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Update: Malaria, U.S. Armed Forces, 2021

Malaria infection remains an important health threat to U.S. service members who are located in endemic areas because of long-term duty assignments, participation in shorter-term contingency operations, or personal travel. In 2021, a total of 20 service members were diagnosed with or reported to have malaria. This was the lowest number of annual cases during the 10-year surveillance period (i.e., January 2012–December 2021) and represents a 28.6% decrease from the 28 cases identified in 2020. The relatively low numbers of cases during 2012–2021 mainly reflect decreases in cases acquired in Afghanistan, a reduction largely due to the progressive withdrawal of U.S. forces from that country. The percentage of 2021 cases of malaria caused by *Plasmodium falciparum* (55.0%; n=11) was the highest of any year of the surveillance period; however, the number of cases was the third lowest observed during the surveillance period. The number of malaria cases caused by *Plasmodium vivax* in 2021 (n=1) was the lowest observed during the surveillance period. The remaining 8 malaria cases were labeled as associated with other/unspecified types of malaria (40.0%). Malaria was diagnosed at or reported from 15 different medical facilities in the U.S.; only 2 were reported outside of the U.S., 1 each in Germany and Africa. Providers of medical care to military members should be knowledgeable of and vigilant for clinical manifestations of malaria outside of endemic areas.

WHAT ARE THE NEW FINDINGS?

The 2021 total of 20 malaria cases among active and reserve component service members was the lowest annual count of cases during the past 10 years. No malaria cases were acquired from Afghanistan. The 2021 proportion of cases (55.0%) due to *P. falciparum* was the highest of the 10-year period; however, the case count remained low compared to previous years.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

The decrease in total counts of malaria cases during the last decade reflects the reduced numbers of service members exposed to malaria in Afghanistan. The persistent threat from *P. falciparum* associated with duty in Africa underscores the importance of preventive measures effective against this most dangerous strain of malaria.

Worldwide, the incidence rate of malaria is estimated to have decreased from 71.1 per 1,000 population at risk in 2010 to 57.5 in 2015 and 56.3 in 2019.[1] The World Health Organization (WHO) reported a slight increase in the estimated rate in 2020 (59.0 per 1,000 population at risk) which was partially attributed to disruptions in the delivery of malaria services (i.e., prevention, diagnosis, and treatment) due to the COVID-19 pandemic. During 2000–2019, malaria-related deaths decreased steadily from 896,000 in 2000 to 562,000 in 2015 and 558,000 in 2019. In 2020, estimated malaria deaths (627,000) increased 12% compared to 2019, with approximately 68% of the excess deaths attributed to pandemic-related disruptions in malaria services. The remaining 32% of excess deaths is reported to reflect a recent change in WHO's methodology for calculating malaria mortality.[1]

Countries in Africa accounted for about 95% of worldwide malaria cases and 96% of malaria-related deaths in 2020.[1] Six African countries including Nigeria (27%), the Democratic Republic of the Congo (12%), Uganda (5%), Mozambique (4%), Angola (3%), and Burkina Faso (3%) accounted for slightly more than half (55%) of all cases globally.[1] Most of these cases and deaths were due to mosquito-transmitted *Plasmodium falciparum* and occurred among children under 5 years of age,[1] but *Plasmodium vivax* , *Plasmodium ovale* , and *Plasmodium malariae* can also cause severe disease.[1–3] Globally in 2020, 2% of estimated malaria cases were caused by *P. vivax*.[1] It is important to note that, while heightened malaria-control efforts have reduced the incidence of *P. falciparum* malaria in many areas, the proportion of malaria cases caused by *P. vivax* has increased in some regions where both parasites coexist (e.g., Djibouti, Pakistan, Venezuela).[3,4]

Since 2007, the *MSMR* has published regular updates on the incidence of malaria among U.S. service members (Army reports began in 1999).[5–7] The *MSMR*'s focus on malaria reflects both historical lessons learned about this mosquito-borne disease and the continuing threat that it poses to military operations and service members' health. Malaria infected many thousands of U.S. service members during World War II (approximately 695,000 cases), the Korean War (approximately 390,000 cases), and the conflict in Vietnam (approximately 50,000 cases).[8,9] More recent military engagements in Africa, Asia, Southwest Asia, the Caribbean, and the Middle East have necessitated heightened vigilance, preventive measures, and treatment of cases.[10–19]

In the planning for overseas military operations, the geography-based presence or absence of the malaria threat is usually known and can be anticipated. However, when preventive countermeasures are needed, their effective implementation is multifaceted and depends on the provision of protective equipment and supplies, individuals' understanding of the threat and attention to personal protective measures, treatment of malaria cases, and medical surveillance. The U.S. Armed Forces have long had policies and prescribed countermeasures effective against vector-borne diseases such as malaria, including chemoprophylactic drugs, permethrin-impregnated uniforms and bed nets, and topical insect repellents containing *N,N*-diethyl-*meta*-toluamide (DEET). When cases and outbreaks of malaria have occurred, they generally have been due to poor adherence to chemoprophylaxis and other personal preventive measures.[11–14]

MSMR malaria updates from the past 9 years documented that the annual case counts among service members after 2011 were the lowest in more than a decade.[7,20–25] In particular, these updates showed that the numbers of cases associated with service in Afghanistan had decreased substantially in the past 9 years, presumably due to the dramatic reduction in the numbers of service members serving there. This update for 2021 uses methods similar to those employed in previous analyses to describe the epidemiologic patterns of malaria incidence among service members in the active and reserve components of the U.S. Armed Forces.

METHODS

The surveillance period was 1 January 2012 through 31 December 2021. The surveillance population included Army, Navy, Air Force, and Marine Corps active and reserve component members of the U.S. Armed Forces. The records of the Defense Medical Surveillance System (DMSS) were searched to identify reportable medical events and hospitalizations (in military and non-military facilities) that included diagnoses of malaria. A case of malaria was defined as an individual with 1) a reportable medical event record of confirmed malaria; 2) a hospitalization record with a primary diagnosis of malaria; 3) a hospitalization record with a nonprimary diagnosis of malaria due to a specific *Plasmodium* species; 4) a hospitalization record with a nonprimary diagnosis of malaria plus a diagnosis of anemia, thrombocytopenia and related conditions, or malaria complicating pregnancy in any diagnostic position; 5) a hospitalization record with a nonprimary diagnosis of malaria plus diagnoses of signs or symptoms consistent with malaria in each diagnostic position antecedent to malaria;[26] or 6) a positive malaria antigen test plus an outpatient record with a diagnosis of malaria in any diagnostic position within 30 days of the specimen collection date. The relevant International Classification of Diseases, 9th and 10th Revision (ICD-9 and ICD-10, respectively) codes are shown in **Table 1**. Laboratory data for malaria were provided by the Navy and Marine Corps Public Health Center.

This analysis allowed 1 episode of malaria per service member per 365-day period. When multiple records documented a single episode, the date of the earliest encounter was considered the date of clinical onset, and the most specific diagnosis recorded within 30 days of the incident diagnosis was used to classify the *Plasmodium* species.

Presumed locations of malaria acquisition were estimated using a hierarchical algorithm: 1) cases diagnosed in a malarious country were considered acquired in that country, 2) reportable medical events that listed exposures to malaria-endemic locations were considered acquired in those locations, 3) reportable medical events that did not list exposures to malaria-endemic locations but were reported from installations in malaria-endemic locations were considered acquired in those locations, 4) cases diagnosed among service members during or within 30 days of deployment or assignment to a malarious country were considered acquired in that country, and 5) cases diagnosed among service members who had been deployed or assigned to a malarious country within 2 years before diagnosis were considered acquired in those respective countries. All remaining cases were considered to have acquired malaria in unknown locations.

TABLE 1. ICD-9 and ICD-10 diagnosis codes used in defining cases of malaria from the records for inpatient encounters (hospitalizations)

	ICD-9	ICD-10
Malaria (*Plasmodium* species)		
P. falciparum	84.0	B50
P. vivax	84.1	B51
P. malariae	84.2	B52
P. ovale	84.3	B53.0
Unspecified	84.4, 84.5, 84.6, 84.8, 84.9	B53.1, B53.8, B54
Anemia	280–285	D50–D53, D55–D64
Thrombocytopenia	287	D69
Malaria complicating pregnancy	647.4	O98.6
Signs, symptoms, or other abnormalities consistent with malaria	276.2, 518.82, 584.9, 723.1, 724.2, 780.0, 780.01, 780.02, 780.03, 780.09, 780.1, 780.3, 780.31, 780.32, 780.33, 780.39, 780.6, 780.60, 780.61, 780.64, 780.65, 780.7, 780.71, 780.72, 780.79, 780.97, 782.4, 784.0, 786.05, 786.09, 786.2, 786.52, 786.59, 787.0, 787.01, 787.02, 787.03, 787.04, 789.2, 790.4	E87.2, J80, M54.2, M54.5, N17.9, R05, R06.0, R06.89, R07.1, R07.81, R07.82, R07.89, R11, R11.0, R11.1, R11.2, R16.1, R17, R40, R41.0, R41.82, R44, R50, R51, G44.1, R53, R56, R68.0, R68.83, R74.0

ICD-9, International Classification of Diseases, 9th Revision; ICD-10, International Classification of Diseases, 10th Revision.

