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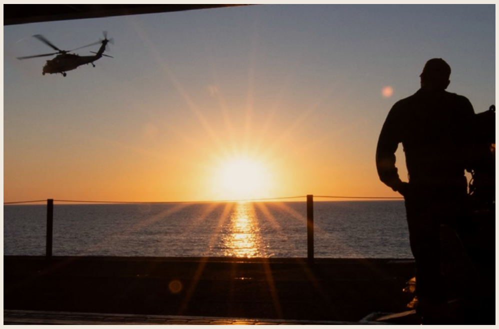

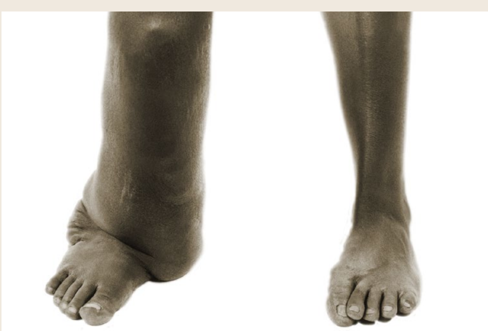

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Vitamin D Deficiency Trends, Risk Factors, and Occupational Risk in Active Component Service Members of the U.S. Armed Forces, 2018–2022

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Vitamin D contains 2 related fat-soluble substances, D3 and D2, that are essential for bone health and overall well-being. The burden of vitamin D deficiency within the active component of the armed forces is unknown. This study describes trends of vitamin D deficiency diagnoses in the active component of the U.S. Armed Forces. Risk factors for vitamin D, such as military occupation, were examined to see if preventive measures and targeted vitamin D screening would be beneficial, as the United States Preventive Task Force does not recommend universal screening for vitamin D, nor does TRICARE cover screening for asymptomatic individuals. The surveillance period covered January 1, 2018 through December 31, 2022. The data were derived from the Defense Medical Surveillance System (DMSS). Vitamin D deficiency was measured using ICD-9-CM and ICD-10-CM diagnoses recorded in inpatient and outpatient medical encounters. Incidence rate and average annual prevalence were calculated. A logistic regression was performed to obtain adjusted odds ratios. The rates of vitamin D deficiency diagnoses among active component service members (ACSMs) remained steady during the study period, with an incidence rate of 16.4 per 1,000 person-years and an average annual prevalence of 2.2%. Female service members, those of older age groups, and indoor workers demonstrated higher rates of vitamin D deficiency. Previously described demographic risk factors such as indoor work and history of obesity or malabsorption syndrome were also associated in this study with vitamin D deficiency in ACSMs, although older age groups in this study were not associated with vitamin D deficiency. Pilots and air crew had the lowest rates of vitamin D deficiency, while health care workers had the highest, when evaluating by occupation.

What are the new findings?

Throughout the study's 2018-2022 period of surveillance, the rates of vitamin D deficiency among active component service members remained steady, with an overall incidence rate of 16.4 per 1,000 person-years and a total average annual prevalence of 2.2%. Female sex, older age, and indoor workers had higher rates of vitamin D deficiency.

What is the impact on readiness and force health protection?

Understanding the trends and risk factors for vitamin D deficiency in active component service members can inform policy that will affect populations that could benefit from education on vitamin D deficiency and prevention, as well as informing clinicians about individuals at risk for vitamin D deficiency. Treatment of vitamin D deficiency may increase physical performance, reduce risk of fractures, and contribute to overall health. Adequate vitamin D levels in the force may increase mission and duty availability.

Vitamin D contains 2 related fat-soluble substances, cholecalciferol (D3) and ergocalciferol (D2), that are essential for bone health and overall well-being.[1,2] Vitamin D deficiency is defined by having a serum 25(OH)D concentration under 50 nmol/liter.[3] Sufficient vitamin D levels in athletes have correlated with better physical performance, increased power, strength, and VO2 max.[4] Deleterious health effects in adults with vitamin D deficiency include increased risk for fractures, muscle weakness, and metabolic bone disease.[1,3,5] In contrast, several studies have highlighted the potential health benefits of adequate vitamin D levels, which can be acquired through diet, dietary supplements, or sun exposure. In particular, those taking daily or weekly vitamin D supplementation have been shown to have lower odds of developing acute respiratory infections.[6]

Vitamin D deficiency is an important consideration for military readiness because of the association with increased risk of infections and injury and worse physical performance, leading to reduced training time and mission availability. Some studies, for example, have highlighted risks to bone health in recruited trainees. Stress fractures are more likely in basic military trainees with low vitamin D levels.[7-9] In female Navy recruits, calcium and vitamin D supplementation reduced incidence of stress fractures.[10] Vitamin D deficiency may play a role in chronic illnesses such as cancers, autoimmune diseases, and cardiovascular disease.[5] Understanding the trends and risk factors for vitamin D deficiency can help identify populations that may benefit from education and interventions to address vitamin D deficiency in active component service members (ACSMs).

The incidence and prevalence of vitamin D deficiency among U.S. ACSMs and any potential risk factors have not been described. The first objective of this study was to describe the trends of vitamin D deficiency in the active component in the past 5 years. The second objective was to identify factors independently associated with a current vitamin D deficiency diagnosis, with particular emphasis on the occupation category. Occupation was a focus because indoor occupations, such as shift workers, health care workers, and submariners, have a higher risks of vitamin D deficiency than outdoor workers, presumably due to less sunlight exposure.[11,12]

Methods

The surveillance period covered January 1, 2018 through December 31, 2022. The surveillance population included all ACSMs of the U.S. Army, Navy, Air Force, and Marine Corps. The data used to determine incident cases of vitamin D deficiency were derived from the Defense Medical Surveillance System (DMSS), which documents both ambulatory encounters and hospitalizations of ACSMs of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System) hospitals and clinics. Periodic Health Assessment (PHA) data have been captured by DMSS since 2018.

Cases of vitamin D deficiency were defined by retrieving diagnostic codes (ICD-9: 268.9 or 268.2, ICD-10: E55.9) in any diagnostic position from the outpatient, inpatient, or Theater Medical Data Store (TMDS). For the incidence analysis, the incident date was defined as the date of the first medical encounter that included a defining diagnosis of vitamin D deficiency. Any ACSM diagnosed with vitamin D deficiency before 2018 was excluded from the incidence analysis, and person-time was censored at the incident date. Aggregated person-years (p-yrs) of service was used as the denominator. For the prevalence analysis, cases were counted each year with an outpatient, inpatient, or TMDS medical encounter with a vitamin D diagnosis in any diagnostic position. One prevalent case was counted per person per year. The mid-year ACSM population was the denominator for calculating average annual prevalence.

Covariates in this analysis included basic demographics, geographic latitude of military unit assignment, obesity, history of malabsorption syndrome, self-reported dietary factors, and vitamin supplementation. Covariates were chosen based on the known association with vitamin D deficiency.[3,5,11,13-18] Countries, states, and ZIP codes (when applicable) of the military unit assignment were divided according to locations at or below 33° and above 33°. Obesity was categorized into 'Yes' or 'No' through a combination of ICD-10 codes and PHA height and weight data. Height and weight data from the PHA were used to calculate BMI, and anyone with a BMI of 30 or greater was classified as having obesity for the year of their weight measurement. In addition, if an individual had an outpatient encounter with an obesity diagnosis (ICD-10: Z683*, Z684*, E660*, E661, E662, E668, or E669), the person was classified as having obesity during that year of diagnosis; otherwise, individuals were categorized as not being obese. Malabsorption syndrome was defined by a prior diagnosis of Crohn's disease, ulcerative colitis, or other type of intestinal malabsorption syndrome (ICD-9: 555*, 556*, and 579*, ICD-10: K50*, K51*, and K90*). Department of Defense Duty Military Occupation Specialty (DMOS) codes were organized into indoor and outdoor occupations.

Dietary factors and multivitamin supplementation were derived from PHA responses. Nutritional factors included frequency of consumption of dairy, calcium-containing foods, and fish within the past 30 days. These factors were chosen because they are known sources of vitamins D2 and D3.[3] The frequency of multivitamin supplementation within the past 12 months (or since the last PHA) was measured. Information about vitamin D supplementation (within the past 12 months) was unavailable until the August 2021 version of the PHA form; therefore, these data were only analyzed for calendar year 2022. Responses to these questions were categorized according to the frequency expected to satisfy vitamin D dietary requirements by the Endocrine Society[3] or current USDA recommendations.[19] For individuals missing a PHA in a given year, responses were imputed from the subsequent or prior year when available; otherwise, responses were left as unknown/missing.

In the secondary analysis, logistic regression was used to calculate the adjusted odds of being diagnosed as a prevalent case in 2022. The independent variables included in the model were sex, age, race and ethnicity, service branch, military unit latitude, obesity, history of malabsorption syndrome, and primary occupation category.

Results

The 104,994 incident cases of vitamin D deficiency diagnoses among ACSMs during the 2018-2022 surveillance period resulted in an overall incidence rate of 16.4 cases per 1,000 p-yrs. The total average annual prevalence of vitamin D deficiency diagnosis among ACSMs during the surveillance period was 2.2%. Incidence rates and average annual prevalence remained steady throughout the study period. The incidence and prevalence peaked during 2021 at 18.3 per 1,000 p-yrs and 2.4%, respectively **(Figure)**. Rates among all categories remained consistent during the surveillance period.

Crude (i.e., unadjusted) incidence rates and prevalence by demographic categories are shown in **Table 1**. The total incidence rate and average annual prevalence were more than 2 times higher among women than men. The rates of vitamin D deficiency increased in those aged 30-39 years compared to those aged 20-29 years and less than age 20 years and were highest in those over age 40 years. Among racial and ethnic groups, rates of vitamin D deficiency were higher for persons other than non-Hispanic Whites. Recruits had the highest vitamin D deficiency diagnosis rates compared to enlisted personnel and officers. The Marine Corps had the lowest vitamin D deficiency diagnosis rates among the service branches. Rates were higher in those assigned to a military unit located above 33° latitude. Those with obesity and a history of malabsorption syndrome had higher rates than those without. Those taking multivitamins and vitamin D supplementation had higher rates than those not using vitamin D

TABLE 1. Incidence Rate (per 1,000 person-years) of First Diagnosis and Total Average Annual Prevalence of Vitamin D Deficiency Diagnosis, Active Component, U.S. Armed Forces, 2018–2022

	Incidence		Average Annual Prevalence	
	No.	Rate	No.	%
Total	104,994	16.4	146,753	2.2
Sex				
Male	69,562	12.9	94,009	1.7
Female	35,432	34.4	52,744	4.6
Age group, y				
<20	6,114	13.1	6,499	1.5
20–29	45,494	12.5	56,970	1.5
30–39	33,807	19.2	49,915	2.6
40+	19,579	35.6	33,369	5.2
Race and ethnicity				
White, non-Hispanic	47,096	13.2	64,023	1.7
Hispanic	18,741	16.9	25,685	2.2
Black, non-Hispanic	26,872	27.1	39,764	3.7
Other	10,254	15.6	14,158	2.0
Unknown	2,031	19.7	3,123	2.8
Military rank				
Recruit	4,900	37.2	4,935	4.5
Enlisted (non-recruit)	81,789	15.8	113,204	2.1
Warrant officer	1,866	21.7	2,889	3.1
Officer	16,439	15.8	25,725	2.3
Branch of service				
Army	44,693	19.3	63,808	2.6
Navy	22,955	14	30,371	1.8
Air Force	30,289	19.4	43,611	2.6
Marine Corps	7,057	7.8	8,963	1.0
Latitude of military unit				
>33 degrees	68,868	18	96,423	2.4
≤33 degrees	35,509	14	49,446	1.9
Unknown	617	12.7	884	1.6
Obese				
No	81,464	14.2	111,406	1.9
Yes	23,530	35.4	35,347	4.7
Malabsorption syndrome				
No	103,132	16.2	143,448	2.1
Yes	1,862	58.1	3,305	8.2
Multivitamin supplementation				
≤Once a week	58,629	15.3	80,669	2.0
>Once a week	34,822	19.8	51,270	2.7
Unknown	11,543	13.9	14,814	1.8
Dairy and calcium-containing foods				
<2 servings per day	76,875	17.1	108,887	2.3
≥2 servings per day	16,576	15.1	23,052	2.0
Unknown	11,543	13.9	14,814	1.8
Fish consumption				
<1 serving per day	85,168	16.9	120,479	2.2
≥1 serving per day	8,283	15	11,460	2.0
Unknown	11,543	13.9	14,814	1.8
Primary occupational category				
Combat-specific	10,216	11.6	13,766	1.5
Motor transport	3,893	18.2	4,756	2.2
Pilot/air crew	1,313	6.4	1,714	0.8
Repair/engineering	22,124	12.1	29,387	1.5
Communications/intelligence	26,867	20.7	39,645	2.8
Health care	14,315	30	22,516	4.2
Other	26,266	17.3	34,969	2.2
Occupation group				
Indoor	23,685	27	36,605	3.7
Outdoor	10,669	13.1	14,206	1.7
All other	70,640	14.9	95,942	1.9
Occupation subgroup				
Indoor: administrative and legal	7,274	26.4	11,341	3.7
Indoor: unmanned vehicle operators	85	7.6	109	0.9
Indoor: non-medical scientists, mathematicians	433	24.7	675	3.5
Indoor: chaplains and assistants	653	26.4	1,014	3.7
Indoor: health care worker	12,763	29.7	19,967	4.1
Indoor: veterinarian services	306	34.5	467	4.6
Indoor: food service and sales	2,171	20.2	3,032	2.6
Outdoor: combat professions	4,846	10.8	6,328	1.4
Outdoor: EOD/UDT/divers	337	12.1	470	1.6
Outdoor: security/firefighters	4,110	14.7	5,360	1.8
Outdoor: military training instructor	1,376	23.8	2,048	3.3
All other	70,640	14.9	95,942	1.9

Abbreviations: No., number; y, years; EOD, explosive and ordnance disposal; UDT, underwater demolition team.

supplementation. The incidence rate in those taking vitamin D supplementation more than once a week and once a week or less often was 52.0 and 15.5 per 1,000 p-yrs, respectively. Pilots and air crew had the lowest rates when evaluated by primary occupational category, while health care occupations had the highest rates. Those with an indoor occupation had more than double the rates of vitamin D deficiency than those with an outdoor occupation.

