABLE 5. Medical evacuations out of CENTCOM for FND, active component, U.S. Armed Forces, 2000–2018

	Total	
	No.	%
Total	162	100.0
Sex		
Male	137	84.6
Female	25	15.4
Age group (years)		
<20	17	10.5
20–24	76	46.9
25–29	38	23.5
30–34	16	9.9
35–39	6	3.7
40–49	9	5.6
50+	0	0
Race/ethnicity group		
Non-Hispanic white	112	69.1
Non-Hispanic black	25	15.4
Hispanic	16	9.9
Asian/Pacific Islander	4	2.5
Other/unknown	5	3.1
Education level		
High school or lower	143	88.3
Some college	7	4.3
Bachelor's or higher	7	4.3
Other/unknown	5	3.1
Marital status		
Single, never married	76	46.9
Married	84	51.9
Other/unknown	2	1.2
Service		
Army	127	78.4
Navy	6	3.7
Air Force	7	4.3
Marine Corps	22	13.6
Military grade		
Enlisted	157	96.9
Officer	5	3.1
Military occupation		
Combat-related[a]	56	34.6
Motor transport	16	9.9
Pilot/air crew	1	0.6
Repair/engineering	37	22.8
Communications/intelligence	30	18.5
Healthcare	5	3.1
Other/unknown	17	10.5
History of depression		
Yes	39	24.1
No	123	75.9
History of PTSD		
Yes	12	7.4
No	150	92.6

[a]Infantry/artillery/combat engineering/armor.
CENTCOM, Central Command; FND, functional neurologic disorder; No., number; PTSD, post-traumatic stress disorder.

brain injury among those working in armor/motor transport were second only to those in combat-specific occupations.[21] The relationship of these conditions to both mechanical and emotional trauma related to training exercises, routine occupational duty, improvised explosive device blast exposure, or other factors is unclear and was not assessed in this study. Rates were lowest among pilots/air crew. This finding has been observed in other studies and may be due to reluctance to seek medical care for conditions that can limit flight status.[22]

There were 162 medical evacuations out of CENTCOM for FND during the study period. By contrast, there were 1,264 medical evacuations for all causes from theater in 2018 alone, and there were more medical evacuations for mental health disorders (n=356; 28.2%) than for any other diagnosis category that year.[23] Mental health disorders, which include FND, have consistently been among the most commonly represented diagnostic categories for medical evacuation over the past several years.[24–27] While there are typically higher ratios of females to males for mental health medical evacuation, data from the present study demonstrated a higher ratio of male to female evacuations for FND. Future studies may be needed to examine the association between medical evacuations for conditions in certain broad diagnostic categories (e.g., mental health disorders; signs, symptoms, and ill-defined conditions; nervous system and sense organs) and a subsequent diagnosis of FND.

The crude overal rate of incident FND diagnoses was lower among individuals who had previously deployed to OEF/OIF/OND compared to that of individuals who had not. One explanation for this difference in overall incidence rates could be the "healthy deployer effect," in which service members who are diagnosed with deployment-limiting conditions are prevented from being deployed. These deployment-limiting conditions include psychiatric disorders that impair duty performance and mental health conditions that pose a substantial risk for deterioration. Because the development of functional symptoms has been related to poor resilience and coping strategies during times of stress,[28,29] future studies may help to better define and identify these qualities in service members to potentially avoid the development of functional symptoms during periods of increased stress.

There are several limitations to this study. Because FND is probably underdiagnosed,[3] the data reported here are likely an underestimate of the true burden of these conditions. In particular, the use of administrative data to capture prevalent cases of FND likely results in an underestimate of the true prevalence since service members were only captured as being a prevalent case if they sought care for FND during the given calendar year. The case definition used to identify incident cases of FND in this study likely reduced the possibility of capturing provider miscoded diagnoses of FND since the case definition excluded cases in which only a single outpatient diagnosis was made, which is a strength. However, it is also possible that this resulted in the exclusion of some true cases of FND.

This study did not adjust for any confounders such as history of adverse childhood events, which have been recognized as a risk factor for the development of FND.[3,30] As mentioned, exposure to specific combat-related stressors, interpersonal stressors, and other occupational stressors related to deployment were not assessed. Prospective cohort studies may be better suited to more adequately characterize the relative impacts that each of these factors has on the development of FND in the deployed setting. Finally, additional research exploring the impact of FND on medical readiness, mission accomplishment, and financial burden to the military is also warranted and may be the focus of future projects.