RESULTS

In 2021, a total of 20 service members were diagnosed with or reported to have malaria **(Table 2)**. This total was the lowest number of cases in any given year during the surveillance period and represents a 28.6% decrease from the 28 cases identified in 2020 **(Figure 1)**. Over half of the cases of malaria in 2021 were caused by *P. falciparum* (55.0%; n=11). Of the 9 cases in 2021 not attributed to *P. falciparum*, 1 (5.0%) was identified as due to *P. vivax* and 8 were labeled as associated with other/unspecified types of malaria (40.0%). Malaria cases caused by *P. falciparum* accounted for the most cases (n=158; 39.2%) during the 10-year surveillance period **(Figure 1)**. Similar to 2020, the majority of U.S. military members diagnosed with malaria in 2021 were male (100.0%), active component members (90.0%), and in the Army (70.0%). In 2021, service members in their 30s (55.0%) accounted for the most cases of malaria **(Table 2)**.

TABLE 2. Malaria cases by *Plasmodium* species and selected demographic characteristics, active and reserve components, U.S. Armed Forces, 2021

	P. vivax	*P. falciparum*	Other/ unspecified	Total	% total
Total	1	11	8	20	100.0
Component					
Active	1	11	6	18	90.0
Reserve/Guard	0	0	2	2	10.0
Service					
Army	1	7	6	14	70.0
Navy	0	2	1	3	15.0
Air Force	0	1	1	2	10.0
Marine Corps	0	1	0	1	5.0
Sex					
Male	1	11	8	20	100.0
Female	0	0	0	0	0.0
Age group (years)					
<20	0	0	0	0	0.0
20–24	0	1	3	4	20.0
25–29	1	1	2	4	20.0
30–34	0	4	1	5	25.0
35–39	0	4	2	6	30.0
40–44	0	1	0	1	5.0
45–49	0	0	0	0	0.0
50+	0	0	0	0	0.0
Race/ethnicity group					
Non-Hispanic White	0	4	3	7	35.0
Non-Hispanic Black	1	7	4	12	60.0
Other/unknown	0	0	1	1	5.0

Of the 20 malaria cases in 2021, more than half (55.0%; n=11) were attributed to Africa; 15.0% (n=3) were attributed to Korea, and no infections were considered to have been acquired in Afghanistan or South/Central America **(Figure 2)**. The remaining cases could not be associated with a known, specific location (30.0%; n=6). Of the 11 malaria infections considered acquired in Africa in 2021, 3 were linked to Djibouti; 2 were linked to unknown African locations, and 1 each were linked to Chad, Cameroon, Ghana, Ivory Coast, Sierra Leone, and Nigeria **(data not shown)**.

During 2021, malaria cases were diagnosed or reported from 18 different medical facilities in the U.S., Germany, and Africa **(Table 3)**. Only 10.2% (n=2) of the total cases with a known location of diagnosis were reported from or diagnosed outside the U.S.

In 2021, the percentage of malaria cases that were acquired in Africa (55.0%; n=11) increased from 2020 (20.0%) and was the highest during the surveillance period **(Figure 2)**. The percentage of malaria cases acquired in Korea (15.0%; n=3) in 2021 was similar to the percentage in 2020 (14.3%).

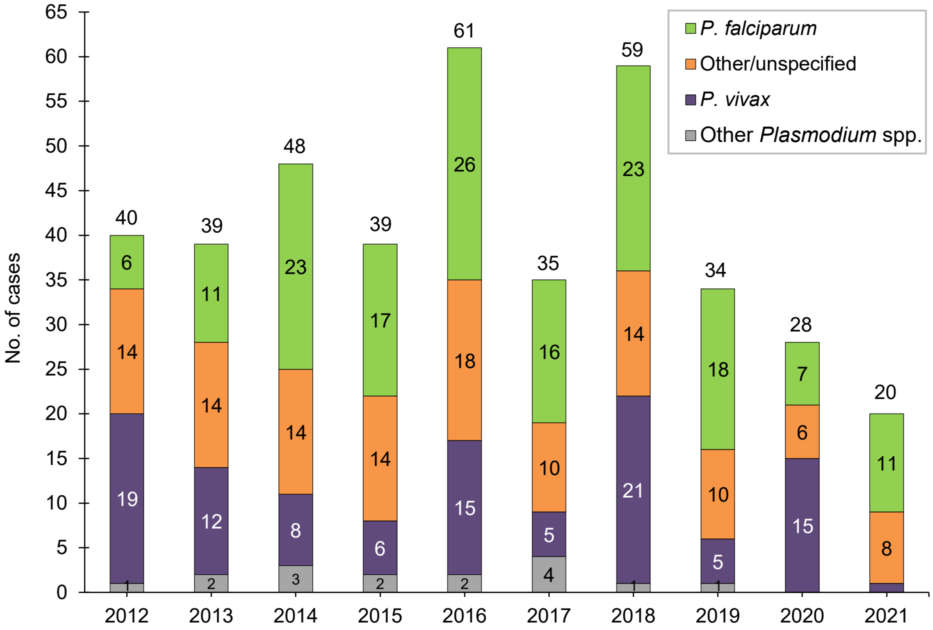
Between 2012 and 2021, the majority of malaria cases were diagnosed or reported during the 6 months from the middle of spring through the middle of autumn in the Northern Hemisphere **(Figure 3)**. In 2021, 65.0% (n=13) of malaria cases among U.S. service members were diagnosed during May–October **(data not shown)**. This proportion is lower than the 72.5% (292/403) of cases diagnosed during the same 6-month intervals over the entire 10-year surveillance period. During 2012–2021, the proportions of malaria cases diagnosed or reported during May–October varied by region of acquisition: Korea (90.2%; 55/61); Afghanistan (79.8%; 83/104); Africa (65.5%; 95/145); and South/Central America (50.0%; 2/4) **(data not shown)**.

EDITORIAL COMMENT

MSMR annual reports on malaria incidence among all U.S. services began in 2007. The current report documents that the number of malaria cases in 2021 decreased from 2020 and was the lowest of any of the previous years in the 2012–2021 surveillance period. Most of the marked decline in the past 9 years is attributable to the decrease in numbers of malaria cases associated with service in Afghanistan. No cases were considered to have been acquired in Afghanistan in 2021. The dominant factor in that trend has undoubtedly been the progressive withdrawal of U.S. forces from that country.

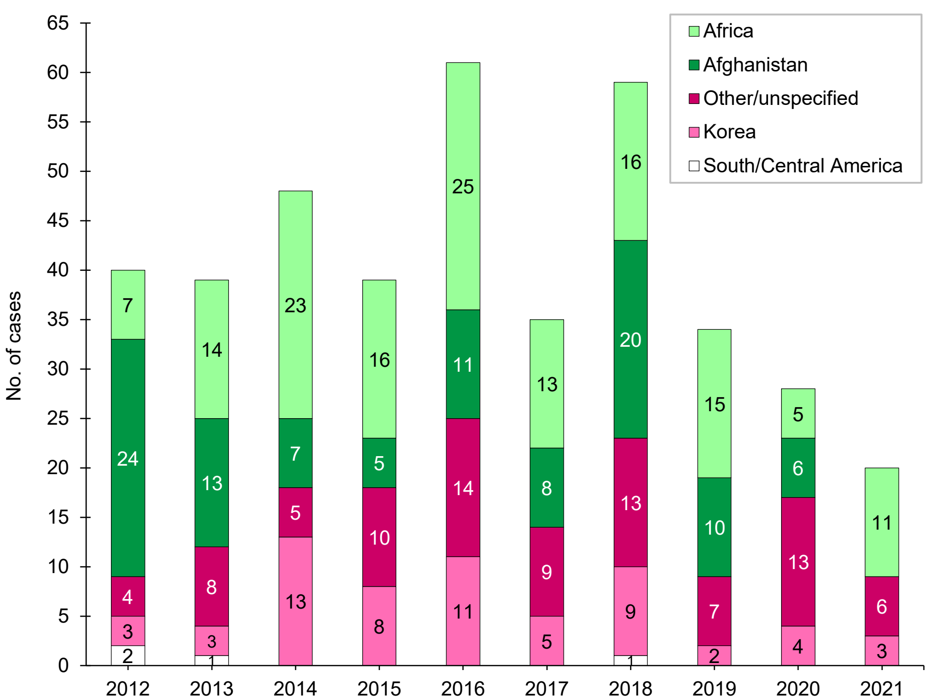
This report also documents the fluctuating incidence of acquisition of malaria in Africa and Korea among U.S. military members during the past decade. The 2021 percentage of cases caused by *P. falciparum* (55.5%) was the highest of any year of the surveillance period. This shift is most likely a result of the decrease in cases in Korea and Afghanistan where the predominant species of malaria has been *P. vivax*.

FIGURE 1. Numbers of malaria cases, by *Plasmodium* species and calendar year of diagnosis or report, active and reserve components, U.S. Armed Forces, 2021–2021



No., number

FIGURE 2. Annual numbers of cases of malaria cases, by location of acquisition, U.S. Armed Forces, 2012–2021



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Malaria caused by the more dangerous *P. falciparum* species is of primary concern in Africa. The planning and execution of military operations on the African continent must incorporate actions to counter the threat of infection by that potentially deadly parasite wherever it is endemic. The 2014–2015 employment of U.S. service members to aid in the response to the Ebola virus outbreak in West Africa is an example of an operation where the risk of *P. falciparum* malaria was significant.[19,27] The finding that *P. falciparum* malaria was diagnosed in more than half of the cases in 2021 further underscores the need for continued emphasis on prevention of this disease, given its potential severity and risk of death. Moreover, a recent article noted the possibility of false negative results for *P. falciparum* on the rapid diagnostic tests favored by units in resource-limited or austere locations.[28] Although additional research is needed, commanders and unit leaders may need to be extra vigilant with forces that are far forward.