In the logistic regression model, pilots and air crew had the lowest odds of vitamin D deficiency compared to other occupations (adjusted odds ratio=0.52, 95% confidence interval=0.47, 0.58) **(Table 2)**. Service members in the active component who were female, of older age, non-Hispanic Black race and ethnicity, at geographic latitude above 33°, obese, and with history of malabsorption syndrome had higher odds of being diagnosed with vitamin D deficiency compared to their respective reference groups. Among the service branches, the Marine Corps had the lowest vitamin D deficiency diagnosis odds.

Discussion

The results of this study show a steady trend of vitamin D deficiency diagnoses among ACSMs between 2018 and 2022. The prevalence of vitamin D deficiency among the active component was lower than that of the U.S. general population. This difference is likely due to methodology, as ICD-9 and ICD-10-coded diagnoses were used in this analysis. In contrast, the NHANES studies performed serum 25(OH)D measurements on samples of the U.S. population, finding a prevalence of 22-24% that varies by age, race, and ethnicity.[13-15] The active component is not routinely screened for vitamin D deficiency,[20] making symptomatic service members more likely to be tested. A cross-sectional study of hospitalized U.S. adults using ICD-10 codes to identify vitamin D prevalence found a rate of 1.8%,[21] similar to the present study's findings.

Demographic factors associated with vitamin D deficiency were consistent with findings reported in studies of the

FIGURE. Vitamin D Deficiency Diagnoses, Active Component, 2018–2022

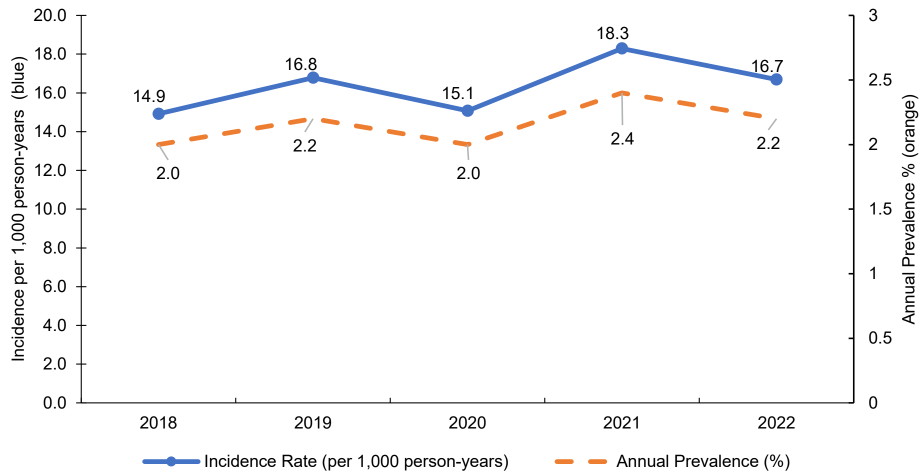

TABLE 2. Adjusted Odds Ratios for Vitamin D Deficiency Diagnosis, Active Component Service Members, 2022

	aOR	95% LL	95% UL
Sex			
Male	Ref	--	--
Female	2.4	2.3	2.5
Age group, y			
<20	Ref	--	--
20–29	0.9	0.8	0.9
30–39	1.4	1.3	1.4
40+	2.6	2.5	2.8
Race and ethnicity			
White, non-Hispanic	Ref	--	--
Hispanic	1.4	1.3	1.4
Black, non-Hispanic	1.8	1.7	1.8
Other	1.1	1.0	1.1
Unknown	1.4	1.3	1.5
Branch of service			
Marine Corps	Ref	--	--
Army	1.9	1.8	2.0
Navy	1.5	1.4	1.6
Air Force	1.6	1.5	1.7
Lattitude of military unit			
≤33 degree	Ref	--	--
>33 degree	1.4	1.4	1.5
Unknown	1.4	1.2	1.6
Obesity			
No	Ref	--	--
Yes	2.2	2.2	2.3
Malabsorption syndrome			
No	Ref	--	--
Yes	2.5	2.3	2.7
Primary occupational category			
Combat-specific	Ref	--	--
Motor transport	1.2	1.1	1.3
Pilot/air crew	0.5	0.5	0.6
Repair/engineering	1.0	0.9	1.0
Communications/intelligence	1.3	1.2	1.4
Health care	1.6	1.5	1.6
Other	1.3	1.2	1.3

Abbreviations: aOR, adjusted odds ratio; LL, lower limit; UL, upper limit; Ref, reference; y, years.

general U.S. population, except for age. In the general U.S. population, the largest proportion of vitamin D deficiency is seen in non-Hispanic Black individuals, followed by Hispanic and non-Hispanic White individuals.[13] In this study, the largest proportion of vitamin D deficiency was seen in non-Hispanic Black ACSMs, those of unknown race and ethnicity, and Hispanic ACSMs. Previously described demographic risk factors, such as obesity,[3,15] a history of malabsorption syndrome,[5,16] residing at a latitude below 33°,[17,18] and working indoors,[11] are associated with vitamin D deficiency among ACSMs. Those with obesity may be at higher risk for vitamin D deficiency, as increased BMI has been shown to correlate with lower vitamin D3 levels due to vitamin D sequestering in body fat.[22] Those with intestinal malabsorption syndromes have reduced uptake of fat-soluble vitamins such as vitamin D.[16] At latitudes farther from the equator, the ozone layer absorbs more ultraviolet-B radiation (required for cutaneous vitamin D production).[17]

In the active component, the 30-39 years and 40 years or older age groups had higher odds of vitamin D deficiency compared to younger age groups, after controlling for covariates and occupation. This result may be partly due to transitioning to a supervisory role as rank increases[23] or increased opportunity for testing and diagnosis of vitamin D deficiency due to more frequent health care contact.[24] Higher rates of vitamin D deficiency in young adults in the general U.S. population may be due to increased time indoors.[25] Obesity prevalence increases by age in the active component,[26] but the higher odds of vitamin D deficiency remain for older members after adjusting for obesity. In those taking more frequent multivitamins and vitamin D supplementation, vitamin D deficiency was more common. This is potentially due to reverse causality, with members likely taking vitamin D supplements because they had been diagnosed with vitamin D deficiency.

In this study, women were more likely to be diagnosed with vitamin D deficiency. This finding may be in part due to increased testing compared to men, although women have been shown to have lower vitamin

D levels in other studies.[13,14,27] Despite our knowledge of the vital role that vitamin D plays in bone health, bone mineral density increases in women in their 30s, and women ages 65 years or older are at higher risk for osteoporotic fracture.[28-30] It is unclear how vitamin D levels in early adulthood predict the risk of osteoporosis later in life. Calcium, and not vitamin D supplementation, has been shown to increase bone mineral density.[31] The time horizon for a study to evaluate this association would be decades.

The higher rates of vitamin D deficiency seen in recruits compared to enlisted ACSMs, warrant officers, and officers may be due to surveillance bias. It is not uncommon for a recruit trainee to have a vitamin D level ordered when being evaluated for a stress fracture. Military training instructors had a prevalence similar to indoor workers, and this may be due to more time spent indoors instructing in a classroom than instructing outdoors. Unmanned vehicle operators had the lowest rates of all the occupation subgroups, and this may be due to training and occupational duties that require time outdoors. This may also be due to flexible schedules allowing on- and off-duty outdoor sunlight exposure or avoiding medical care and laboratory testing. It is important to note that pilots and air crew had the lowest odds of developing vitamin D deficiency of the primary occupational categories. In conjunction with the higher rates of melanoma in aviators,[32] the lower rates of vitamin D deficiency are likely due to increased sunlight exposure in this occupation. Although we were unable to evaluate submariners in this study specifically, it is known that they do not receive ultraviolet-B exposure during patrol and are exposed to other factors that may affect bone health.[12]

In those who receive little sunlight exposure, supplementing vitamin D or consuming foods containing vitamin D may become essential to maintain adequate 25(OH) D serum levels. The recommended daily allowance for vitamin D in the general population is 600 IU daily.[33] Still, higher levels may be needed for those without sunlight, such as submariners on patrol. A dosage of 1,000 IU daily has been proposed for submariners.[34]

There were some limitations to this study, which potentially included unmeasured confounding. The incidence and prevalence were likely underestimated compared to studies of the U.S. population using NHANES data due to the reliance on ICD-coded diagnosis data. It was impossible to capture off-duty sunlight exposure and sunscreen use, which may confound associations with other demographic risk factors such as age or occupation. PHA data are collected for patient-provider health assessments and decision-making and are not designed for epidemiologic surveillance, which led to the inability to establish temporality between dietary factors and vitamin supplementation with vitamin D deficiency. PHA dietary and vitamin data are self-reported, leading to misclassification bias and generating many unknown values from missing PHAs or non-responses.

Future studies may consider sampling ACSMs and performing serum 25(OH) D measurements via liquid chromatography coupled with tandem mass spectrometry (LC-MS/MS) for more accurate estimates of the incidence and prevalence of vitamin D deficiency in the active component. This will help inform future policies on screening and treatment. LC-MS/MS is considered the 'gold standard' for measuring 25(OH) D, as other assays have intrinsic analytical issues.[35] Clinicians should consider individual risk factors for measuring vitamin D levels (e.g., persons other than non-Hispanic White individuals, having obesity or malabsorption syndrome, female sex, indoor occupation, and residing at a latitude above 33°), particularly if a service member gets little exposure to sunlight. It would be reasonable to allow targeted vitamin D screening in at-risk members. Additionally, education and ensuring adequate intake (600 IU daily) for all active component members is essential, with a particular focus on those at risk for vitamin D deficiency. Higher levels of vitamin D intake may be necessary in those with negligible to no sunlight exposure (i.e., submariners on patrol).

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Incidence and Risk Factors for Hip Fractures Among U.S. Armed Forces Active Component Women Compared to Men, 2018–2022

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Women, who comprise approximately 18% of the U.S. Armed Forces, suffer disproportionately higher rates of musculoskeletal injuries among active component service members. Using a retrospective study design, this study calculated incidence rates and rate ratios for acute hip fractures and hip stress fractures from January 1, 2018 through September 30, 2022 among female and male active component U.S. military members. Women who were younger than age 20 years, in recruit training, serving in the Army or Marine Corps, engaged in combat-related occupations, and with body mass indexes in the underweight or normal weight categories had the highest rates of both types of fractures. Women who had progressed beyond the recruit training phase had a higher female-to-male rate ratios of hip stress fractures than recruits. Despite an overall decline during the surveillance period, rates of acute hip fracture and hip stress fracture were higher among women than men. Changes in training and fitness policies may have contributed to the hip fracture rate declines among women. Continued efforts are needed to further reduce injuries among women.

What are the new findings?

From January 2018 through September 2022, the recorded incidence of both acute and stress hip fractures among active component U.S military women declined while the female-to-male rate ratio remained elevated. The female-to-male rate ratio was alarmingly high for hip stress fractures in service women who had advanced beyond recruit training.

What is the impact on readiness and force health protection?

This study includes data for hip fracture rates before and after several military branches implemented changes to training and physical fitness. These data could be used in concert with future studies of hip fractures to evaluate the efficacy of those changes in decreasing injury rates among military service women.

In December 2022 the U.S. Department of Defense (DOD) reinforced that women's health equity remains a priority and that understanding the unique health needs of women is essential to addressing a variety of health conditions including musculoskeletal injuries (MSKIs). In 2022, injuries and musculoskeletal diseases were ranked first and third, respectively, for the attributable burden of illness in U.S. active component service members.[1] MSKIs occur because of acute trauma or cumulative microtrauma from overuse to skeletal muscles, bones, tendons, joints, and ligaments. They can present as sprains, strains, fractures, dislocations, tendinitis, or bursitis and occur when mechanical energy is transferred to the tissue that exceeds the tissue's tolerance.[2]

The most common sites for MSKIs among active component U.S. military populations include the lower extremities and spine.[3-5] Among U.S. active duty Army service members in 2021, acute trauma accounted for 11% and microtrauma from overuse accounted for 70% of MSKIs.[2] Women, who comprise 18% of the total U.S. military, tend to suffer higher rates of MSKIs than men.[2,5-8] Furthermore, studies demonstrate that MSKIs differentially affect the hip regions in women.[5-7] Hip fractures in particular account for a small percentage of all MSKIs in the military but can be disproportionately costly.[9] They are defined as breaks in the upper portion of the femur bone and can occur acutely from traumatic forces or from the accumulation of microfractures from repetitive submaximal forces such as those that occur during strenuous physical training.[10]

Hip fractures result in increased health care provision, a significant amount of lost training or duty days, and high risk of medical separation from the military.[9,11] The average cost of treating hip fractures in active duty soldiers in 2017 was estimated to be greater than $14,000 per case.[11] Cases that required treatment in the inpatient setting exceeded the cost of treating other lower extremity fractures by approximately $5,000 to $10,000 per case.[11] Soldiers who experienced hip fractures lost between 48 to 149 work days on average, depending on whether inpatient treatment was required.[11] Furthermore, a different study found that 67% of active duty military members did not return to duty following surgical intervention for hip stress fracture (HSF).[12] For Army recruits who experienced any type of lower extremity stress fracture during basic training, 33% of men and 42% of women were medically separated despite attempts at physical rehabilitation, which, on average, took greater than 70 days.[13]

Hip fractures pose a challenge for the military, not only in maintaining force readiness but for retention as well, for female service members in particular.