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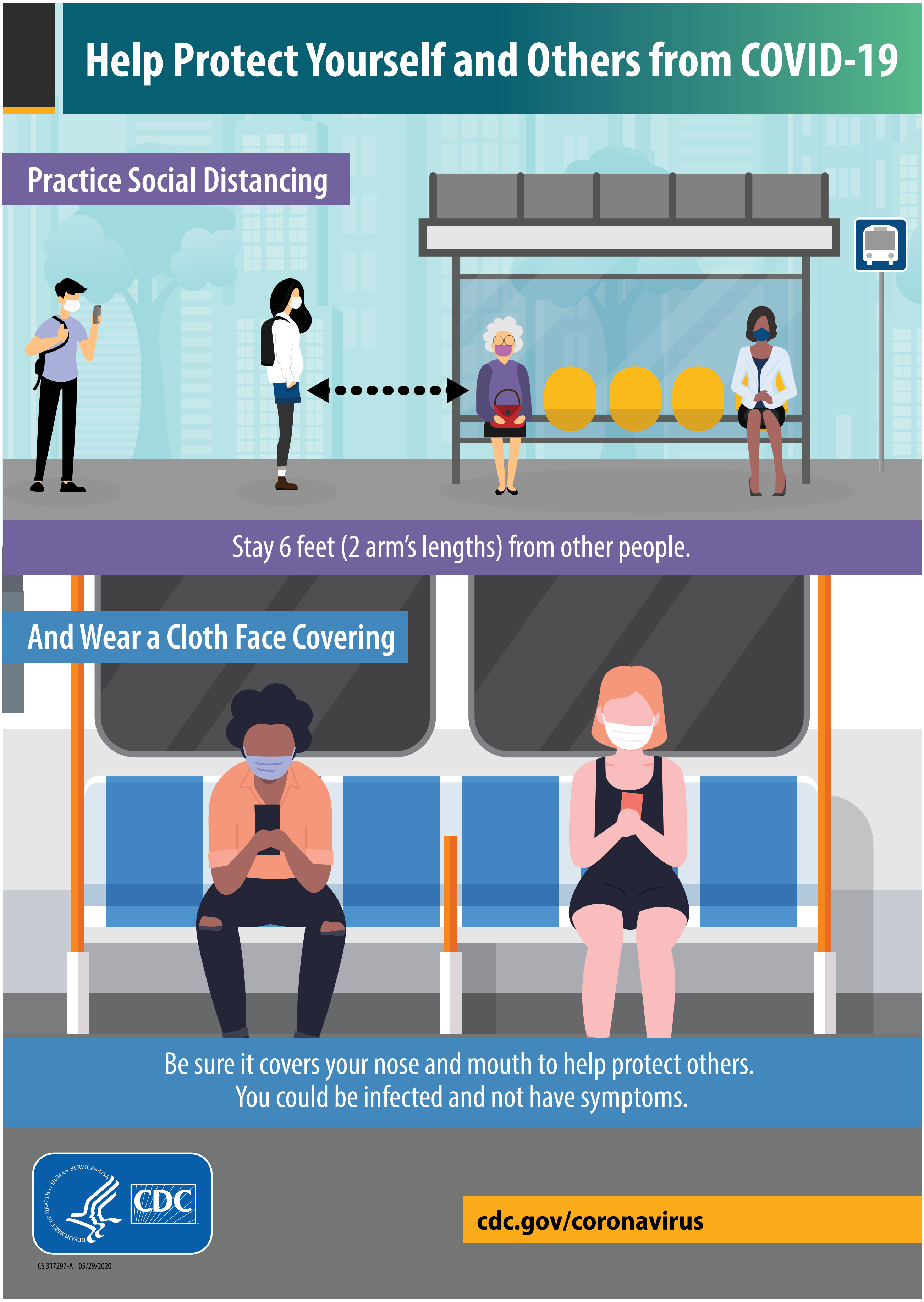
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Practice Social Distancing
Stay 6 feet (2 arm's lengths) from other people.
And Wear a Cloth Face Covering
Be sure it covers your nose and mouth to help protect others.
You could be infected and not have symptoms.
CDC
cdc.gov/coronavirus
CS 317297-A 05/29/2020

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