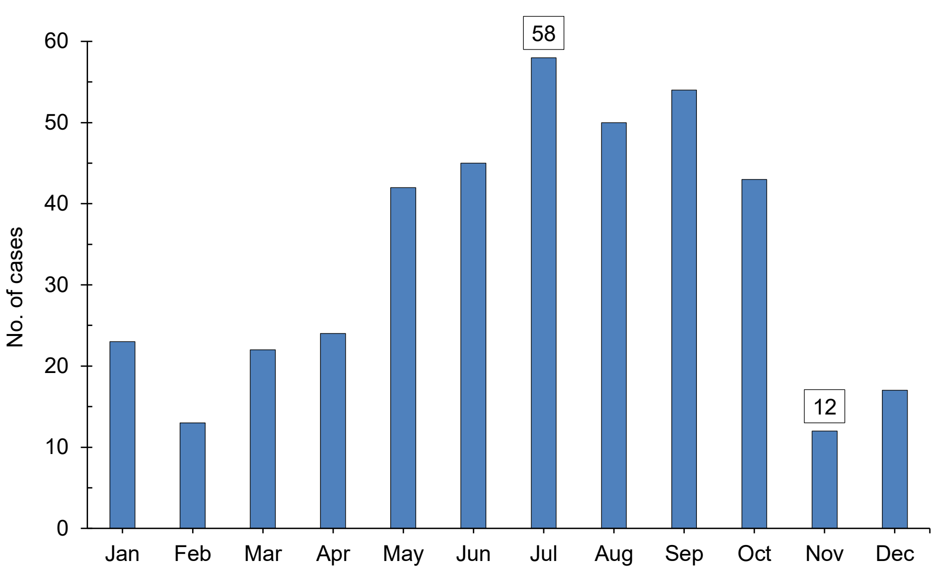
The observations about the seasonality of diagnoses of malaria are compatible with the presumption that the risk of acquiring and developing symptoms of malaria in a temperate climatic zone of the Northern Hemisphere would be greatest during May–October. Given the typical incubation periods of malaria infection (approximately 9–14 days for *P. falciparum*, 12–18 days for *P. vivax* and *P. ovale*, and 18–40 days for *P. malariae*)[26] and the seasonal disappearance of biting mosquitoes during the winter, most malaria acquired in Korea and Afghanistan would be expected to cause symptoms during the warmer months of the year. However, it should be noted that studies of *P. vivax* malaria in Korea have found that the time between primary infection and clinical illness among different *P. vivax* strains ranges between 8 days and 8–13 months and that as many as 40–50% of infected individuals may not manifest the symptoms of their primary illness until 6–11 months after infection.[29,30] Klein and colleagues reported a cluster of 11 U.S. soldiers with *P. vivax* malaria who were likely infected at a training area located near the southern border of the demilitarized zone in 2015.[31] Nine of the malaria cases developed their first symptoms of infection 9

TABLE 3. Number of malaria cases, by geographical locations of diagnosis or report and presumed location of acquisition, active and reserves components, U.S. Armed Forces, 2021

Location where diagnosed or reported	Korea	Afghanistan	Africa	South/ Central America	Other/ unknown location	Total	
	No.	No.	No.	No.	No.	No.	%
NMC, San Diego, CA	0	0	1	0	1	2	10.0
Carl R. Darnall AMC, Fort Hood, TX	0	0	2	0	0	2	10.0
412th Medical Group, Edwards AFB, CA	0	0	1	0	0	1	5.0
96th Medical Group, Eglin AFB, FL	1	0	0	0	0	1	5.0
Dwight D. Eisenhower AMC, Fort Gordon, GA	0	0	0	0	1	1	5.0
Winn ACH, Fort Stewart, GA	0	0	1	0	0	1	5.0
Tripler AMC, HI	0	0	0	0	1	1	5.0
Blanchfield ACH, Fort Campbell, KY	0	0	0	0	1	1	5.0
Bayne-Jones ACH, Fort Polk, LA	1	0	0	0	0	1	5.0
Walter Reed National Military Medical Center, MD	0	0	1	0	0	1	5.0
Womack AMC, Fort Bragg, NC	0	0	1	0	0	1	5.0
NMC, Camp Lejeune, NC	0	0	1	0	0	1	5.0
Hohenfels AHC, Germany	0	0	1	0	0	1	5.0
Conner Troop Medical Clinic, Fort Drum, NY	0	0	0	0	1	1	5.0
Clark Clinic, Fort Bragg, NC	0	0	0	0	1	1	5.0
Farrelly Health Clinic, Irwin ACH, Fort Riley, KS	1	0	0	0	0	1	5.0
Expeditionary Medical Facility, Djibouti	0	0	1	0	0	1	5.0
Location not reported	0	0	1	0	0	1	5.0

NMC, Navy Medical Center; AMC, Army Medical Center; AFB, Air Force Base; ACH, Army Community Hospital

FIGURE 3. Cumulative numbers of diagnoses and reported cases of malaria, by month of clinical presentation or diagnosis, U.S. Armed Forces, January 2012–December 2021



No., number

or more months after exposure and after their departure from Korea.[31] Transmission of malaria in tropical regions such as sub-Saharan Africa is less subject to the limitations of the seasons as in temperate climates but depends more on other factors affecting mosquito breeding such as the timing of the rainy season and altitude (below 2,000 meters).[32]

There are significant limitations to this report that should be considered when interpreting the findings. For example, the ascertainment of malaria cases is likely incomplete; some cases treated in deployed or non-U.S. military medical facilities may not have been reported or otherwise ascertained at the time of this analysis. Furthermore, it should be noted that medical data from sites that used the new electronic health record for the Military Health

System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter data for individuals seeking care at any of these facilities from July 2017 and through 2019 were not included in the current analysis.

Diagnoses of malaria that were documented only in outpatient settings without records of a positive malaria antigen test and that were not reported as notifiable events were not included as cases. Also, the locations of infection acquisitions were estimated from reported relevant information. Some cases had reported exposures in multiple malarious areas, and others had no relevant exposure information. Personal travel to or military activities in malaria-endemic countries were not accounted for unless specified in notifiable event reports.

As in prior years, in 2021 most malaria cases among U.S. military members were treated at medical facilities remote from malaria endemic areas. Providers of acute medical care to service members (in both garrison and deployed settings) should be knowledgeable of and vigilant for the early clinical manifestations of malaria among service members who are or were recently in malaria-endemic areas. Care providers should also be capable of diagnosing malaria (or have access to a clinical laboratory that is proficient in malaria diagnosis) and initiating treatment (particularly when *P. falciparum* malaria is clinically suspected).

Continued emphasis on adherence to standard malaria prevention protocols is warranted for all military members at risk of malaria. Personal protective measures against malaria include the proper wear of permethrin-treated uniforms and the use of permethrin-treated bed nets; the topical use of military-issued, DEET-containing insect repellent; and compliance with prescribed chemoprophylactic drugs before, during, and after times of exposure in malarious areas. Current Department of Defense guidance about medications for prophylaxis of malaria summarizes the roles of chloroquine, atovaquone-proguanil, doxycycline, mefloquine, primaquine, and tafenoquine.[33,34]

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Obesity Prevalence Among Active Component Service Members Prior to and During the COVID-19 Pandemic, January 2018–July 2021

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This study examined monthly prevalence of obesity and exercise in active component U.S. military members prior to and during the COVID-19 pandemic. Information about obesity (BMI≥30) and self-reported vigorous exercise (≥150 minutes per week) were collected from Periodic Health Assessment (PHA) data. From 1 January 2018 through 31 July 2021, there was a gradual increase in obesity and an overall decrease in vigorous exercise. Comparing the mean monthly percentage of obesity during the 12-month period prior to the pandemic to the 12 months after its start showed an overall increase in obesity (0.43%); however, no obvious spike in the obesity trend was apparent following the onset of the pandemic. The prevalence of vigorous exercise showed an abrupt decrease following the onset of the COVID-19 pandemic, but this change did not coincide with an abrupt change in the obesity trend. These results suggest that the COVID-19 pandemic had a small effect on the trend of obesity in the active component U.S. military and that obesity prevalence continues to increase.

WHAT ARE THE NEW FINDINGS?

The prevalence of obesity in the military, as measured by the PHA, had been increasing prior to the pandemic and has continued to do so since the start of the pandemic. However, the onset of COVID-19 and the decline in self-reported exercise behaviors did not appear to have a large impact on the magnitude of the increasing trend in obesity prevalence.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Understanding the impacts of COVID-19 lockdowns on fitness and health could assist in guiding policies to maintain health and readiness should future pandemics or societal disruptions occur.