Previous studies have focused on military recruits when assessing for HSFs and have not compared HSF rates in the different service components.[6,7,9,14,15] No studies to date have examined rates of acute hip fracture (AHF) among military women and men. The aim of this study was to describe the incidence and potential risk factors of AHF and HSF among female active component U.S. service members compared to males. Associations between demographic factors and incidence of AHF and HSF were assessed, including age, race and ethnicity, branch of service, military occupation, and recruit status. In addition, the associations between body mass index (BMI) and both types of hip fractures were assessed.

Methods

This study employed a retrospective cohort study design to determine female and male service members' incidence rates of AHF and HSF. The surveillance period was January 1, 2018 through September 30, 2022. The population of interest included all individuals who served in the active component of the U.S. Army, Navy, Air Force, and Marine Corps. The study excluded U.S. Coast Guard members and reservists and personnel serving in the National Guard because the medical records for these populations were incomplete in the Defense Medical Surveillance System (DMSS) during the defined study period.

Data for this study pertaining to health encounters and demographic information were obtained from the DMSS.[17] The International Classification of Diseases, 10th Revision, Clinical Modification (ICD-10-CM) seventh digit code was utilized to identify inpatient and outpatient AHF (S72 codes) and HSF (M84359A) encounters. A hip fracture was considered new if at least 60 days had passed since the last qualifying hip fracture encounter for an individual. For cases with inpatient and outpatient encounters on the same day, the inpatient encounter was selected for analysis.

BMI data came from the Military Entrance Processing Station (MEPS) and Periodic Health Assessment (PHA) databases within DMSS. For individuals with multiple weight records documented for a given calendar year, the last record of that year was used to calculate BMI. For individuals who had no weight records in a given year, their BMI category from the previous year was utilized.

Demographic factors included age, race and ethnicity, service branch, recruit status, and occupation. Age was categorized as: less than 20 years, 20-29 years, 30-39 years, and 40 years and older. For race and ethnicity, individuals were considered non-Hispanic White, non-Hispanic Black, Hispanic, or other/unknown. Service branch categories included the Army, Air Force, Navy, and Marine Corps. Occupational categories were obtained using Defense Enrollment Eligibility Reporting System DOD primary occupation codes for infantry, other combat-specific positions (which include artillery, armor, and combat engineer positions), motor transport, pilot and air crew, repair and engineering, communications and intelligence, health care, and other/unknown **(Table 1)**. The other/unknown category included new recruits.

Incidence rates were calculated per 10,000 person-years (p-yrs). Female and male service members were analyzed separately. Incidence rate ratios (RRs) and their corresponding 95% confidence intervals (CIs) were calculated to compare injury rates between women and men.[16] BMI was calculated as body weight (lb.) / height^2 (in^2) x 703). BMI was categorized as underweight (<18.5), healthy weight (18.5-24.9), overweight (25.0-29.9), and obese ($\geq$30).

Results

From January 1, 2018 through September 30, 2022, 2,886 incident cases of hip fractures occurred over a total of 6,220,311 p-yrs. Of the total cases, 44% were AHF (356 in females and 924 in males) and 56% were HSF (802 in females and 804 in males). **Table 2** summarizes incidence rates of AHF and HSF among women and men by demographic factors and BMI. For both AHF and HSF, higher incidence rates occurred in female compared to male service members.

Female service members under age 20 years experienced AHF and HSF at rates 4.7 times (95% CI: 3.5, 6.2) and 6.8 times (95% CI: 5.7, 8.1) higher than males in the same age group, respectively. Women between 20 and 29 years old had 1.7 times (95% CI: 1.5, 2.0) and 3.8 times (95% CI: 3.3, 4.3) higher rates of AHF and HSF than men in the same age group, respectively. Higher rates of hip fractures were seen in women compared to men in all racial and ethnic groups. Female Hispanic service members in particular experienced HSF at a rate 6.2 times (95% CI: 5.0, 7.7) higher than males.

Female service members serving in the Army and Marine Corps sustained AHF at rates 2.2 times (95% CI: 1.9, 2.6) and 4.6 times (95% CI: 3.6, 6.1) higher, respectively, than those in males. The RR of HSF between female and male service members were greater than 4.0 in all 4 services, with the highest RR between female

TABLE 1. DEERS DOD Codes Used to Identify Military Occupations

Occupation	Code(s) that begin with:
Infantry	1010
Other, combat-specific	101, 102, 103, 104, 143, 220500
Motor transport	106, 181, 280300
Pilot/air crew	105, 220100, 220200, 220300, 220400
Repair/engineering	11, 16, 17, 24
Communications/intelligence	12, 15, 23, 27
Health care	13, 26
Other/unknown	Other

Abbreviations: DEERS, Defense Enrollment Eligibility Reporting System; DOD, Department of Defense.

TABLE 2. Incidence of Acute Hip Fractures and Hip Stress Fractures Among Active Component U.S. Service Members by Demographic Characteristics, 2018–2022

	Acute Hip Fractures						
	Female		Male		Female/Male		
	No.	Rate[a]	No.	Rate[a]	RR	95% LL	95% UL
Total	356	3.4	924	1.8	1.9	1.7	2.1
Age group, y							
<20	104	12.4	96	2.7	4.7	3.5	6.2
20–29	206	3.4	548	1.9	1.7	1.5	2.0
30–39	35	1.3	205	1.4	0.9	0.6	1.3
40+	11	1.3	75	1.5	0.9	0.5	1.7
Race and ethnicity							
White, non-Hispanic	158	3.6	603	2.0	1.8	1.5	2.1
Black, non-Hispanic	66	2.6	130	1.8	1.5	1.1	2.0
Hispanic	90	4.3	130	1.5	2.8	2.2	3.7
Other	42	2.8	61	1.1	2.6	1.8	3.9
Branch of service							
Army	195	5.7	484	2.6	2.2	1.9	2.6
Navy	42	1.3	140	1.1	1.2	0.8	1.7
Air Force	42	1.3	131	1.1	1.2	0.9	1.7
Marine Corps	77	10.0	169	2.2	4.6	3.6	6.1
Occupation							
Infantry	0	0.0	90	2.3	0.0	--	--
Other, combat-specific	18	6.2	94	2.1	2.9	1.8	4.8
Motor transport	17	5.1	38	2.5	2.1	1.2	3.7
Pilot/air crew	3	1.8	22	1.1	1.7	--	--
Repair/engineering	53	2.5	239	1.5	1.7	1.3	2.3
Communications/intelligence	87	2.6	144	1.4	1.8	1.4	2.3
Health care	60	3.1	55	1.6	1.9	1.3	2.7
Other/unknown	118	5.0	242	2.4	2.1	1.7	2.6
Recruit basic training							
Yes	84	37.5	128	12.3	3.1	2.3	4.0
No	272	2.6	796	1.6	1.7	1.5	1.9
Body mass index							
Obese (≥30)	12	1.3	87	1.3	1.0	0.6	1.9
Overweight (25≤30)	83	2.8	317	1.6	1.8	1.4	2.3
Normal weight (18.5≤25)	178	4.8	311	2.4	2.0	1.7	2.4
Underweight (<18.5)	11	9.2	9	3.1	2.9	1.2	7.1
Unknown	72	2.5	200	1.7	1.5	1.1	1.9

	Hip Stress Fractures						
	Female		Male		Female/Male		
	No.	Rate[a]	No.	Rate[a]	RR	95% LL	95% UL
Total	802	7.6	804	1.6	4.9	4.4	5.4
Age group, y							
<20	328	39.0	207	5.7	6.8	5.7	8.1
20–29	416	6.8	509	1.8	3.8	3.3	4.3
30–39	52	1.9	79	0.5	3.5	2.4	4.9
40+	6	0.7	9	0.2	4.2	1.5	11.9
Race and ethnicity							
White, non-Hispanic	344	7.8	502	1.7	4.6	4.0	5.3
Black, non-Hispanic	176	6.8	105	1.4	4.8	3.8	6.1
Hispanic	211	10.2	139	1.6	6.2	5.0	7.7
Other	71	4.8	58	1.0	4.7	3.4	6.7
Branch of service							
Army	528	15.5	607	3.2	4.8	4.3	5.4
Navy	22	0.7	20	0.2	4.3	2.4	7.9
Air Force	36	1.1	24	0.2	5.6	3.3	9.4
Marine Corps	216	28.2	153	2.0	14.4	11.7	17.8
Occupation							
Infantry	3	17.1	72	1.9	9.1	--	--
Other, combat-specific	34	11.8	78	1.8	6.6	4.4	9.9
Motor transport	20	6.0	24	1.6	3.8	2.1	6.9
Pilot/air crew	3	1.8	1	0.1	36.2	--	--
Repair/engineering	118	5.6	139	0.9	6.6	5.2	8.4
Communications/intelligence	201	6.0	136	1.4	4.4	3.5	5.5
Health care	96	4.9	38	1.1	4.4	3.0	6.4
Other/unknown	327	13.9	316	3.1	4.4	3.8	5.2
Recruit basic training							
Yes	300	134.1	398	38.3	3.5	3.0	4.1
No	502	4.9	406	0.8	6.1	5.3	6.9
Body mass index							
Obese (≥30)	11	1.2	49	0.7	1.7	0.9	3.3
Overweight (25≤30)	195	6.6	245	1.2	5.4	4.4	6.5
Normal weight (18.5≤25)	464	12.5	356	2.8	4.5	3.9	5.2
Underweight (<18.5)	29	24.3	18	6.3	3.9	2.2	7.0
Unknown	103	3.6	136	1.2	3.1	2.4	4.0

Abbreviations: No., number; y, years; RR, rate ratio; LL, lower limit; UL, upper limit.
Note: Confidence interval estimates are unstable due to small group sizes.
[a]Rate per 10,000 person-years.

and male Marines at 14.4 (95% CI: 11.7, 17.8). Female recruits sustained higher rates of both AHF and HSF than male recruits (RR 3.1; 95% CI: 2.3, 4.0 and RR 3.5; 95% CI: 3.0, 4.1), respectively. The female-to-male RR for HSF was larger for non-recruits than recruits (6.1; 95% CI: 5.3, 6.9 and 3.5; 95% CI: 3.0, 4.1), respectively, however.

The female-to-male RR for AHF was highest for combat-specific occupations (RR 2.9, 95% CI: 1.8, 4.8). The female-to-male RR for HSF was highest for combat-specific (RR 6.6, 95% CI: 4.4, 9.9) and repair/engineer (RR 6.6, 95% CI: 5.2, 8.4) occupations. Few women in this cohort identified as having infantry or pilot/air crew occupations.

At a maximum, BMI measurements were obtained 2 years from the HSF date. Of the 1,369 HSF cases that had a BMI measurement within 2 years, the median time between fracture and BMI measurement was 82 days and the mean was 108 days. Of the 1,024 AHF cases that had a BMI measurement within 2 years, the median time between AHF and BMI measurement was 119 days and the mean was 163 days. There was an inverse relationship between BMI and hip fracture among both sexes.

Figures 1a and **1b** show an overall decline in the incidence rates of AHF by 48% and HSF by 63% in women, respectively. Despite this downward trend among cases of hip fractures, women continued to experience higher rates of hip fractures than men during each year of the surveillance period.

FIGURE 1a. Incidence Rates of Acute Hip Fractures Among Active Component U.S. Service Members by Year, 2018–2022

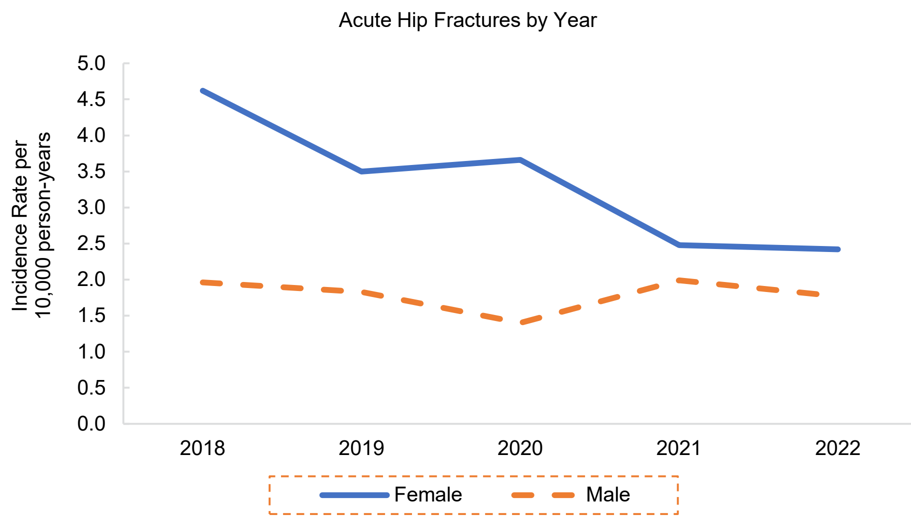
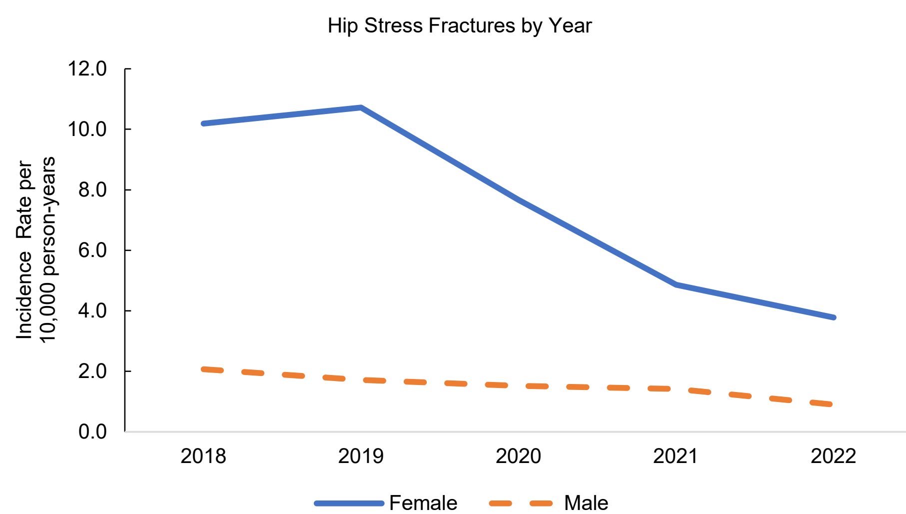


FIGURE 1b. Incidence Rates of Hip Stress Fractures Among Active Component U.S. Service Members by Year, 2018–2022



Discussion

The overall incidence of AHF and HSF in women in the active component U.S. military in this study declined between 2018 and 2022. The decline in hip fractures may be in part due to the COVID-19 pandemic, which affected physical training activities due to mandates to stay at home and maintain social distancing. Another possible explanation for this decline may be due service-specific changes such as those made by the Army and Marine Corps. In 2019, the Marine Corps started training women and men in sex-integrated recruit units, which was associated with fewer injuries among individuals.[18] In 2020, the Army implemented its Holistic Health and Fitness program and a new physical fitness test to reduce MSKIs by promoting whole-body strength-training.[19]

A prior study that assessed HSF from 2009 to 2012 reported incidence rates of 16.8 and 2.9 per 10,000 p-yrs for active duty women and men, respectively.[20] Comparatively, the incidence rates in our study were lower: 7.6 and 1.6 per 10,000 p-yrs for women and men, respectively. This downward trend may reflect the military's increased investments in funding research and programs to prevent injuries while improving performance and rehabilitation after injuries.[21,22]

Despite the overall decline, the rates of hip fractures in this study were higher for women for each year of the surveillance period when compared to men. Differences between women and men for anatomical, biomechanical, physiological, and fitness factors have been cited as contributing to higher rates of injuries in military women.[5-7,15] Women tend to have wider pelvises, longer femora, and narrower bones, on average, with thinner cortices than men.[15] Physiological factors related to irregular menstrual cycles and iron deficiency have also been found to increase risk of stress fractures in military women.[6]

In this study, age younger than 20 years was associated with higher risk of both AHF and HSF in women, consistent with previous data.[20,23] One study in Army recruits reported that age older than 20 years conferred higher risk of stress fractures overall.[24] That study did not, however, stratify the data by site of fracture and included stress fractures of the lower leg and foot.[24]

Unexpectedly, while the rate of HSF in women who had progressed beyond the recruit period was lower overall than those going through recruit training, the female-to-male RR was higher for women outside the recruit training phase (6.1 vs. 3.5 per 10,000 p-yrs). These findings highlight that women are at higher risk than men for life- and career-changing injuries throughout their military service. Many studies have previously focused on injury rates between female and male recruits.[7,9,14,25] No studies, however, have compared rates of either type of hip fractures in women in recruit training versus operational units. Sustaining hip fractures may result in permanent physical restrictions, which affect service members' opportunities for progression and retention.[6] MSKIs in general were associated with higher rates of discharge in women when compared to men.[6]

Army or Marine Corps service and a combat-related occupation also placed women in this study population at increased risk of AHF in comparison to men. Marine Corps and a combat-related or repair/engineer occupations placed women at higher risk of HSF than men. There were few women in the infantry-specific occupations, and as a result, no AHFs and few HSFs were seen in women during the surveillance period. These findings are consistent with published findings.[5,20,23] For military women, researchers found that marching with a heavy load and running long distances resulted in a higher proportion of MSKIs when compared to men.[5,6] Lower levels of strength and aerobic fitness upon entering basic training were also associated with higher risk of injuries, specifically in female recruits.[6,7,14]

While this study was unable to assess for any associations between level of fitness and risk of hip fracture, these results show an inverse relationship between BMI and incidence of hip fractures among women and men. Higher rates of hip fractures were seen among service members in the underweight and normal weight categories. These findings are counterintuitive, given the evidence that higher BMI was shown to be associated with higher rates of MSKIs.[26] Women in all BMI categories sustained higher rates of hip fractures than men, except for women in the obese category, in relation to AHF. Previous studies have shown an association between low BMI and higher risk of stress fractures among military populations.[6,24,27] This study did not adjust for confounding nor modifying factors, and comparisons were made based on crude rates.

This study has other limitations. BMI data obtained from MEPS and PHAs were self-reported. Furthermore, this study was unable to quantify the long-term impact of hip fractures and whether that differed for men versus women. Rates of medical discharge, numbers of lost duty days, durations of physical restriction, and permanent disabilities resulting from hip fractures were not assessed. No studies to date, however, had assessed for risk of AHF in relation to BMI, making our findings unique. Future studies are needed to identify modifiable factors such as nutrition or training techniques that can mitigate the risk for devastating fractures in military women, as well as track duration of rehabilitation and rate of medical discharges after hip fractures.

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Malaria in the Australian Military, 2008–2022

Christopher Moller, MBBS; Ken Lilley; Fiona McCallum, PhD; G. Dennis Shanks, MD, MPH

Australian Defence Force (ADF) personnel train and operate in malarious regions that include neighbouring countries with high burden and species with latent hepatic parasites.[1] We summarized longitudinal malaria case data, following a prior 10-year period review to 2007.[2] Malaria case entries within the ADF Malaria and Infectious Diseases Institute (ADFMIDI)-managed Central Malaria Register (CMR) were examined. Data from cases confirmed between January 1, 2008 through December 31, 2022 were analyzed. Sixty ADF members were diagnosed with malaria, including 1 with a mixed *Plasmodium falciparum* and *P. vivax* infection. Of 61 malaria infections, 69% (42 of 61) were *P. vivax*. *P. vivax* infection resulted in delayed initial case presentation (more than 4 weeks after exposure) in at least 36% (15 of 42) of cases, and 5 personnel experienced further relapse. Most *P. vivax* infections were acquired in the U.S. Indo-Pacific Command (INDOPACOM) and *P. falciparum* in the U.S. Africa Command (AFRICOM) regions. The ADF experienced ongoing reduced malaria case incidence following high rates in the early 2000s. Maintenance of prophylactic vigilance, both for eradicating dormant hypnozoites and preventing *P. vivax* relapse, remains important, however.

What are the new findings?

Between 2008 and 2022 annual malaria case rates among Australian military personnel were approximately 5.4 per 100,000 person-years, or one-third of Australian civilian case rates. Most cases were caused by *P. vivax*, acquired in Papua New Guinea within the U.S. Indo-Pacific Command, which reflects high regional endemicity and the regular training and operations within the region.

What is the impact on readiness and force health protection?

Malaria rates among regionally-deployed personnel remain relatively low following high rates, and medical response, in the early 2000s. Ongoing *P. vivax* predominance and relapse, however, highlight that vector bite prevention awareness, adherence to drug regimens, as well as efficacious new anti-malarials to improve prophylaxis and combat dormant hypnozoite forms, remain necessary.

Australia is within the U.S. Indo-Pacific Command (INDOPACOM) Area of Operations. While malaria is no longer endemic to Australia, deployments in the region have resulted in significant numbers of active troops being infected,[2] with risk of loss of combat manpower from illness. Many near neighbors have high burdens, with a high proportion of cases caused by hypnozoite-forming *P. vivax* and *P. ovale*, compared to other World Health Organization (WHO) regions.[1] This presents unique challenges for malaria prevention and surveillance due to increased risk of delayed presentation and relapse.[3,4] There are no diagnostic means to determine hypnozoite carriage,[5] and a limited number of medications available to clear hypnozoites from the liver,[6] making force health protection in INDOPACOM challenging.

Risk-based Australian Defence Force (ADF) health guidance against malaria mandates the use of personal protective measures, including long-sleeved and -legged uniforms, bed nets, permethrin treatment of uniforms and nets, DEET-based topical repellent and compliance with chemoprophylaxis regimens. Doxycycline has been the first-line chemoprophylaxis against malaria since 1990. On leaving a malarious area, primaquine is used for eradication and radical cure in personnel without glucose-6-phosphate dehydrogenase deficiency. Alternative prophylactic regimens using atovaquone/proguanil, since 2006, or tafenoquine, registered in 2018, are available for those members in whom this protocol is not suitable. Military members presenting with fever within 3 months of deployment to a malarious area are tested for malaria, including peripheral blood polymerase chain reaction (PCR).

The ADF Malaria and Infectious Disease Institute (ADFMIDI) conducts surveillance and research to protect personnel against malaria and other vector-borne diseases. ADFMIDI maintains the Central Malaria Register (CMR), which receives and collates demographic, travel, disease, and treatment information from suspected and confirmed cases of malaria in ADF personnel. CMR enables disease trend monitoring, reporting, and response within the ADF. The most recent published review of malaria cases in the ADF covered the 10-year period preceding and including 2007.[2] It documents massive *P. vivax* burden following large-scale personnel deployments in the Southwest Pacific region, with outcome modifications to primaquine regimen, vector control, and personnel preventative awareness. *P. vivax* relapse may be associated with reduced primaquine metabolism.[7,8] Factors other than human cytochrome P450 2D6 (CYP2D6) phenotype, however, such as personnel adherence or parasite tolerance to primaquine, were found likely to contribute.[9] This report describes confirmed malaria cases reported to the CMR database during the 15-year period from 2008 to 2022.

Methods

The ADF maintains a register of personnel diagnosed with malaria. Case reporting by diagnosing clinician or health centre to ADFMIDI, via template electronic form, is mandatory under the direction of ADF Joint Health Command. CMR database information includes patient demographic details, military service type, illness onset date, malaria diagnosis date, malaria species, dates of movement between countries, country of acquisition, and administered prophylaxis and eradication treatments.

All 90 ADF CMR entries from January 1, 2008 through December 31, 2022 were exported from the database and individually cross-checked against original reports received by ADFMIDI. Suspected reported cases without confirmatory microscopy- or PCR- pathology data were excluded. Average ADF malaria case rates for the 15-year time period were determined using 2015 (mid-year) demographic data, for which both age group and gender data were available, as denominator.[10] Comparison Australian figures were sourced and determined using the Australian Government National Notifiable Disease Surveillance System data.[11] ADF malaria cases occurred either 'during travel', if disease onset was prior to departure from a malarious area, or 'after travel', if disease onset occurred after leaving the malarious area. Malaria cases of *P. vivax* and *P. falciparum* were classified as 'delayed' if clinical presentation was more than 28 days after departure from a malaria-endemic area.[12] *P. vivax* disease case presentation occurring subsequent to primary clinical presentation, with no chance for malaria re-exposure, was defined as 'relapse' and was not counted as a separate infection. Case demographic information was summarised. Countries of malaria acquisition were grouped within unified combatant command regions for result analysis and presentation.

Results

During the 15 years from January 1, 2008 through December 31, 2022, 60 Australian military members were diagnosed with malaria. One member had a mixed species infection consisting of *P. vivax* and *P. falciparum* acquired from, and presenting in, Sudan—in the U.S. Africa Command (AFRICOM) region—to total 61 infections in 60 personnel, representing an annual incidence rate of approximately 5.4 cases per 100,000 person-years (p-yrs) among ADF personnel **(Table)**. The majority of malaria infections were *P. vivax* (42 /61, 68.9%, 3.7 cases /100,000 p-yrs), followed by *P. falciparum* (13/61, 19.7%, 1.1 cases / 100,000 p-yrs). Three cases were caused by unknown malaria species, while *P. knowlesi*,[13] *P. malariae*, and *P. ovale* caused 1 infection each. Infections occurred most commonly in Regular Forces personnel (59/61, 96.7%, 5.2 cases/100,000 p-yrs), Army members (50/61, 82.0%, 4.4 cases/ 100,000 p-yrs), and male service members (57/61, 93.4%, 5 cases/100,000 p-yrs). The age group most infected was 20-29 years (29/61, 47.5%, 2.6 cases/100,000 p-yrs).

At least 1 confirmed malaria case (1.3/100,000 p-yrs) occurred annually during most years of the 15-year period under review **(Figure 1)**. The frequency of malaria case presentation was variable across the time period, including a notable absence of cases in 2020-2021, coinciding with a reduction in all travel and deployment activities due to the COVID-19 pandemic. Most malaria infections were acquired in the INDOPACOM region (39/61, 63.9%, 3.4/100,000 p-yrs), including 35 from Papua New Guinea. Eleven infections (11/61, 18.0%, 0.9/100,000 p-yrs) each also occurred from the AFRICOM and CENTCOM regions **(Figure 2, Supplementary Figure 1)**. *P. vivax* in members returned from the INDOPACOM region made up half of the total infection count (31/61, 50.8%), while the majority of *P. falciparum* infections were from the AFRICOM region (8/13, 61.5%), consistent with the most common circulating malaria species.