The increasing prevalence of obesity is a major problem affecting the overall and long-term health of the U.S. population. During 2017–2018, 42.4% of all U.S. adults met the threshold for obesity and 9.2% were classified as severely obese compared to 30.5% and 4.7% in 1999–2000, respectively.[1] Obesity is responsible for an estimated $190 billion in excess medical costs and over 100,000 preventable cancer cases each year.[2,3]

The worsening trend of weight gain in the American public has also been reflected within the armed services. The overall prevalence of obesity within the active component increased from 16.3% in 2015 to 17.9% in 2019.[4] As per Department of Defense Directive No. 1308.1, "Maintaining desirable body composition is an integral part of physical fitness, general health, and military appearance".[5] Not only does obesity within the military ranks negatively impact the professional perception of the military, it also compromises its readiness and leads to functional limitations. For example, incidence of musculoskeletal injuries,[6] excess health care utilization, and 90 day attrition have been found to be higher in overweight and obese service members and military recruits.[7,8] In addition to various adverse physical effects, obesity is associated with multiple mental health disorders including depression, anxiety, and substance abuse disorders.[9,10]

The onset of the COVID-19 pandemic in March 2020[11] led to significant restrictions in activities that may have further exacerbated the worsening problem of obesity within the active military. This study sought to explore trends in population-level prevalence of obesity within the active component U.S. military population before and after the start of the COVID-19 pandemic. Investigations of the general public during COVID-19 have shown that members of certain demographic groups (race, ethnicity, age, and income) were more susceptible to weight gain during pandemic lockdowns.[12] As pandemic and lockdown events continue to be a concern into the foreseeable future, evaluating multiple covariates within this population may help to identify certain groups that are more susceptible to weight gain under these conditions. Insight into this subject within the U.S. military could help inform the development of systems that maintain health and military readiness should any future societal disruptions occur.

For many reasons, the pandemic may have influenced obesity prevalence; they include halting of daily unit physical training, deferred physical fitness testing, and stay at home orders restricting non-essential movement. Not surprisingly, previous investigations into the overweight or obesity status of military personnel have shown vigorous exercise to be inversely associated with obesity,[13] but there are other factors like overeating and stress that may have had an impact on service members' weights during this time.

Reducing attrition and retaining personnel is a constant problem for the armed services. Almost three-quarters (71%) of young adults in the U.S. between the ages of 17 and 24 do not meet requirements for military service because of inadequate educational attainment, overweight/obesity and other physical conditions, or history of criminal activity or illicit drug use.[14] This concerning statistic highlights the importance of retaining qualified personnel, as the pool of qualified candidates has become increasingly smaller over time.

The overall objective of this study was to assess the relationship between COVID-19 and obesity prevalence in active component U.S. military members via 3 aims. The first aim was to determine the prevalence of obesity before and after the start of the COVID-19 pandemic. The second aim was to evaluate the trend of service member self-reported vigorous exercise during the COVID-19 pandemic. The third aim was to identify how many service members were separated from service due to obesity, with the goal of gauging the recent impact of obesity on attrition in the active component U.S. military and potentially identifying areas of focus to reduce weight gain and aid in service member retention.

METHODS

The study population for this investigation included active component U.S. military members in the Army, Navy, Air Force, and Marine Corps who completed a Periodic Health Assessment (PHA) between 1 January 2018 and 31 July 2021. PHA and demographic data were obtained from the Defense Medical Surveillance System (DMSS), which serves as the central repository of medical surveillance data for the U.S. Armed Forces. Women with a pregnancy/birth-related diagnosis (International Classification of Diseases, 10th Revision [ICD-10] code beginning with "O") in any diagnostic position in a record of an inpatient or outpatient encounter within 9 months of the date that their weight was recorded were excluded. Duplicate PHAs or those with listed weight more than 1 year old were also excluded.

Each service member is required to complete a PHA annually. Height (recorded in inches) and weight (recorded in pounds) data were obtained from Section II questions 2 and 3 of the PHA and are recorded by the service provider at the time of the PHA encounter, or derived from the patient medical record. Height and weight were subsequently used to calculate body mass index (BMI) using the formula: weight (lb) x 703/[height (in)]^2.[15] A service member with a BMI ≥30 was classified as obese.[16] Records where weight was less than 40 lb or greater than 370 lb, height was less than 30 inches or greater than 100 inches, and where BMI was less than 12 or greater than 45 were excluded, as these measurements were assumed to be data entry errors.

Monthly PHA data on physical activity were obtained from the results of section VII question 6: "In a typical week, I do VIGOROUS physical activities (VIGOROUS activities cause HEAVY sweating or LARGE increases in breathing or heart rate) __ Days per week; __ Minutes per day on the days you do work out". Minutes per day of vigorous exercise was multiplied by days exercised per week to determine total minutes per week of vigorous exercise. All military service members are expected to exercise 5 days a week as part of their duty requirements. For the purpose of this study, those service members endorsing 30 minutes of vigorous intensity exercise 5 times a week (totaling 150 minutes) were considered to have met vigorous exercise requirements. Service members on a profile limiting their ability to participate fully in a physical fitness test were identified by a "yes" response on section IV question 8.a. of the PHA "Do you currently have a waiver or profile for any part of your Service's physical fitness test?"

DMSS data were used to identify individuals separated from service using interservice separation codes (ISC) 1017 and 2017 (failure to meet weight or body fat standards). Those who had their weight recorded between 1 January 2018 and 31 December 2019 and were classified as obese were followed through the latest date that separation data were available, which was 31 August 2021 at the time of the analysis. In addition, the median number of days since diagnosis of obesity was summarized and stratified by sex, age group, military service branch, race/ethnicity group, rank, marital status, education level, military occupation, geographic region at the time of the weight measurement, and whether the service member had a waiver or profile for any part of the physical fitness test reported at the time of the PHA.

To assess trends in prevalence of obesity within the active component U.S. military population before and during the COVID-19 pandemic, the prevalence of obesity for each month in the surveillance period was calculated using the date of the weight measurement. In addition, trends were stratified by presence of fitness test limiting profile and self-reported weekly vigorous exercise of at least 150 minutes/week. Among the service members who completed a PHA between 1 August 2020 and 31 July 2021, prevalence of obesity was calculated for each of the covariates of interest to determine which subgroups were more or less likely to be obese. Mean change in monthly prevalence of obesity was also calculated by subtracting the mean monthly obesity prevalence during the 1-year period prior to the declaration of the pandemic (March 2019–February 2020) from the 1-year period after the start of the pandemic (March 2020–February 2021).

RESULTS

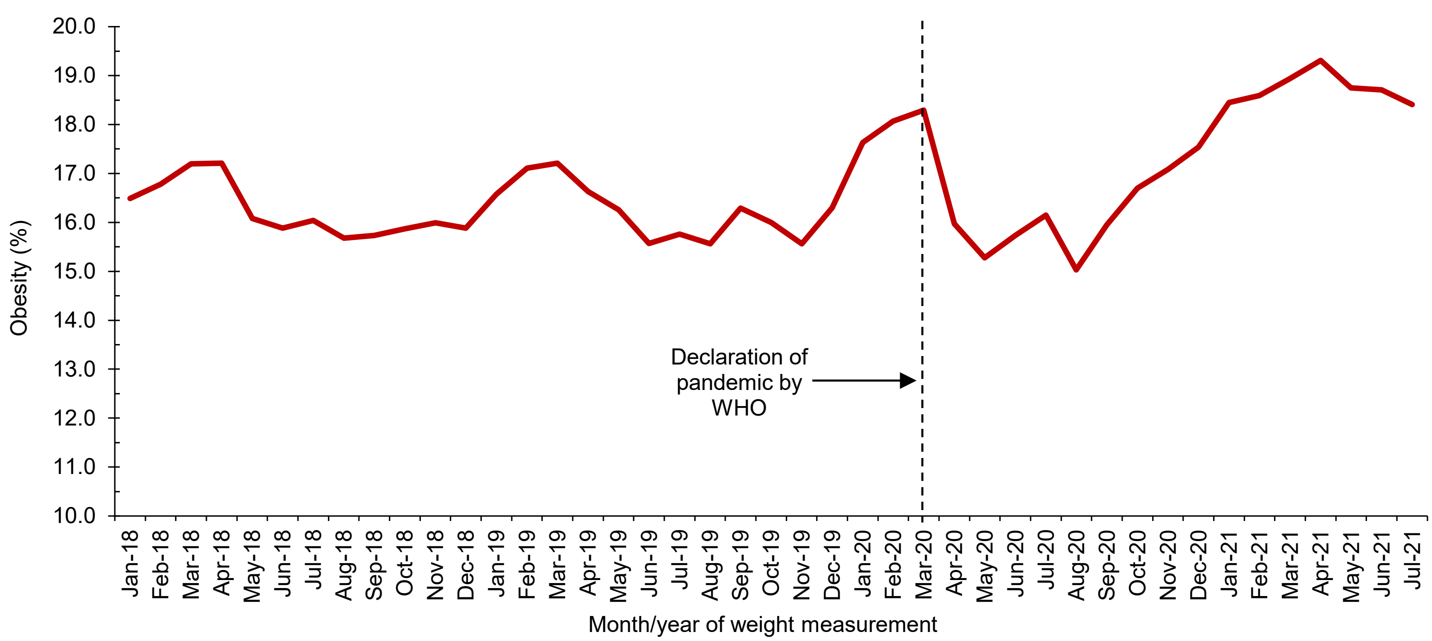
A total of 2,948,625 PHAs were completed from 1 January 2018 through 31 July 2021. Of these completed assessments, 315,960 (10.7%) contained missing or invalid BMI values and were excluded **(data not shown)**. The majority of PHAs (84.3%) were completed by male service members and 15.6% were completed by female service members, which closely approximates the sex distribution of the active component. The population of service members who completed PHAs during the surveillance period also closely approximated estimates of the active component overall in terms of marital status, education level, rank, and age.[17] However, the Navy was underrepresented in the population of service members who completed PHAs; Navy members made up 17.5% of the study population compared to 25.1% of the total population of active component service members in 2019.[17]