Complete entry and exit dates to malarious areas were available for 53 of the 60 personnel, with 20 cases presenting during travel and 33 presenting after travel. Case onset during travel did not appear to follow any temporal pattern **(Supplementary Figure 2a)**. Both *P. falciparum* and *P. vivax* infections occurred in personnel who presented after travel **(Supplementary Figure 2b)**. Fifteen personnel had delayed case presentation caused by *P. vivax*, likely due to parasite re-emergence from liver hypnozoites. Of the 42 personnel who experienced *P. vivax* infection, 5 (5/42, 11.9%) experienced relapse, including 3 individuals who reported partial or complete non-compliance with the primaquine eradication regimen.

Time of onset to first relapse following the start of *P. vivax* case treatment was 43 to 210 days (median 67 days). One of these 5 people went on to have a second relapse 69 days after commencement of a known-completed course of primaquine, prescribed following the first episode of relapse.

Discussion

Australian military forces commonly undertake exercises, assistance operations, and joint military activities with other host countries in INDOPACOM. The determined annual malaria case rate of 5.4 per 100,000 p-yrs in ADF personnel is higher than that experienced by U.S. Armed Forces, which reported 403 cases during the 10-year period 2012 to 2021, and a rate of 1.4 per 100,000 p-yrs following 30 infections recorded during 2022.[14,15] This difference in case rates may reflect the closer proximity of Australia to malaria-endemic countries in addition to the dislocation of U.S. service members' duty locations from the regions of malaria transmission within their malaria-endemic countries of deployment.[15]

TABLE. Numbers of Malaria Infections in ADF Personnel, 2008–2022

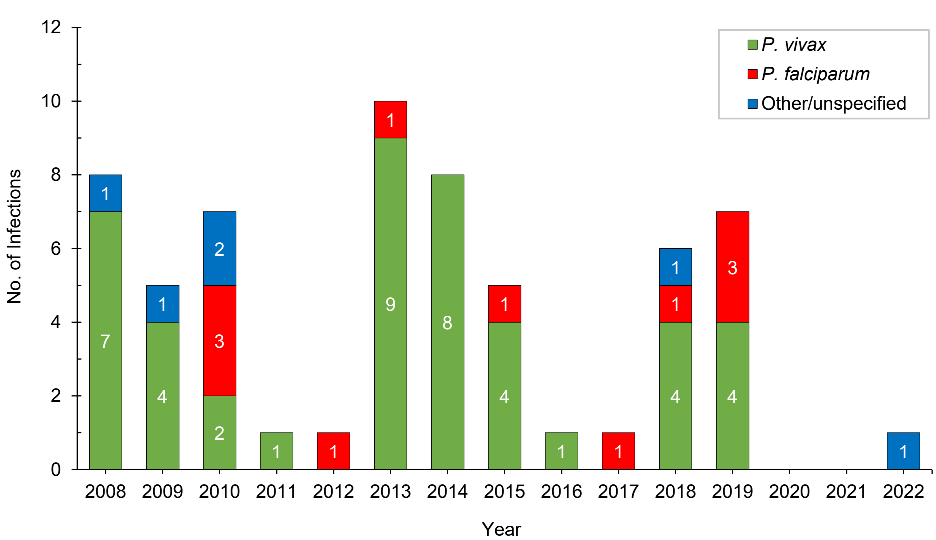
	P. vivax	*P. falciparum*	Other Species	Total	Total	ADF Reference Population (Apr. 2015)[b]	
	No.	No.	No.	No.	%	No.	%
Total	42	13	6	61	100.0	75,567	100
Sex							
Male	39[a]	12[a]	6	57	93.4	63,930	84.6
Female	3	1	0	4	6.6	11,411	15.1
Age group, y							
<20	3	0	0	3	4.9	1,931	2.6
20-29	21	6	2	29	47.5	26,359	34.9
30-39	11[a]	6[a]	2	19	31.1	19,562	25.9
40-49	6	1	2	9	14.8	14,947	19.8
50+	1	0	0	1	1.6	10,249	13.6
Component							
Regular forces	42[a]	12[a]	5	59	96.7	58,751	77.7
Reservist	0	1	1	2	3.3	16,816	22.3
Service category							
ARA	33[a]	12[a]	5	50	82.0	42,870	56.7
RAN	2	0	1	3	4.9	15,663	20.7
RAAF	7	1	0	8	13.1	17,034	22.6

Abbreviations: ADF, Australian Defence Force; *P, Plasmodium*; No., number; y, years; ARA, Australian Regular Army; RAN, Royal Australian Navy; RAAF, Royal Australian Air Force.

[a] Count includes 1 member with a mixed *P vivax* and *P falciparum* infection.

[b] Values may not sum due to rounding in reference document.

FIGURE 1. Malaria Infections in ADF Personnel by Year, 2008–2022



Abbreviations: ADF, Australian Defence Force; *P, Plasmodium*; No., number.

Differing force chemoprophylaxis approaches, including drug mechanism and site of action, may also play a role.[16] This ADF malaria case rate is approximately one-third of that determined from the Australian civilian population over the same period (15.8 / 100,000 p-yrs). A lower awareness or uptake of malaria preventative and prophylactic measures by civilian travelers compared with ADF personnel, and differing regions of travel, may contribute.

The finding that ADF malaria infections occurred most commonly in young adult men in full-time service with the Australian Regular Army broadly reflects the demographics of the Australian military.[10] The high malaria infection rate of 4.4 cases per 100,000 p-yrs within the Army compared with the other 2 services likely reflects an increased chance of malaria exposure resulting from the typical environments and activities of land-based forces, compared to those of air or sea operations, as well as the higher number of Army compared with Air Force or Navy personnel in the ADF. The distribution of infections between sexes was disproportionate to the demographics of the ADF, with only 6.6% (4 / 61) occurring in female service members compared to a reported ADF female participation rate of 15.1%.[10] The reasons for this are unclear based on the data available, but reflect the possibility for reduced female, compared with male, force deployment ratios to malaria-endemic regions.

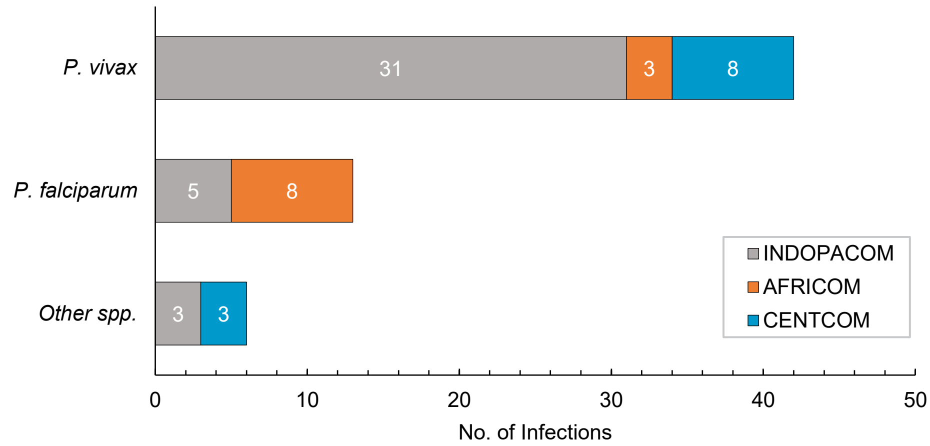
Annual ADF malaria case numbers, though relatively low, differed markedly during this 15-year period. No major changes in malaria prevention or prophylactic drug or dose regimens, to which this difference could be attributed, were adopted over this time. The majority of cases occurred from Papua New Guinea, including clustered outbreaks in 2013-2015 and 2018-2019, following conduct of annual training exercises in country regions with high rates of malaria transmission. Additionally, intermittent malaria cases from personnel deployed in Afghanistan as part of Australia's contribution to Operation Slipper contributed to elevated case numbers in 2008 and 2010. Other malarious regions to which ADF personnel deployed and from which cases were reported include Timor Leste, until 2013, during a period of dramatic decline in country case numbers,[17, 18] and northeastern Africa, with a small contingent present from 2011.[19] The majority species reported following infection from both Papua New Guinea and Afghanistan was *P. vivax* (**Supplementary Figure 1**), which reflects the capacity for hypnozoite-based relapse, as well as regional species prevalence.[20] In comparison, malaria among U.S. service personnel has most commonly been acquired within Africa, with the majority of cases caused by *P. falciparum*.[14,15] Similar to the ADF, the U.S. Armed Forces reported a reduced number of malaria cases in 2021 and 2022, attributable to the progressive withdrawal of personnel from Afghanistan and the restrictions to international travel imposed by the COVID-19 pandemic.[14,15]

A limitation to our study is the possibility that ADF CMR case notifications were incomplete, including for personnel who may have attended non-military settings for medical treatment and care. Submitted data were not always complete, and notifications without reported confirmation of malaria diagnosis were excluded, so case numbers may have been higher than those presented. ADF personnel numbers and demographics varied over the study period, although the use of 2015 denominator data was unlikely to have greatly modified results. Analysis of malaria rates against those of personnel deployed to high-risk regions over the study period would have improved clarity but was beyond the scope of this report. In 2015, 4 Royal Australian Naval (RAN) personnel were infected with *P. falciparum* malaria in Tanzania during a piracy patrol in the Indian Ocean (in AFRICOM). These cases were not reported through the CMR, affecting presentation of summary case results, including service (Navy), malaria species (*P. falciparum*), and region of malaria infection (AFRICOM).[21]

Suppressive prophylactic agents treat blood-stage malaria parasites but the 8 amino-quinolones are the only medications available to eradicate hypnozoites from the liver.[22] Since 2000, the ADF has prescribed 30mg primaquine base daily for 14 days.[2] CMR reporting is mandated, so most events, including relapse, are captured, although reporting indicates absent, incomplete or low-dose treatment in some instances. With aim for efficacy, ADF policy encourages advice from ADFMIDI or other infectious diseases specialists on anti-malarial management, and relapse treatment should be monitored. Some personnel experienced relapses despite documented appropriate primaquine eradication, likely due to differences in body mass and drug metabolism.[7, 23] Tafenoquine has a long half-life and efficacy against liver, blood-stage, and hypnozoite parasites, so may progressively prove useful as a weekly prophylaxis against all strains of malaria, without the need for a radical cure regimen when personnel leave a malarious area.[24]

Malaria risk to deployed military forces will continue to evolve as missions and associated geographies change. The greatest recent malaria challenge faced by the ADF was in Timor Leste beginning in 1999, with mass *P. vivax* relapse events documented following post-exposure prophylaxis and radical cure, at a time when very little endemic disease was reported.[2,25] This emphasises the ongoing requirement for vigilant use of malaria preventative measures and for improved diagnostics and drug regimens against hypnozoite stage parasites for regionally deployed ADF personnel.

FIGURE 2. Malaria Infections by Species and Region of Acquisition, ADF Personnel, 2008–2022



Abbreviations: ADF, Australian Defence Force; *P, Plasmodium*; INDOPACOM,Indo-Pacific Command; AFRICOM, Africa Command; CENTCOM, Central Command; spp., species; No., number.

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Disclaimer

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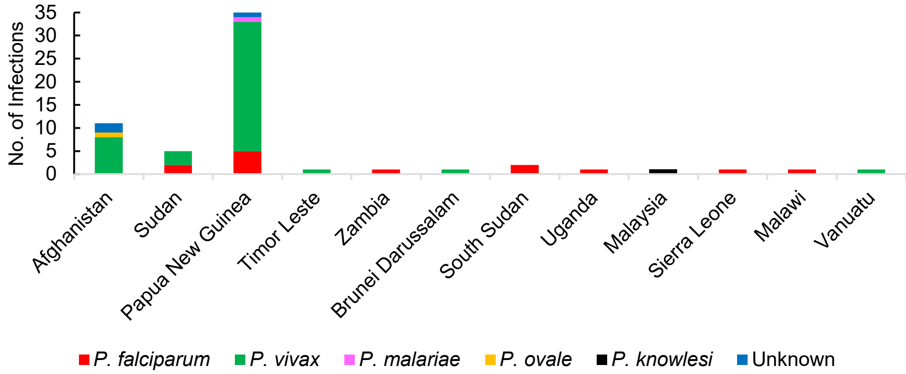
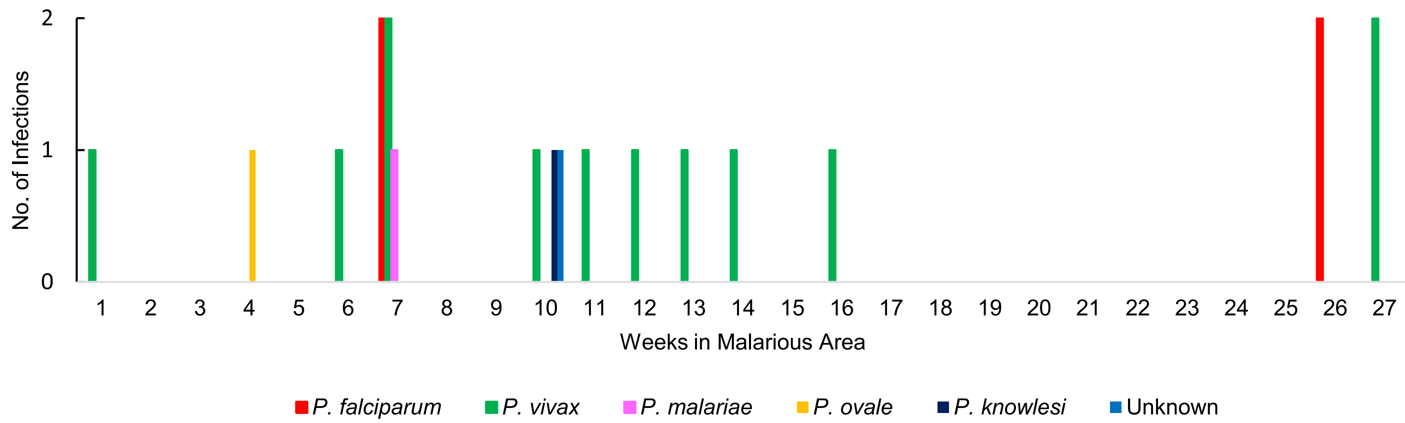
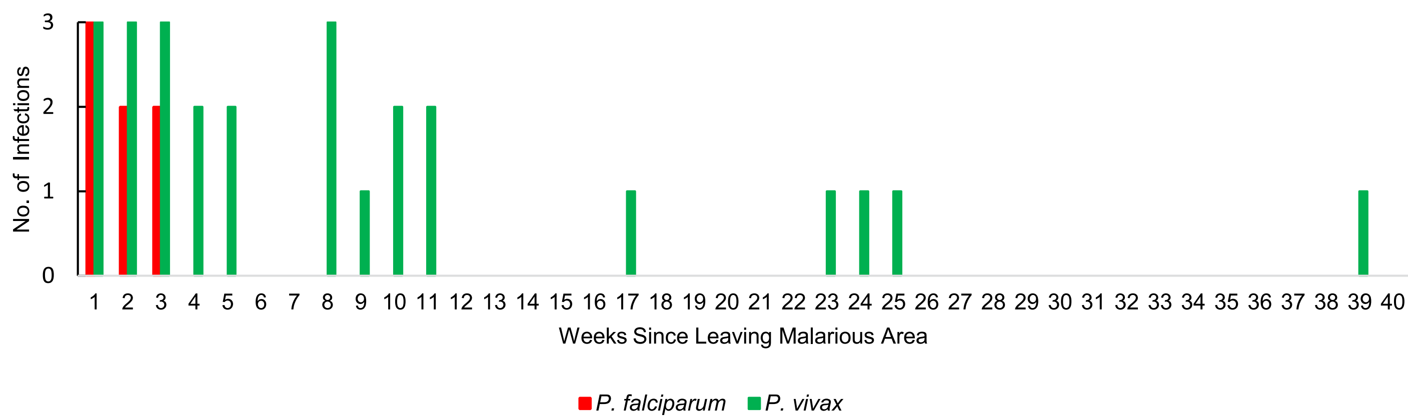
SUPPLEMENTARY FIGURE 1. Number of Malaria Infections in ADF Personnel by Species and Country of Acquisition



SUPPLEMENTARY FIGURE 2a. Number of Malaria Infections in ADF Personnel by Number of Weeks Since Arrival in Malarious Area



SUPPLEMENTARY FIGURE 2b. Number of Malaria Infections in ADF Personnel by Number of Weeks Since Leaving Malarious Area



Lymphatic Filariasis in Soldiers Exposed in INDOPACOM

G. Dennis Shanks, MD, MPH; James K Smith, MB ChB, MBA, MPH

Some military organizations in the U.S. Indo-Pacific Command (INDOPACOM) give returning soldiers presumptive treatment for filariasis. As there have been few clinical cases in recent decades, the historical basis for this chemotherapy was reviewed. During the Second World War, U.S. Marines stationed on Polynesian islands such as Tonga, Samoa, and Fiji experienced clinical lymphatic filariasis. Although thousands of both U.S. and Australian soldiers served in New Guinea, few, if any, cases of lymphatic filariasis were ascribed to Melanesia. While the French Army reported dozens of cases of filariasis among its service members during the 1950s Vietnam conflict, the U.S. military experienced only a few cases among the nearly 2 million service members who served in Vietnam in the 1960s. Australian soldiers deployed to Timor Leste in the 21st century showed rare seroconversions to filaria but no clinical disease. Following mass drug administration to eliminate lymphatic filaria in the INDOPACOM region, exposure in deployed soldiers rarely occurs and preventive chemotherapy should cease.

"No specific therapy was employed because none of the men were ever very ill and findings were so transitory that no baseline for accurate evaluation could be obtained. From the time of first observation until the present there was a progressive improvement in the overall picture, so that any compound employed might have given the impression of being beneficial."—Chief Medical Officer Captain L.T. Coggeshall, 1946, after receiving evacuated U.S. Marine Corpsmen with filariasis infections from INDOPACOM during the Second World War.[1]

Filariasis is a nematode infection of humans spread by mosquitoes that is infamous for its end stage syndrome of elephantiasis or severe edema caused by lymphatic damage. Mass drug administration (various combinations of diethylcarbamazine, albendazole, and ivermectin) has greatly reduced the global burden of this neglected tropical disease, but the disfigurement of this severe chronic disease gives lymphatic filariasis an impact beyond its acute clinical symptoms. Realizing that some modern militaries (including the Australian Defence Force) were continuing to give presumptive anthelminthic treatment to soldiers returning from Melanesian deployments, the historical basis for this practice was investigated to determine its appropriateness. The military impact of lymphatic filariasis was largely limited to U.S. Army or Marine Corps units defending a few Pacific islands (Tonga, Samoa, Fiji) during the Second World War.[2] Given the near absence of traveler infections in New Guinea and the greatly reduced worm burden in endemic populations, presumptive routine treatment for lymphatic filariasis should cease and treatment limited to those diagnosed with acute infections.

The U.S. military was aware of the risk of malaria during the Second World War campaign in the Southwest Pacific from its colonial history in the Philippines, but was much less prepared for the epidemic of lymphatic filariasis in a few island defence battalions in Polynesia starting in 1942.[2] Sudden deployment of defensive forces ahead of what was feared to be further Japanese island invasions to cut Australian lines of sea communication with the U.S. resulted in inexperienced soldiers living in close proximity to the local Polynesian population. Epidemic lymphatic filariasis in the U.S. military was largely limited to islands such as Tonga and Samoa, with diurnally active parasites; few if any filarial infections resulted from the many soldiers sent to New Guinea, with nocturnally active parasites.[2]

Some soldiers developed acute symptoms such as lymphangitis, adenitis, and scrotal swelling weeks and months following exposure to *Wuchereria bancrofti*, which initially mystified medical officers who were both unfamiliar with tropical diseases and had no means of laboratory diagnosis. More than 10,000 cases of lymphatic filariasis are estimated to have resulted from less than 38,000 men exposed, of which 90% of cases occurred in a few U.S. Marine Corps island defense battalions.[1]

The major impact of the disease was psychological, related to the unknown cause and genital involvement among exclusively male military units isolated on Pacific islands far from any combat operations.[3] No microfilaria were seen in the blood, and the few adult worms could not be demonstrated without direct pathological examination of lymph nodes. Great uncertainty prevailed among medical officers, which in turn promoted rumors among other service members. A few dramatic cases of elephantiasis among Polynesians increased concerns about the long-term effects of this unfamiliar tropical disease.

An administrative decision was enacted to remove sick men from the area until they could be diagnosed and treated, leading to the formation of several general hospitals in the U.S. specifically for tropical diseases. Most of those thought to have lymphatic filarial infections were sent to the U.S. Marine Corps Barracks in Klamath Falls, Oregon, which at its peak in 1944 had up to 2,000 inpatients **(Figure)**.[4] The senior medical officer at Klamath Falls, Captain L.T. Coggeshall, as the ninth Charles Franklin Craig Lecturer of the American Society of Tropical Medicine in 1944, stated:

> "There is a very prominent psychic element in the picture, as could be expected with an infection that involved the genitalia plus the reaction after seeing the grotesque deformities in the natives with elephantiasis. Men are concerned about sterility and the possibility that continued assaults on the lymphatic system will leave a permanent lymph edema."[4]

Treatment largely consisted of rehabilitation and sports, trying to break any association with the 'sick role'.[5] No chemotherapy was available or given, except for malaria relapses that occurred in some soldiers who had been deployed in the Solomon Islands.

Entire U.S. Army units were repatriated as combat ineffective due to lymphatic filariasis.[6-8] Several hundred soldiers of the 134th Field Artillery and 404th Engineer Company were stationed on the main island of Tonga (Tongatabu or Tongtapu) from May 1942 until May 1943, when they were exposed to *Wuchereria bancrofti*.[2] The soldiers began to develop symptoms—lymphangitis, scrotal swelling, inguinal adenopathy—after leaving Tonga, starting in August 1943, and were sent to an Army field hospital in New Guinea in January 1944. After being deployed for 27 months (7 of which were in hospital in New Guinea) those soldiers were then repatriated to Moore General Hospital in North Carolina in July 1944, through the end of the war. At no time did either unit participate in combat operations.[2]

Post-war syndromes are often difficult to evaluate, but now, decades later, it can be definitively stated that almost none of the feared long-term sequelae of lymphatic filariasis among U.S. soldiers occurred from infection during the Second World War.[9] Only 1 case of elephantiasis was reported by a Veterans Administration hospital out of more than 10,000 symptomatic infections.[10]

Subsequent Indo-Pacific regional wars have demonstrated a very limited number of filarial infections in service members. During the French war in Indochina, 151 cases of filarial disease *Brugia malayi* were diagnosed in French soldiers in Algeria, following their return from Vietnam in 1951.[11] The epidemic largely consisted of tropical eosinophilic pneumonia with adenopathy and pulmonary asthma. No microfilaria were seen in blood, and most soldiers either experienced spontaneous illness resolution or were treated with diethylcarbamazine without sequelae.

The U.S. Army in Vietnam had even fewer cases of lymphatic filarial infection described despite the deployment of more than 2 million U.S. soldiers and high infection rates in local Vietnamese defensive forces. Two case reports were found in the literature. In 1 case, a U.S. soldier with *Wuchereria bancrofti* microfilaria was observed after 11 months, and his adenopathy resolved on treatment.[12] Another case was seen in a U.S. veteran with adenopathy and persistent eosinophilia that responded to diethylcarbamazine despite no microfilaria detection.[13]

Australian military cases of lymphatic filariasis in the Indo-Pacific Command (INDOPACOM) were difficult to associate with Pacific islands, as most cases from the World Wars were thought to be due to exposure as children in Queensland.[14] Up to 10% of soldiers recruited from Queensland in the early 20th century were infected with filaria, based on a case series of 4,000 persons whose blood was examined in Southeast Queensland.[14] Only 24 cases of lymphatic filarial infection (22 in Australia, 2 in New Guinea; < 1:30,000) were diagnosed in Australian soldiers during the Second World War, despite high infection rates in local New Guinea populations.[15]

No Australian military cases of filariasis were noted during the Vietnam War. After 6 months' exposure in Timor Leste,

FIGURE. Marine Barracks, Klamath Falls, Oregon, circa 1944, Where Many U.S. Service Members Were Hospitalized for Filariasis After Infection in INDOPACOM

Photograph in the public domain, courtesy of the Arlington Public Library in partnership with The Portal to Texas History, a digital repository hosted by the University of North Texas Libraries.

some Australian soldiers had positive serological tests, most of which were thought to be due to exposure to dog filaria in Australia.[16] There was no evidence of disease or symptoms attributable to filaria. The overall conclusion was that seroconversion after exposure for 6 months was unusual, and disease risk was nearly nonexistent.[16]

There have been no recognized infections attributed in decades to lymphatic filariasis in the Australian Defence Force. Current helminthic disease reported from the U.S. Department of Defense in 2021 agrees with this extremely low risk assessment.[17] From 2012 to 2018, few (<40 / year) tissue-invasive nematode infections were reported, and of those ascribed to filaria, few were confirmed cases based on laboratory testing. Similarly, travel medicine cases of lymphatic filariasis in civilians have been rare, usually only occurring in those living closely with local populations for extended periods of time.[18]

Although historical reviews state that the military needs to remain aware of the risk of lymphatic filarial infections in INDOPACOM, based on the U.S. Second World War experience in Polynesia, recent evidence of service member infection is vanishingly rare, and likely to remain so, due to the great decrease in disease burden from mass drug administration in Polynesia and Melanesia.[19] Currently, the Australian Defence Force gives both albendazole and ivermectin to soldiers returning from Melanesian field exercises, whereas the New Zealand Defence Force and U.S. military forces do not. Although use of albendazole and ivermectin in millions of people reinforces the extremely favorable safety profiles of these medications, there seems to be little medical justification for their use in redeploying soldiers in INDOPACOM. Serosurveillance of the Papua New Guinea Defence Force, whose soldiers are exposed to filaria from birth, also show extremely low rates of infection. A 2019 survey of 235 soldiers from Papua New Guinea's North Coast found no evidence of current filarial infection, based on microscopy and rapid diagnostic testing.[20]

Psychological aspects may still determine how one experiences worms or rates risk of infection, but given the current difficulties in compliance with any preventive medicine intervention, it seems best to eliminate preventive measures that cannot be justified with current data. Those living within endemic populations for extended periods such as Special Forces members may be exceptions, but use of prophylactic anti-filarial medications should no longer be part of health planning for modern military units in the INDOPACOM region.

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Disclaimer

The opinions expressed are those of the authors and do not necessarily reflect those of the Australian Defence Force or the U.S. Department of Defense.

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Notice to Readers

Updates to the Environmental Hazards Study: Mortality Among U.S. Service Members Deployed to Karshi-Khanabad Air Base, Uzbekistan Study Are Now Available

Updates to the *Environmental Hazards Study: Mortality Among U.S. Service Members Deployed to Karshi-Khanabad Air Base, Uzbekistan* are now available for public review at https://health.mil/Military-Health-Topics/Health-Readiness/Environmental-Exposures/Environmental-Hazards-Study-K2. This study investigated deaths among U.S. service members who served at Karshi-Khanabad Air Base (K2) in Uzbekistan between October 2001 and December 2005. Researchers looked at factors including age, race, and branch of service. No clear links between serving at K2 and overall death rates from October 1, 2001 through December 31, 2019 were found from examining the data.