During the study period, the monthly prevalence of obesity ranged from a low of 15.0% in August 2020 to a high of 19.3% in April 2021 with substantial fluctuations by month throughout the period **(Figure 1)**. There was a 0.33% absolute increase in mean monthly obesity prevalence between the 12-month period prior to the pandemic and the 12 months after the start of the pandemic **(Table 1)**. Examination of the consecutive monthly absolute differences in obesity prevalence over time showed seasonal patterns with consecutive monthly increases in obesity prevalence generally occurring during winter months and consecutive monthly decreases tending to occur in summer months **(Figure 2)**. Among female service members, the absolute difference between the mean monthly obesity prevalence during the pandemic period and the pre-pandemic period was 0.90% compared to a 0.26% rise in men **(Table 1)**. Among the services, the Navy and Marine Corps demonstrated the largest absolute increase in mean monthly obesity prevalence from the pre-pandemic period to the pandemic period (0.78% and 0.77%, respectively). Compared to their respective counterparts, other relatively high absolute increases in mean monthly obesity prevalence occurred among service members aged 40 years or older (0.82%), non-Hispanic Black service members (0.48%), junior enlisted members (0.62%), those with "other" marital status (0.75%), and those with an occupation in motor transport (0.75%) **(Table 1)**.

The percentage of active component service members reporting vigorous exercise fluctuated throughout the surveillance period and did not coincide with a shift in the overall obesity trend **(Figure 3)**. Evaluation of the consecutive monthly absolute differences in vigorous exercise over time showed seasonal patterns where vigorous exercise prevalence tended to have consecutive monthly increases beginning in early spring and consecutive monthly decreases beginning in early fall **(Figure 4)**. Comparison of the average monthly prevalence of vigorous exercise in the 12 months before and after the start of the pandemic demonstrated that vigorous exercise decreased variably across the service branches with the Navy showing the greatest absolute decrease of 5.2% **(Table 2)**. Active component service members in combat-specific occupations displayed fewer fluctuations over time in the percentages meeeting the vigorous exercise requirement compared to those in other occupational groups **(Figure 5)**. Exercise trends by age group, rank, sex, race/ethnicity group, and service branch were similar throughout the surveillance period **(data not shown)**.

A total of 878 service members (0.46%) who had their weight measured between 1 January 2018 and 31 December 2019 were separated from service by August 2021 for failure to meet weight or body fat standards **(Table 3)**. The median time from being classified as obese to separation from military service was 324 days. Higher percentages of obese active component service members aged 18–20 (2.35%) and 20–24 (1.30%) were separated because of obesity compared to older service members, especially those aged 40 or older (0.02%). Junior enlisted personnel were more likely to be separated for obesity (1.39%) compared to senior enlisted (0.12%) or junior officers (0.05%), and there were no senior officers (O4–O10) or warrant officers separated during the study period. Army and Marine Corps members were more likely to be separated for obesity, at 1.04% and 0.93%, respectively, compared to <0.01% in the Air Force and the Navy.

FIGURE 1. Obesity prevalence among active component service members who completed PHAs, U.S. Armed Forces, January 2018–July 2021



PHA, Periodic Health Assessment; WHO, World Health Organization.

TABLE 1. Percentage of active component service members who completed PHAs[a] and were classified as obese, by demographic and military characteristics

	No.	Total	Prevalence[a] (%)	Change in prevalence[b]
Total	119,650	687,818	17.4	0.33
Sex				
Male	104,284	572,869	18.2	0.26
Female	15,366	114,949	13.4	0.90
Age group (years)				
18–<20	1,230	34,213	3.6	0.39
20–24	22,877	211,656	10.8	0.45
25–29	28,569	167,016	17.1	0.29
30–34	24,918	115,704	21.5	0.34
35–39	23,187	88,607	26.2	0.22
40+	18,869	70,622	26.7	0.82
Race/ethnicity group				
Non-Hispanic White	58,253	384,031	15.2	0.24
Non-Hispanic Black	25,984	110,766	23.5	0.48
Hispanic	21,950	116,206	18.9	0.20
Other/unknown	13,463	76,815	17.5	0.47
Education level				
High school or less	68,363	412,346	16.6	0.41
Some College	22,467	94,303	23.8	0.65
Bachelor's or advanced degree	27,271	170,153	16.0	0.21
Other/unknown	1,549	11,016	14.1	-0.42
Marital status				
Single, never married	33,292	289,523	11.5	0.55
Married	78,417	361,188	21.7	0.40
Other	7,941	37,107	21.4	0.75
Service				
Army	47,580	271,441	17.5	0.41
Navy	32,234	120,562	26.7	0.78
Air Force	33,383	219,145	15.2	0.32
Marine Corps	6,453	76,670	8.4	0.77
Grade				
Junior enlisted (E1–E4)	32,262	272,020	11.9	0.62
Senior enlisted (E5–E9)	70,149	284,964	24.6	0.36
Warrant officer	2,153	10,047	21.4	-0.42
Junior officer (O1–O3)	7,336	74,131	9.9	-0.31
Senior officer (O4–O10)	7,750	46,656	16.6	0.22
Military occupation				
Combat-specific[c]	14,317	97,103	14.7	0.10
Motor transport	3,205	18,293	17.5	0.75
Pilot/air crew	3,877	31,377	12.4	0.44
Repair/engineering	39,217	198,973	19.7	0.07
Communications/intelligence	27,350	150,686	18.2	0.50
Health care	12,408	70,592	17.6	0.72
Other/unknown	19,276	120,794	16.0	0.63
Region				
Northeast	4,603	25,543	18.0	-0.90
Midwest	7,927	44,154	18.0	0.42
South	59,561	328,969	18.1	0.52
West	30,426	187,334	16.2	-0.03
Overseas	14,725	90,786	16.2	0.37
Unknown/missing	2,408	11,032	21.8	1.97
Has a waiver/profile for any part of physical fitness test at time of PHA				
Yes	20,658	61,702	33.5	0.42
No	98,968	625,922	15.8	0.76
Met vigorous exercise minimum				
Yes	60,575	361,163	16.8	-0.09
No	48,792	268,449	18.2	0.66

[a]Based on the most recent PHA completed between August 2020 and July 2021. PHAs were excluded if completed by a woman who had a pregnancy-related/birth-related diagnosis within 1 year of the weight measurement, if the PHA was completed more than 1 year from the date of the weight measurement, or if the BMI measurement was missing or invalid.
[b]Difference in mean monthly obesity from period from 1 March 2020 through 28 February 2021 (pandemic) and period from 1 March 2019 through 29 February 2020 (pre-pandemic).
[c]Infantry/artillery/combat engineering/armor.
No., number; PHA, Periodic Health Assessment; BMI, body mass index.

EDITORIAL COMMENT

The trends identified in this study suggest that the COVID-19 pandemic may have been associated with an increase in obesity prevalence among active component service members, but it was not an immediate abrupt jump in obesity prevalence. Instead, the steadily increasing trend of obesity that occurred prior to the pandemic continued with only a modest increase beginning in August 2020. Given the abrupt implementation of COVID-19 restrictions, which included the closing of gyms and parks, modification of many military base operations, as well as an increase in alcohol consumption, screen time, and decreased exercise among U.S. adults,[18] a larger increase in the prevalence of obesity might have been expected.

Examination of trends in the prevalence of obesity and percentages of active component service members meeting minimum exercise requirements revealed cyclical patterns. During the pre-pandemic period, obesity prevalence generally peaked in March and April followed by pronounced drops in the summer months. This pattern was even more pronounced after the start of the pandemic with obesity prevalence peaking in April 2021 at a level higher than at any point during in the pre-pandemic period.

A potential explanation for this pattern could be seasonal behaviors following the holiday and Permanent Change of Station (PCS) seasons that lead to service members gaining weight and subsequently dropping weight afterwards in order to pass biannual testing for height and weight. Prevalence of vigorous exercise, on the other hand, increased in the early spring and peaked at the start of fall, which may be reflective of changes in the ambient temperature and outdoor exercise conditions. Service members in combat-specific occupations, who are most strictly held to daily physical training regimens as part of their profession, showed the least seasonal change in exercise compared to other service members, further supporting this explanation.