Key Findings

The study found no significant difference in overall death rates between service members who served at K2 and those who did not. A more in-depth analysis of health issues is necessary to fully understand the impact of serving at K2.

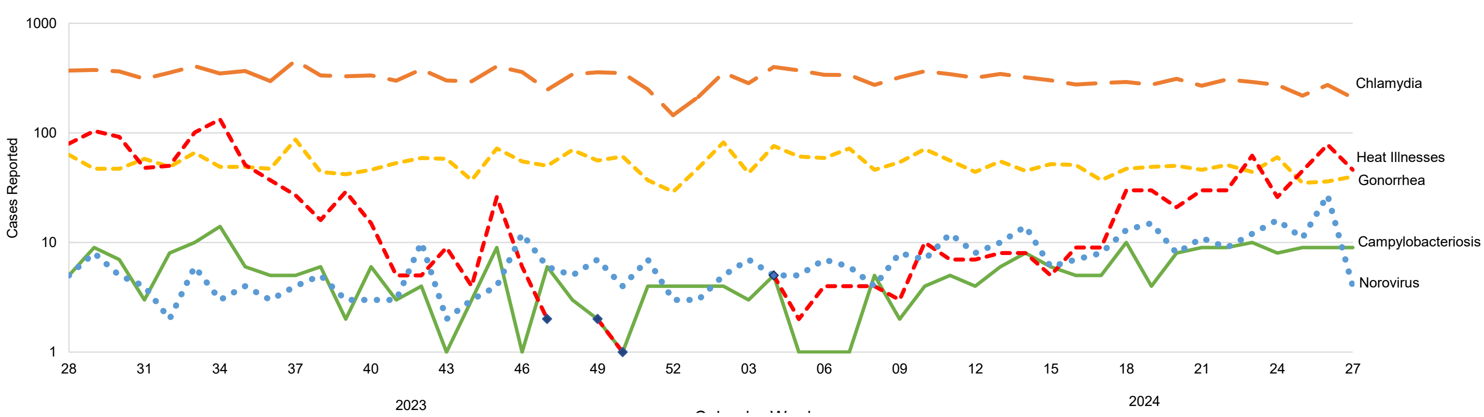
Next Steps

This completed study has helped inform a second, ongoing, and more detailed investigation focusing on specific illnesses instead of death rates. The Johns Hopkins University and the Veterans Health Administration have partnered to conduct this in-depth study of other health outcomes associated with K2 deployment. Further inquiries can be sent to: dha.ncr.health-surv.mbx.webmaster@health.mil

Reportable Medical Events at Military Health System Facilities Through Week 27, Ending July 6, 2024

Matthew W.R. Allman, MPH; Anthony R. Marquez, MPH; Katherine S. Kotas, MPH; Idalia Aguirre, MPH

TOP 5 REPORTABLE MEDICAL EVENTS BY CALENDAR WEEK, ACTIVE COMPONENT (JULY 1, 2023 – JUNE 29, 2024)



Abbreviation: RMEs, reportable medical events.

Note: Cases are shown on a logarithmic scale. There were 0 heat illness cases in the following weeks in 2023: 48, 51-52, and weeks 1 and 3 in 2024. Markers were added to represent instances of heat illnesses not visible on the logarithmic scale graph.

Reportable Medical Events (RMEs) are documented in the Disease Reporting System internet (DRSi) by health care providers and public health officials throughout the Military Health System (MHS) for monitoring, controlling, and preventing the occurrence and spread of diseases of public health interest or readiness importance. These reports are reviewed by each service's public health surveillance hub. The DRSi collects reports on over 70 different RMEs, including infectious and non-infectious conditions, outbreak reports, STI risk surveys, and tuberculosis contact investigation reports. A complete list of RMEs is available in the *2022 Armed Forces Reportable Medical Events Guidelines and Case Definitions*.[1] Data reported in these tables are considered provisional and do not represent conclusive evidence until case reports are fully validated.

Total active component cases reported per week are displayed for the top 5 RMEs for the previous year. Each month, the graph is updated with the top 5 RMEs, and is presented with the current month's (June 2024) top 5 RMEs, which may differ from previous months. COVID-19 is excluded from these graphs due to changes in reporting and case definition updates in 2023.

For questions about this report, please contact the Disease Epidemiology Branch at the Defense Centers for Public Health–Aberdeen. Email: dha.apg.pub-health-a.mbx.disease-epidemiologyprogram13@health.mil

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TABLE. Reportable Medical Events, Military Health System Facilities, Week Ending July 6, 2024 (Week 27)[a]

Reportable Medical Event[b]	Active Component[c]					MHS Beneficiaries[d]
	May 2024	June 2024	YTD 2024	YTD 2023	Total, 2023	June 2024
	No.	No.	No.	No.	No.	No.
Amebiasis	1	1	7	10	15	1
Arboviral diseases, neuroinvasive and non-neuroinvasive	0	0	0	0	3	0
COVID-19-associated hospitalization and death[e]	1	3	22	67	113	21
Campylobacteriosis	37	37	145	136	270	27
Chikungunya virus disease	0	0	0	1	2	0
Chlamydia trachomatis	1334	1084	7971	8860	17508	175
Cholera	0	0	1	2	4	0
Coccidioidomycosis	3	2	34	13	36	2
Cold weather injury[f]	4	1	133	96	152	N/A
Cryptosporidiosis	5	10	41	40	67	3
Cyclosporiasis	0	1	1	5	15	2
Dengue virus infection	1	0	5	2	7	0
E. coli, Shiga toxin-producing	10	11	39	30	69	6
Ehrlichiosis/Anaplasmosis	1	0	1	0	28	0
Giardiasis	4	8	47	41	78	2
Gonorrhea	220	177	1371	1376	2763	18
Haemophilus influenzae, invasive	1	0	3	0	1	0
Hantavirus disease	0	0	0	1	2	0
Heat illness[f]	130	219	444	350	1255	N/A
Hepatitis A	2	0	5	4	8	0
Hepatitis B, acute and chronic	7	2	49	86	155	6
Hepatitis C, acute and chronic	2	1	16	30	52	1
Influenza-associated hospitalization[g]	2	1	35	5	29	5
Lead poisoning, pediatric[h]	N/A	N/A	N/A	N/A	N/A	7
Legionellosis	0	0	3	3	5	1
Leishmaniasis	0	0	0	1	1	0
Leprosy	0	0	0	0	2	0
Leptospirosis	0	0	0	2	4	0
Lyme disease	11	11	44	36	70	10
Malaria	1	0	4	9	28	1
Meningococcal disease	0	1	1	2	4	0
Mpox	0	4	8	0	5	1
Norovirus	53	66	244	290	419	55
Pertussis	3	1	10	3	15	9
Post-exposure prophylaxis against Rabies	47	56	291	286	598	49
Q fever	0	0	0	1	2	0
Rubella	0	0	0	2	2	0
Salmonellosis	14	17	60	42	129	17
Shigellosis	4	8	27	31	59	0
Spotted Fever Rickettsiosis	4	3	9	21	31	3
Syphilis (all)	48	31	345	477	945	10
Toxic shock syndrome	0	0	2	1	2	0
Trypanosomiasis	0	0	1	1	1	0
Tuberculosis	1	0	2	3	11	1
Tularemia	0	0	1	1	1	1
Typhoid fever	0	0	0	1	2	0
Typhus fever	0	0	1	3	3	2
Varicella	3	2	9	5	12	10
Zika virus infection	0	0	1	0	0	0
Total case counts	1,954	1,758	11,433	12,376	24,983	446

Abbreviations: MHS, Military Health System; YTD, year-to-date; no., number; *E., Escherichia*; N/A, not applicable.
[a] RMEs reported through the DRSi as of Jul. 31, 2024 are included in this report. RMEs were classified by date of diagnosis or, where unavailable, date of onset. Monthly comparisons are displayed for the period of May 1, 2024–May 31, 2024 and Jun. 1, 2024–Jun. 30, 2024. YTD comparison is displayed for the period of Jan. 1, 2024–Jun. 30, 2024 for MHS facilities. Previous year counts are provided as the following: previous YTD, Jan. 1, 2023-Jun. 30, 2023; total 2023, Jan. 1, 2023–Dec. 31, 2023.
[b] RME categories with 0 reported cases among active component service members and MHS beneficiaries for the time periods covered were not included in this report.
[c] Services included in this report include the Army, Navy, Air Force, Marine Corps, Coast Guard, and Space Force, including personnel classified as FMP 20 with duty status of Active Duty, Recruit, or Cadet in DRSi.
[d] Beneficiaries included the following: individuals classified as FMP 20 with duty status of Retired and individuals with all other FMPs except 98 and 99. Civilians, contractors, and foreign nationals were excluded from these counts.
[e] Only cases reported after case definition update on May 4, 2023. Includes only cases resulting in hospitalization or death; does not include cases of hospitalization or death reported under the previous COVID-19 case definition.
[f] Only reportable for service members.
[g] Influenza-associated hospitalization is reportable only for individuals under 65 years of age.
[h] Pediatric lead poisoning is reportable only for children aged 6 years or younger.

Instructions for Authors of MSMR Manuscript Submissions

Revised August 2024

Criteria for Publication

Appropriateness

The *Medical Surveillance Monthly Report* is dedicated to reporting evidence-based estimates of the incidence, distribution, impact, or trends of illness and injuries among members of the United States Armed Forces and other beneficiaries (e.g., family members, retirees, civilian employees) of the Military Health System. *MSMR* reports generally focus on data or public health information directly relevant to the health, safety, and well-being of MHS beneficiaries or military members' operational readiness. Submissions with a focus beyond the U.S. Armed Forces may be considered if relevant and generalizable to a current military health issue.

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Submissions should follow the general structure and reporting standards for epidemiological studies and surveillance reports, adhering to criteria specific to the study design or report type. Objectives should be clearly stated and specific. Data analyses should use standardized, validated, and accepted scientific methods with sufficient data samples to adequately address the objectives of the report. Results should be interpreted with an ultimate aim of presenting accurate and potentially actionable public health information (e.g., policy changes, practice or areas for further research). Conclusions should result directly from evidence presented and reflect the stated intention of the study design. Any significant limitations due to data quality should be included. Reports that are primarily descriptive (i.e., not testing a proposed hypothesis) should discuss results within relevant context (e.g., setting, existing knowledge or literature, etc.) and not overstate the significance or implications of their findings. Use of active voice, in addition to succinct language, are strongly encouraged.

Originality

Reports must be submitted exclusively to *MSMR*, original analysis, and otherwise unpublished in the peer-reviewed literature, either previously or in the future. As part of the submission package, all prior related publications and presentations must be disclosed, including presentations (oral or poster) at scientific conferences or technical publications internal to a governmental agency. Updates of surveillance summaries previously published in *MSMR* will be considered if they add significant new information.

Timeliness

Reports should employ the most current data available from surveillance systems or analyses of electronic health records, surveys, case reports, or other studies. Data from emergency response or outbreak investigations should be no older than 12 months at time of submission. Generally, data presented as a Full or Brief Report should include a recent surveillance period preferably within the last 10 years, with a rationale provided for the chosen timeframe.

Clarity

Reports should be organized according to the specifications for each report type and logically developed throughout all sections. Use of acronyms should be minimized, as much as possible.

Types of Reports

Full Reports

Full Reports present the verified results of a completed epidemiological investigation or study that answers a question of military health importance. All Full Reports are submitted to 2 voluntary, independent reviewers for peer review.

The Introduction, Methods, Results, and Discussion sections of a Full Report should not exceed 2,500 words. Full Reports exceeding 2,500 words may be considered if supported justification is presented. Cited references are recommended to be limited at 25. Data tables and figures should complement the text succinctly and logically.

Full Reports comprise 14 elements or sections, in the following order:

1. *Title*: Concise and informative, reflecting the main focus or finding(s) and incorporating key terms. Refrain from using colons if possible. (A title page is not necessary.)
2. *Authors*: List all authors immediately below the title, according to authorship guidelines in Submission Formats. *MSMR* policy requires that *all* authors satisfy *all* International Committee of Medical Journal Editors (ICMJE) authorship criteria:
   - Substantial contributions to the conception or design of the work, or acquisition, analysis or interpretation of data for the work.
   - Drafting of the work and critical revision of important intellectual content.
   - Final approval of version to be published.
   - Agreement to accountability for all aspects to ensure questions of accuracy or integrity are appropriately investigated and resolved.

Type of Report	Recommended Word Count	Maximum Tables and Figures	Recommended Maximum References	Peer Review
Full Report	≤2,500	Minimum necessary to support succinct data presentation	25	Yes
Brief Report	≤1,000	2	10	Yes
Outbreak Report	≤2,000	Minimum necessary to support succinct data presentation	25	Yes
Case Report	≤1,000	Minimum necessary to support succinct data presentation	10	Yes
Surveillance Snapshot	≤500	1	10	No
Letter to the Editor	≤1,000	Typically not applicable	5	Reviewed by *MSMR* editors.
Historical Perspective	≤2,000	Typically 2; additional may be considered upon request	25	Yes
Notice to Readers	≤500	Typically not applicable	--	No
Images in Health Surveillance	≤500	As required to support aim of submission	5	No
Guest Editorial	≤2,000	Typically 2; additional may be considered upon request	25	As applicable; at the discretion of the editor-in-chief.