There have been few studies in adults studying the longitudinal effects of the COVID-19 pandemic on obesity, but a

FIGURE 2. Monthly differences in obesity prevalence in the active component, U.S. Armed Forces, February 2018–July 2021

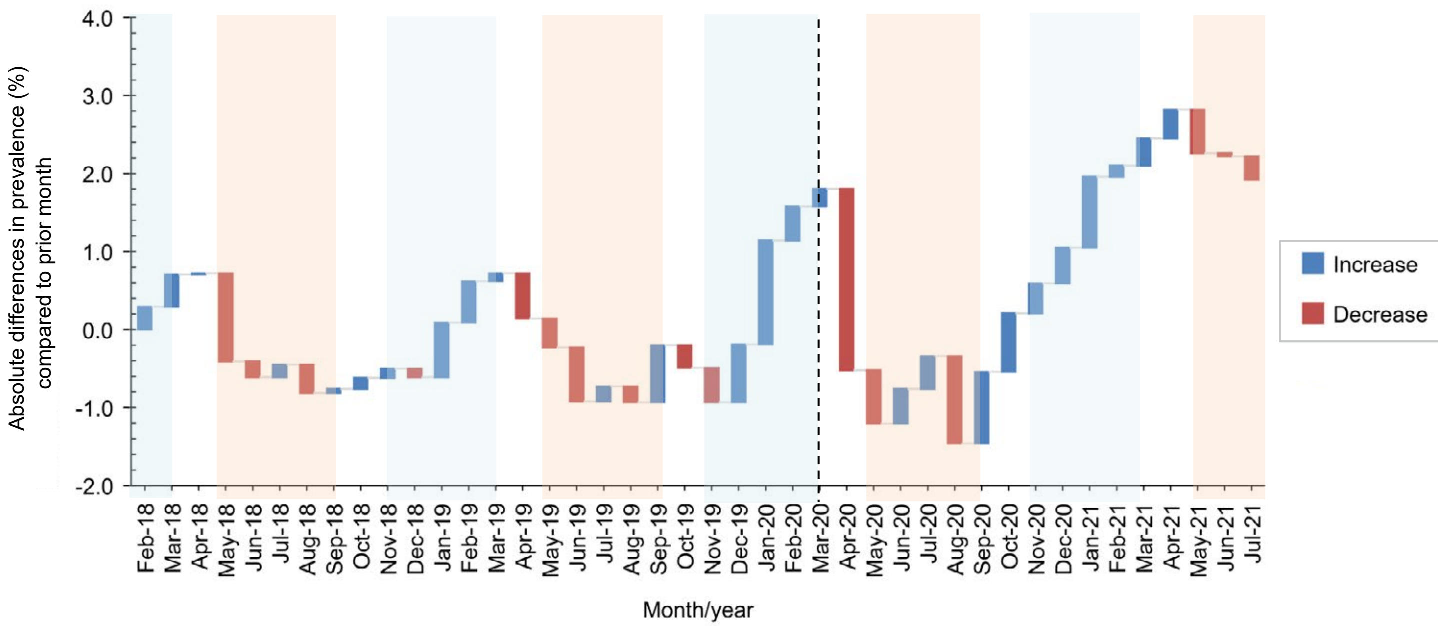
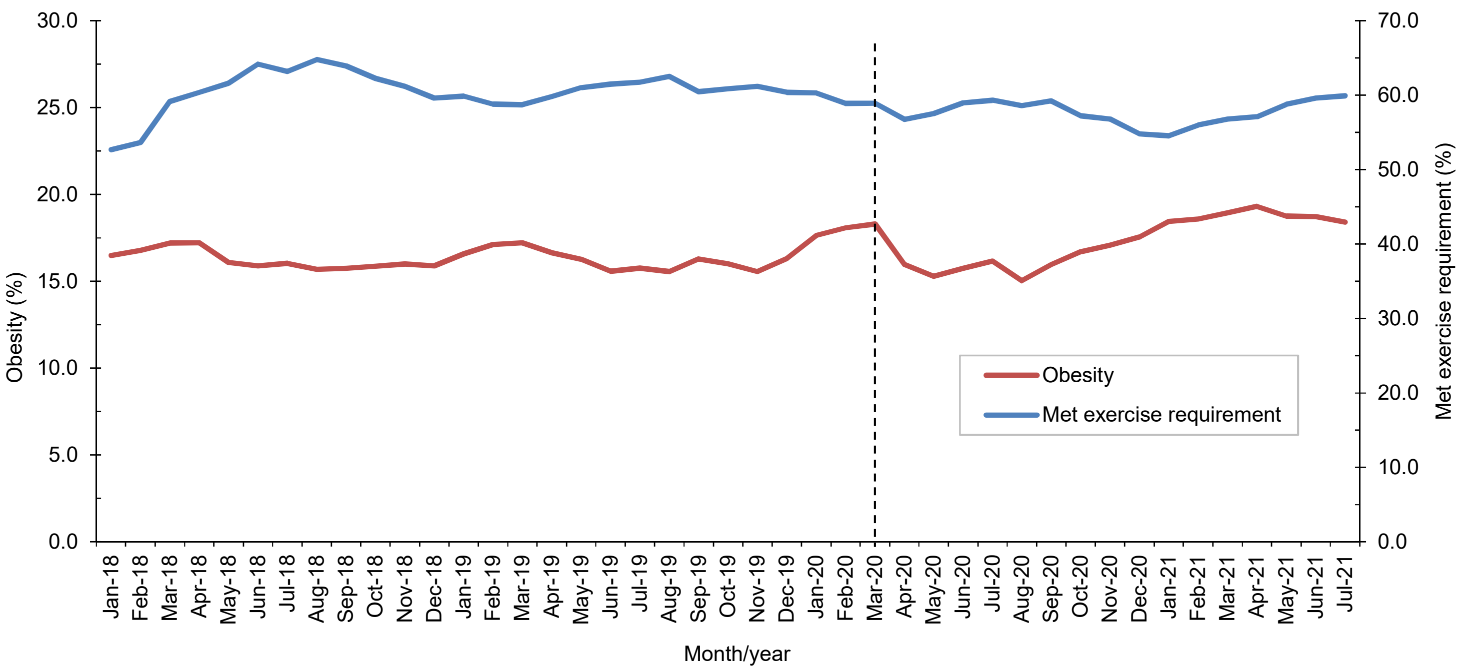


FIGURE 3. Obesity prevalence compared to prevalence of active component service members meeting vigorous exercise requirements, January 2018–July 2021



study of the civilian U.S. population evaluating 2–20 year-olds showed an increase in obesity in all age groups evaluated.[19] Though there are substantial differences in the ages and health profiles of these populations, this investigation showed similar findings with subjects in every age category showing increased prevalence of obesity secondary to the pandemic. Military members continue to maintain obesity levels well below their respective civilian counterparts;[1] however, the continued rise in obesity in the military is concerning.

Younger and lower ranking service members were more likely to be separated for failure to meet height/weight standards. One explanation for this could be that those service members who screened positive for obesity at an earlier point in their careers are more likely to fail verification via service-specific body measurements ("tape testing") compared to those who have served longer. It is also possible that higher ranking individuals with more time in service are less easily replaceable and therefore less likely to have this standard applied for separation due to manning concerns.

Considering they had just recently met height and weight standards to qualify for accession, this raises the possibility that better instilling good exercise and dietary habits in young service members could lead to better overall retention of this subgroup.

This is one of the first studies to evaluate obesity trends in the military in the context of COVID-19. However, there are several limitations that should be considered when interpreting the results. First, BMI calculations do not account for variability in body type or muscular composition, especially in a young athletic population; therefore, BMI measurements use can lead to misclassification bias in favor of obesity, but these instances are rare. More accurate reporting of obesity could be performed by using results from each service's follow-on body composition testing; however, these data were not available for this study. Second, service members' vigorous exercise results were based on self-reporting and did not include moderate exercise, so the estimates presented here may not be an accurate representation of total physical exertion.

Future studies could consider studying a retrospective cohort of service members who became obese during the pandemic to identify specific risk factors for weight gain, as this could help to elucidate trends that were difficult to detect on a population level via this study of cross-sectional monthly prevalence. Such a study design would allow for examination of factors like dietary intake, and alcohol and tobacco consumption, all of which may have changed during the pandemic.[18] The evidence of the cyclic trends of obesity and exercise also warrants further investigation as these patterns may reveal a failure to maintain accountability of service members' fitness outside of the times when physical fitness testing is performed. Identifying ways to improve consistent behaviors throughout the year may help to stem the increasing levels of obesity observed in the military. If this increasing obesity trend continues, current anti-obesity initiatives including utilization of wellness centers, dietary options in base dining facilities, and hours restricting access to exercise facilities should be re-examined to better tackle this problem.

TABLE 2. Percentage of active component service members who reported ≥150 minutes of vigorous physical activity on PHAs[a] by demographic and military characteristics

	No.	Total	Prevalence[a] (%)	Change in exercise[b]
All	361,320	630,083	57.3	-3.2
Sex				
Male	314,110	529,893	59.3	-3.1
Female	47,210	100,190	47.1	-3.6
Age group (years)				
18–<20	19,666	30,239	65.0	-1.9
20–24	118,889	189,780	62.6	-3.4
25–29	91,790	154,307	59.5	-3.2
30–34	58,539	108,385	54.0	-3.5
35–39	41,436	82,505	50.2	-3.5
40+	31,000	64,867	47.8	-2.3
Race/ethnicity group				
Non-Hispanic White	204,340	355,652	57.5	-3.1
Non-Hispanic Black	59,039	100,577	58.7	-3.6
Hispanic	61,840	105,513	58.6	-3.5
Other/unknown	36,101	68,341	52.8	-3.5
Education level				
High school or less	222,393	371,078	59.9	-3.3
Some college	46,806	88,064	53.1	-3.9
Bachelor's or advanced degree	87,127	160,923	54.1	-2.8
Other/unknown	4,994	10,018	49.9	-2.8
Marital status				
Single, never married	160,291	260,903	61.4	-3.1
Married	181,911	335,096	54.3	-3.4
Other	19,118	34,084	56.1	-3.2
Service				
Army	188,038	271,333	69.3	-2.7
Navy	44,867	98,832	45.4	-5.2
Air Force	88,366	192,245	46.0	-4.3
Marine Corps	40,049	67,673	59.2	-3.1
Grade				
Junior enlisted (E1–E4)	149,791	242,707	61.7	-3.4
Senior enlisted (E5–E9)	143,942	262,675	54.8	-3.3
Warrant	5,594	9,854	56.8	-2.6
Junior officer (O1–O3)	41,191	70,937	58.1	-3.3
Senior officer (O4–O10)	20,802	43,910	47.4	-2.0
Military occupation				
Combat-specific[c]	71,275	94,861	75.1	-1.3
Motor transport	10,243	16,687	61.4	-3.6
Pilot/air crew	13,838	29,648	46.7	-3.2
Repair/engineering	94,874	176,759	53.7	-4.3
Communications/intelligence	76,943	137,393	56.0	-3.4
Health care	33,599	64,821	51.8	-3.5
Other/unknown	60,548	109,914	55.1	-3.4
Region				
Northeast	15,062	23,989	62.8	-0.9
Midwest	21,739	40,229	54.0	-5.0
South	178,200	304,281	58.6	-3.2
West	95,747	169,541	56.5	-3.0
Overseas	46,072	82,854	55.6	-3.4
Unknown/missing	4,500	9,189	49.0	-6.7
Has a waiver/profile for any part of physical fitness test at time of PHA				
Yes	27,624	55,458	49.8	-2.4
No	333,649	574,534	58.1	-3.5

[a]Based on the most recent PHA completed between August 2020 and July 2021. PHAs were excluded if completed by a woman who had a pregnancy-related diagnosis within 1 year of the weight measurement, if the PHA was complete more than 1 year from the date of the weight measurement, if the BMI measurement was missing or invalid, or if the response to the vigorous excercise question was missing
[b]Difference in vigorous exercise from period from 1 March 2020 through 28 February 2021 (pandemic) and period from 1 March 2019 through 29 February 2020 (pre-pandemic).
[c]Infantry/artillery/combat engineering/armor.
No., number; PHA, Periodic Health Assessment.

FIGURE 4. Monthly absolute differences in prevalence of active component service members meeting vigorous exercise requirement, February 2018–July 2021

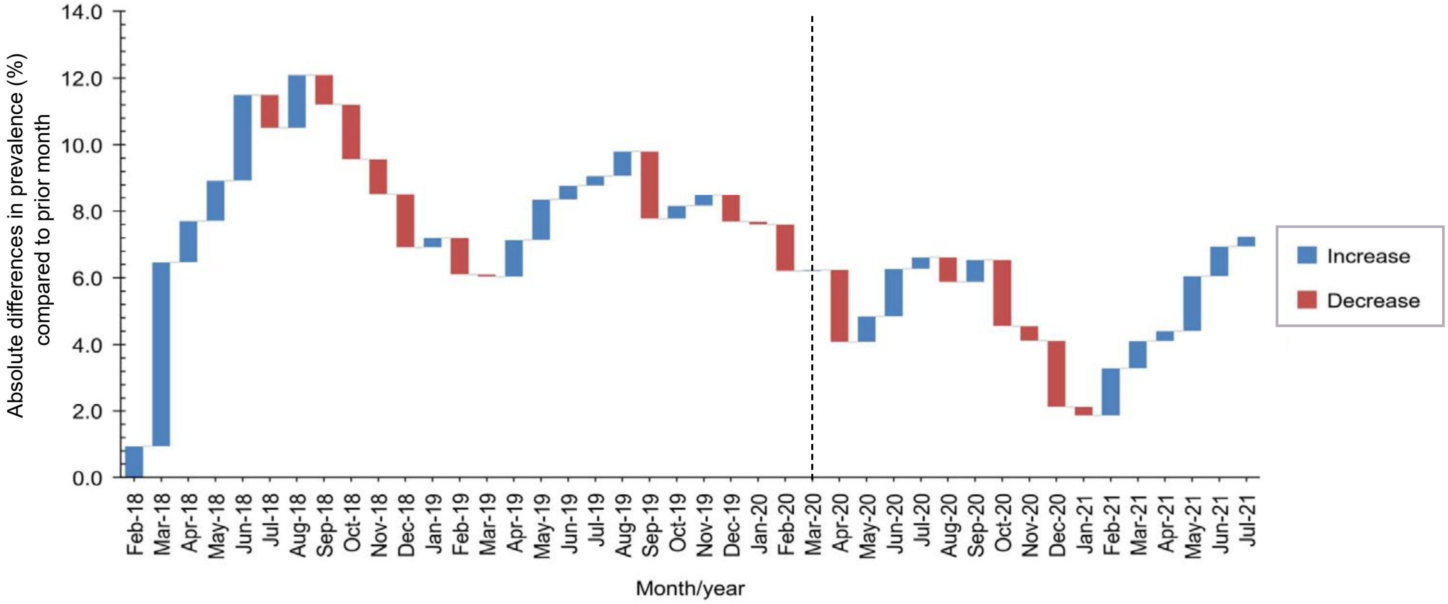
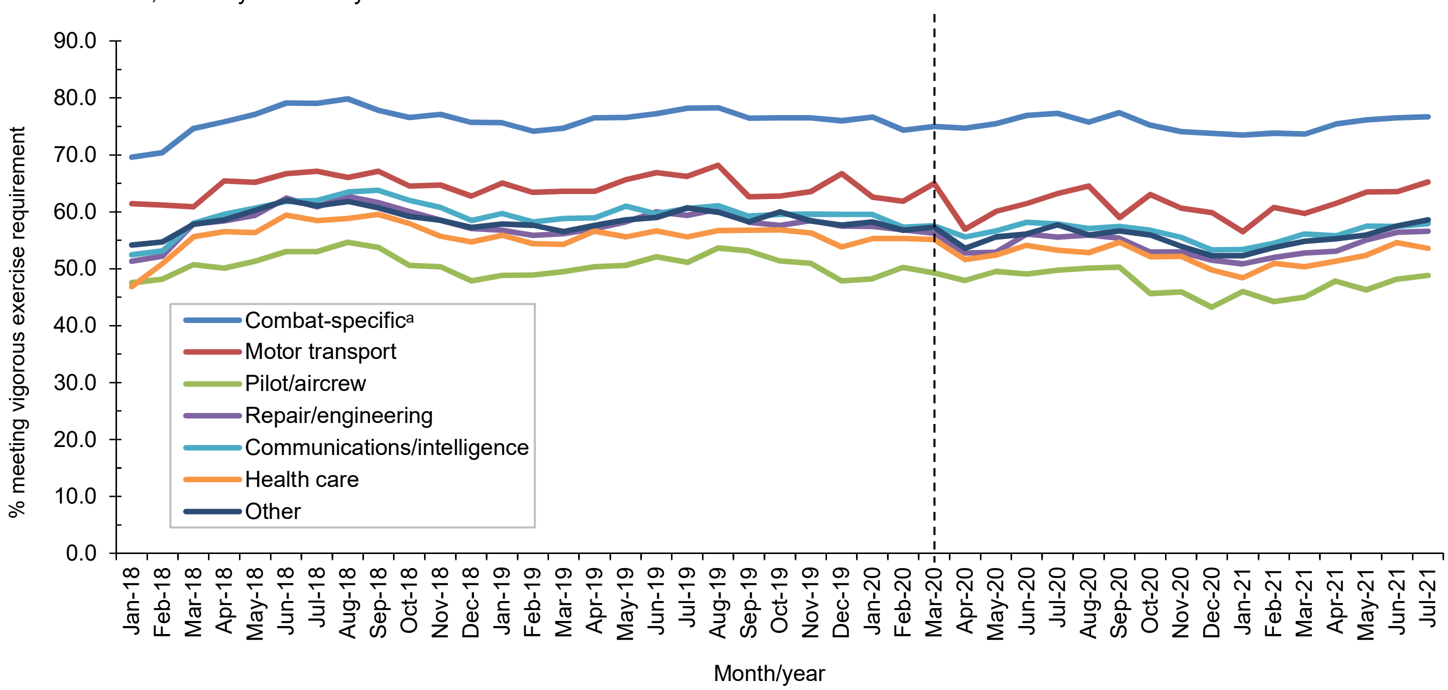


FIGURE 5. Percentages of active component service members who reported meeting the vigorous exercise requirement[a] on the PHA, U.S. Armed Forces, January 2018–July 2021



[a]≥150 minutes of vigorous physical activity in a typical week.
[b]Infantry/artillery/combat engineering.

Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect the official policy of the Department of Defense or the U.S. Government.