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   - For the new findings statement, in 50 words or less, highlight, in plain English, the key findings of the analysis or report that either are new or significant within the discipline or context.
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6. *Background*: Include contextual information (i.e., concise review of the topic background, existing knowledge or literature, and relevant prior discussions) as they relate to the goals, expected findings and implications of the work being reported, focusing on relevance to U.S. military populations or operations. Conclude with the objective or specific question(s) the report aims to answer.
7. *Methods*: Specify, as appropriate, the target population, time period, definitions, exposures, outcomes or endpoints, other characteristics of interest, sources and methods of data collection, and data summary and statistical analysis methods. The Methods section must contain sufficient detail to allow reproduction or verification of the study. If the analysis involved databases or methods previously published, limited text should be devoted to such information available elsewhere, with references. Additionally, the Methods section must describe how the data were obtained, including the source(s), case and covariate definitions, and the most recent date the data sources were refreshed.
8. *Results*: Communicate, logically and concisely, the findings and analysis results. With the exception of emphasis on important or significant observations, do not repeat numerical data presented in tables and graphs; limit tables and figures to those required to explain and support the argument and report key outcomes identified in Methods. Descriptive studies should prioritize analyzing and presenting data that can connect findings with the identification of trends, the hypotheses generation, or guiding public health actions.
9. *Discussion*: Provide interpretive comments that address the importance of the study findings. Contextualize the main findings within broader military or general public health conditions or concerns, including previously published comparative studies, as applicable. Articulate both study strengths and limitations, including likely impacts of the limitations (e.g., shortcomings of data sources, sources of bias).

Propose specific strategies for future studies or changes in practice. Descriptive studies should limit their discussions to noteworthy trends, strengths and limitations, and suggestions for future work without overstating the significance or implications of the findings.

10. *Author Affiliations*: List the affiliations of all authors immediately following the conclusion of the manuscript.
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12. *Disclaimers*: Disclose any service-specific or DOD disclaimers. Submissions from within any DOD service or agency must receive a legal and public affairs review by the authors' organization(s).
13. *References*: Cite a recommended maximum of 25, directly related to the topic of discussion. All references must be cited within the text, using superscripted notations. List references using AMA style. See Submission Formats for formatting requirements.
14. *Tables and figures*: The number of tables and figures should complement the text, succinctly and logically. Submit in a separate Excel file. See Submission Formats for formatting requirements.

Brief Reports

Brief Reports condense 12 of the 14 elements of a Full Report—an Abstract and Military Relevance sections are not required—to 1,000 words maximum. Brief Reports are generally suitable for most descriptive studies, due to their simplified and limited Methods and Discussion sections. Brief reports are generally limited to 1 or 2 tables and figures, with a maximum of 10 references. All Brief Reports are peer-reviewed.

TIP: Simplicity expedites the review of a Brief Report, which either summarize data analyses or provide an update on prior reporting. Example.

Outbreak Reports

Outbreak Reports detail the chronology of an epidemiologic investigation with a surveillance period that precedes the submission date by no more than 12 months. Outbreak Reports include all 14 elements required for Full Reports and should not exceed 2,000 words. The Methods section should include details on how the event meets the definition of an outbreak. Summarize the epidemiological investigation with case definitions or case-defining activities, information on the suspected or laboratory confirmation (if available) of etiology of the outbreak and study design. The Results should provide a comprehensive description of the outbreak by describing case characteristics (e.g., clinical characteristics), as well as person, place, and event timeline measurements. The Discussion may include a brief summary of public health interventions, interpretation of results, implications for public health practice, and recommendations for future prevention and control. All Outbreak Reports are peer-reviewed.

TIP: This type of report may include clusters of disease where no specific etiology was discovered after a thorough investigation. Example.

Case Reports

Case Reports, limited to 1,000 words, describe a disease occurrence for sharing timely, pertinent, and potentially actionable information for medical, scientific, or educational purposes. Case Reports should clearly establish a relevance to matters of public health importance. Case Reports should include a Summary of each case(s) followed by a Discussion, and may contain images, as appropriate. Specific section headers may be proposed by authors. Acknowledgments, Disclaimers, and References should be included, when applicable. All Case Reports are peer-reviewed. Example.

Surveillance Snapshots

Surveillance Snapshots depict the incidence or distribution of disease in a single chart. Surveillance Snapshots can include 1 or 2 paragraphs of text (with no section heading), limited to 500 words. Surveillance Snapshots are not peer-reviewed but are subject to editorial review that may include consultation with other AFHSD staff. Acknowledgments, Disclaimers, and References should be included, as applicable. Example.

Letters to the Editor

Letters to the Editor offer timely and concise opinions or interpretations of articles published previously in *MSMR*. Letters should not include unpublished data and should be submitted within 1 year of the referenced article's publication. Letters are not peer-reviewed, but it is customary for the editorial team to send each letter to the author(s) of the original work for an opportunity to reply; the authors' response is generally published as a companion. Text is limited to 1,000 words, with references limited to 5. Tables and figures are discouraged but may be considered on an individual basis. Acknowledgments, Disclaimers, and References should be included, as applicable. Letters are subject to abridgement and editing for style and content. Example.

Historical Perspectives

Historical Perspectives discuss the historical impact(s) of a disease or condition, on a specific military operation or the military overall. Historical Perspectives are limited to 2,000 words and can contain 1 or 2 images. The section headers can be proposed by the authors; Acknowledgments, Disclaimers, and References should be included, as applicable. Historical Perspectives may be peer-reviewed by historians or relevant subject matter experts. Example.

Notices to Readers

Notices to Readers announce changes in recommended public health practices (e.g., vaccine recommendations) or the availability of clinical or surveillance resources (e.g., laboratory testing), in 500 words or less. Notices to Readers are not peer-reviewed. *MSMR* does not publish meeting announcements or summaries of past meetings. Example.

Images in Health Surveillance

Images in Health Surveillance illustrate militarily-relevant public health information with photographs, drawings, or other images, with accompanying text limited to 500 words, and no section headers. Acknowledgments, Disclaimers, and References should be included, as applicable. Example.

Guest Editorials

Editorials are usually invited but may be proposed. An editorial may serve as an opinion piece, or a comprehensive narrative relevant to public health professionals serving MHS beneficiaries. This may include a narrative review of literature or knowledge base, an update on the current understanding and state-of-the art of the topic, theory, and practice of epidemiology or military public health sciences. Editorials are generally limited to 2,000 words and may contain up to 2 tables or figures. The section headers of this report may be proposed by the authors. Acknowledgments, Disclaimers, and References should be included, as applicable. Example.

Other Article Types

May be proposed in an email to the editor.

Submission Formats

MSMR follows the American Medical Association Manual of Style, 11th edition as well as the MHS Editorial Style Guide. Please refer to the AMA Manual if specific questions about formatting or structure are not addressed in these instructions. Submissions should be sent to the *MSMR* editor at dha.ncr.health-surv.mbx.msmr@health.mil.

The following items are required for submission:

- a Microsoft Word document of the manuscript text for the proposed article
- a complete Authorship Submission Form
- a complete ICMJE Disclosure Form
- a Microsoft Excel file containing any associated tables and figures, or associated images, as applicable.

Manuscript Text

All manuscript text should be submitted in one Microsoft Word file, using the structure and section headers (if applicable), as noted for each Type of Report. Please submit all Word documents in 12-point Times New Roman font, with text double-spaced, and leave right margins unjustified (ragged). Do not embed tables or charts in the Word document (see Tables and Figures). A title page is not required.

Word limits only apply to the body of the text (i.e., exclude Title, Authorship, Structured Abstract, References): 2,500 words for Full Reports; 2,000 words for Outbreak Reports, Topical Reviews, and Historical Perspectives; 1,000 words for Brief Reports and Case Reports; and 500 words of text may accompany Surveillance Snapshots, Images in Health Surveillance, and Notices to Readers, Submissions longer than these suggested word counts will be considered individually and must be justified by the authors in their submission e-mails.

Standard usage specified by *MSMR* (that may be adjusted during the editorial process) includes:

- All numbers in the text should be expressed in numeral form, including one (e.g., as 1), except when the first word of a sentence; this is in accordance with AMA guidelines.
- "Female" and "male" are adjectives to modify another category, e.g. "female service members" or "male participants," with the terms "women" and "men" used in nominative references to sex category or specific individuals.
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- Because "impact" is specific medical terminology (related to impaction), *MSMR* uses the verb "affect" or other synonyms for the transitive verb case, per the MHS Editorial Style Guide.
- Health care is always written as 2 words in *MSMR*, both as a noun or adjective.

References

References should be listed in accordance with AMA style:

- List authors by last name and initials with no punctuation other than commas separating authors. When listing articles with more than 6 authors, list only the first 3 authors with "et al."
- Only proper nouns are capitalized in article or chapter titles; all nouns are capitalized and italicized in primary source (e.g., journal, published report, book) titles.
- Use journal title abbreviations as cited in PubMed; italicize journal title abbreviations, and book and published report titles.
- Journal issue citations should include no spaces after the year of publication, which should be followed by a semicolon; then the volume number with issue number in parentheses, followed by a colon and the page number(s).
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Example references:

1. Webber BJ, Tacke CD, Wolff GG, et al. Cancer incidence and mortality among fighter aviators in the United States Air Force. *J Occup Environ Med*. 2022;64(1):71-78. doi:10.1097/JOM.0000000000002353
2. Armed Forces Health Surveillance Division. Armed Forces Reportable Medical Events Guidelines and Case Definitions. Defense Health Agency, U.S. Department of Defense. Oct. 2022. Accessed Apr. 6, 2023. https://www.health.mil/Reference-Center/Publications/2022/11/01/Armed-Forces-Reportable-Medical-Events-Guidelines
3. O'Connor FG, Sawka MN, Deuster P. Disorders due to heat and cold. In: Goldman L, Schafer AI, eds. *Goldman-Cecil Medicine*. 25th ed. Elsevier Saunders;2016:692-693. [If no DOI is available, provide current URL preceded by "Accessed (date)".]

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2. *Drafting of the work and critical revision for important intellectual content*: Each author should provide substantive comments during the review process. Authors should record comments during the review process so each author's contributions to the final product can be verified.
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Tables and Figures

Tables and figures must be submitted as a separate Microsoft Excel file, **not** embedded in the text. Authors should study tables in recent *MSMR* reports for style. Microsoft Excel is the preferred software for generating tables and figures. Figures generated using other software (e.g., SAS, SPSS) will be considered on an individual basis.

TIP: Authors should study tables in example and previously published reports for specific style guidance.

Photographs that illustrate a prevention intervention, risk factor, or outbreak setting are encouraged. Only submit photographs within the public domain; if a photo credit is required, submit the name with the photograph.

Feature	Style Guidelines
Excel file structure	Tables and figures should be presented on separate worksheets. Figures must include a link to the underlying data in tabular form, if not embedded on the same worksheet.
Title nomenclatures, numbering, and naming conventions	Table and figure numbers should be written in **ALL CAPITAL LETTERS, BOLD FONT**. If only 1 table/figure exists, do not label with a number (e.g., **TABLE.**). Otherwise, number each table consecutively in the order mentioned in the text (e.g., **TABLE 1**, **TABLE 2**, etc.). Table and figure titles should be written with initial capital letters. If a date is indicated in the table title, use a short or en-dash (e.g. **TABLE 1**. Absolute and Relative Morbidity Burdens Attributable to Various Illness and Injuries, Active Component, U.S. Armed Forces, 2016). All text in tables and figures, including titles, should be Arial font, black, size 8 point.
Data presentation	All data values should be expressed to 1 decimal place (e.g., 5.1, 16.4). Do not bold, italic, or underline any data. All numerical data in columns should right-justified (set to right horizontal [indent], vertical center, indent=1). All non-numerical text in column cells should be left-justified. In general, counts are column graphs and rates are line graphs (particularly for trends over time). Pie charts and 3-D graphs should not be used. All data or text in tables and figures should be Arial font, black, size 8 point.
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Figure formatting	No border or gridlines should be used within the chart area. All *x*-axis labels are either aligned horizontally or vertically (no angled labels). If the axis label is easily implied, such as year, a label is not required. Graphs with primary and secondary *y*-axes should be clearly labeled to show which bars or lines correspond to each axis. Some other ways to distinguish between the axes when using 2, are solid versus dashed lines (try not to use neon, bright, or light colors as they are difficult to read). To adhere to Section 508 compliance, colors cannot exclusively nor primarily be the distinguishing element in any figure. Instead, to aid both readers who are color-blind in addition to adaptive reading devices for those with more severe visual impairment, gradations or variations for differing lines, bars, or sections thereof are requested for all figures. Place legends within the figures. Add a gray border around the legend at 0.5 line weight, if applicable. X- and y-axis lines should be .5 in width and black in color. Tick marks on the x-axis should include major type (outside) while tick marks on the y-axis should include major type (cross) and minor type (inside). All data or text in figures should be Arial font, black, size 8 point.
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Data consistency and textual citation	Ensure data values are consistent between the text and tables, use the same precision and units of measurement throughout. Every table or figure presented should be cited within the text.

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Services and Agencies

Prior to submission, authors must initiate clearance processes from their respective services or agencies and from human subjects review boards, as appropriate. Manuscripts pending clearance may be submitted to *MSMR* for consideration, but publication will be deferred indefinitely until ALL clearance documentation is received by the *MSMR* staff. Authors should check with their individual departments to ascertain if additional clearances need to be obtained from agencies outside their normal chain of command. Clearance documentation is required for all named authors on the manuscript, not just the corresponding author. If the respective service or agency requires statements to be published with the manuscript, this should be included under the Disclosure section.

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Submit to the editor via email at dha.ncr.health-surv.mbx.msmr@health.mil. Please see the Submission Formats section for all formatting requirements and instructions. Submit the Microsoft Word report document, Excel tables and figure file (or photographs, if applicable), and authorship submission form as separate attachments.

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