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TABLE 3. Obese service members who were subsequently separated for failure to meet weight or body fat standards, active component service members with a BMI measurement classifying them as obese during 1 January 2018–31 December 2019

	No. separated	Total	%	Median no. days to separation
Total	878	192,273	0.46	324
Sex				
Male	791	170,356	0.46	331
Female	87	21,917	0.40	236
Age group (years)				
18–<20	61	2,598	2.35	484
20–24	497	38,317	1.30	307
25–29	232	45,408	0.51	338
30–34	64	39,623	0.16	330
35–39	18	36,333	0.05	445
40+	6	29,994	0.02	466
Race/ethnicity group				
Non-Hispanic White	464	96,439	0.48	313
Non-Hispanic Black	159	41,263	0.39	379
Hispanic	211	33,345	0.63	312
Other/unknown	44	21,226	0.21	393
Education level				
High school or less	801	108,649	0.74	315
Some College	52	37,604	0.14	416
Bachelor's or advanced degree	20	43,619	0.05	399
Other/unknown	5	2,401	0.21	537
Marital status				
Single, never married	490	51,555	0.95	340
Married	363	128,437	0.28	315
Other	25	12,281	0.20	211
Service				
Army	786	75,421	1.04	322
Navy	7	48,060	0.01	537
Air Force	1	59,745	0.00	122
Marine Corps	84	9,047	0.93	325
Rank				
Junior enlisted (E1–E4)	740	53,202	1.39	317
Senior enlisted (E5–E9)	131	109,078	0.12	361
Warrant	0	3,600	0.00	0
Junior officer (O1–O3)	7	12,930	0.05	537
Senior officer (O4–O10)	0	13,463	0.00	0
Military occupation				
Combat-specific[b]	154	21,514	0.72	264
Motor transport	38	4,760	0.80	277
Pilot/air crew	1	5,964	0.02	228
Repair/engineering	263	63,690	0.41	346
Communications/intelligence	221	44,260	0.50	340
Health care	69	19,037	0.36	445
Other/unknown	132	33,048	0.40	305
Region				
Northeast	74	7,211	1.03	433
Midwest	42	13,071	0.32	250
South	385	92,820	0.41	321
West	255	50,918	0.50	308
Overseas	116	24,383	0.48	362
Unknown/missing	6	3,870	0.16	595
Has a waiver/profile for any part of physical fitness test at time of PHA				
Yes	267	43,179	0.62	294
No	603	148,294	0.41	345
Unknown/missing	8	800	1.00	312

[b]Infantry/artillery/combat engineering/armor.
BMI, body mass index; No., number; PHA, Periodic Health Assessment.

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Brief Report: Refractive Surgery Trends at Tri-Service Refractive Surgery Centers and the Impact of the COVID-19 Pandemic, Fiscal Years 2000–2020

Brandon Sellers, BS (2d Lt, USAF); J. Richard Townley, MD (Lt Col, USAF); Corby Ropp, DO (CAPT, USN); Gary Legault, MD (LTC, USA)

Since the official introduction of laser refractive surgery into clinical practice throughout the Military Health System (MHS) in fiscal year 2000, these techniques have been heavily implemented in the tri-service community to better equip and improve the readiness of the U.S. military force. Military studies of refractive surgery date back to 1993, but prior to full military utilization of laser refractive surgery, spectacles or contact lenses were the mainstay to correct refractive error among military personnel.[1,2] Studies on the prevalence of refractive error, including myopia, hyperopia, and astigmatism, have shown that these conditions are quite common among active component service members.[3,4] Reversing such error through refractive surgery has been documented to improve military readiness, operational capability, and the quality of life of U.S. service members.[5]

There are 26 Department of Defense (DoD) Warfighter Refractive Surgery Centers that offer a combination of vision-correcting procedures such as photorefractive keratectomy (PRK), laser assisted in situ keratomileusis (LASIK), laser epithelial keratomileusis (LASEK), small incision lenticule extraction (SMILE), implantable collamer lens (ICL), and refractive lens exchange (RLE).[6–8] The capability to readily perform surgery with laser technology using the latest refractive surgery platforms highlights the importance of optimized vision to the DoD.

The COVID-19 pandemic introduced numerous obstacles which contributed to the reduction in the number of procedures performed. These obstacles included the closure of surgical centers and lack of temporary duty travel (TDY) patients. The pandemic also resulted in a shift to pre-operative testing for COVID-19 and virtual pre-operative briefings which could potentially result in delayed or cancelled refractive surgeries.

The objective of this report was to describe trends in total numbers of refractive surgeries over the last 21 fiscal years and to demonstrate how the early COVID-19 pandemic affected military refractive surgery trends.

METHODS

Data on all refractive surgery cases performed at 26 DoD Warfighter Refractive Surgery Centers were compiled by the U.S. Navy refractive surgery program manager and presented at the 2021 virtual Military Refractive Surgery Safety and Standards Symposium annual meeting.[6–8] These data are summarized in this report.

The surveillance period was from 1 October 1999 through 30 September 2020 (fiscal years 2000–2020). The surveillance population included active duty service members (active component and activated Reserve/Guard members) who met eligibility criteria for refractive eye surgery. Criteria for qualifying for refractive surgery may have differed among the services, but in general, service members had to have had at least 18 months left in their service commitments, a commander's authorization letter, and no adverse personnel actions. In addition, 3 Air Force locations performed refractive surgery on a small number of non-service member beneficiaries of the Military Health System as part of a research protocol (accounting for <0.03% of Air Force refractive surgical cases for fiscal year 2020).

RESULTS

For fiscal years 2000–2020, a total of 746,950 refractive surgeries were reported from the 26 Warfighter Tri-Service Refractive Surgery Centers. The number of surgeries performed each fiscal year ranged from a low of 4,381 refractive surgeries in 2000 to a peak of 50,690 surgeries in 2005 with an average of 35,569 surgeries per year **(Figure 1)**. In fiscal year 2020, 20,270 refractive surgeries were performed which represents a 38.6% decrease from the number of cases performed in 2019 (n=33,039).

During the surveillance period, there were 363,058 surgeries performed at Army refractive centers, 216,568 at Navy refractive centers, and 167,324 at Air Force refractive centers. The number of surgeries for all services declined from fiscal year 2019 to fiscal year 2020 (Army, 39.8% decrease; Navy, 34.6% decrease; Air Force, 41.0% decrease) **(Figure 1)**.

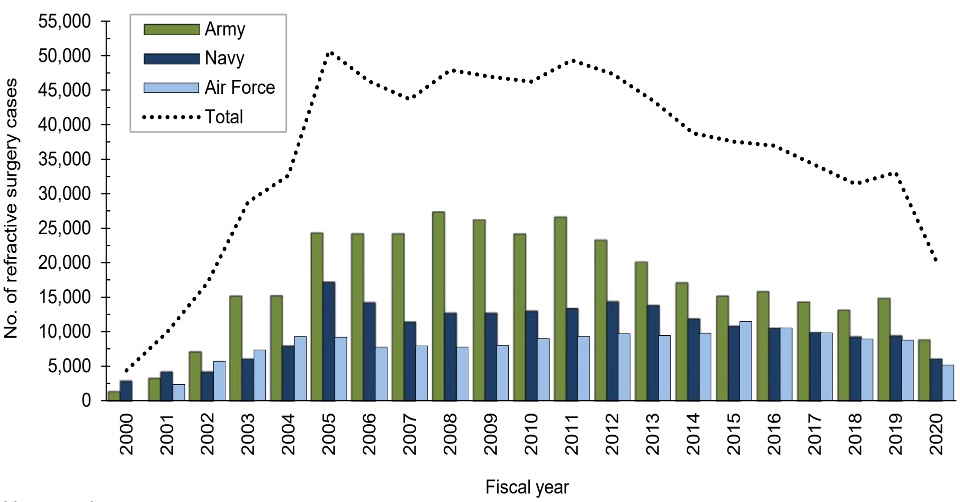
In 2020, the types of refractive surgery approximately consisted of 65.1% PRK (n=13,201), 27.6% LASIK/LASEK (n=5,585), 4.5% SMILE (n=920), 2.7% ICL (n=540), and 0.1% RLE (n=24) **(Figure 2)**. The percentage distributions of type of refractive surgery were similar among all the services in 2020.

EDITORIAL COMMENT

This report describes trends in the numbers of refractive surgeries performed during the 21 year surveillance period, including the COVID-19 pandemic. Since fiscal year 2000, the tri-service ophthalmology community conducted 746,950 vision corrective surgeries at 26 DoD Warfighter

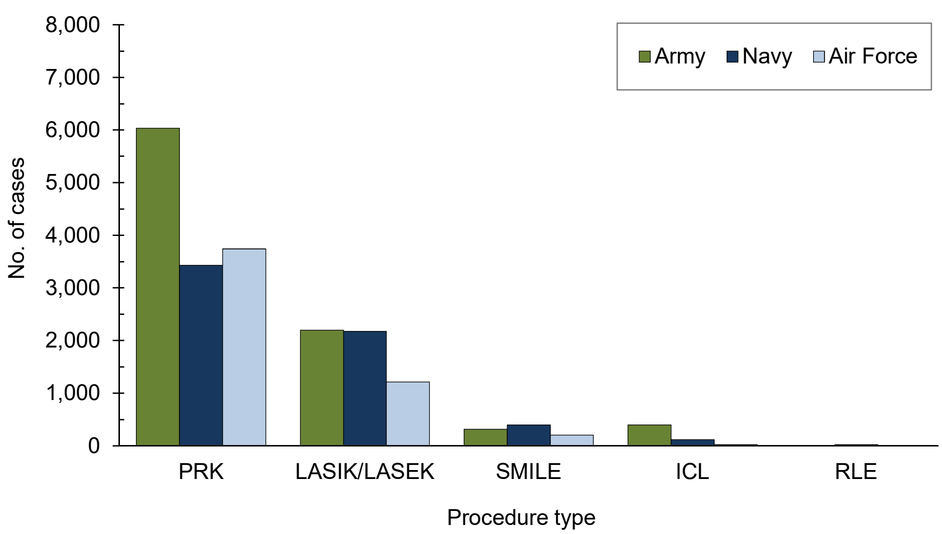
Refractive Surgery Centers. The large number of refractive cases reported and the amount of refractive surgery centers present in the DoD speaks to the valued importance of optimal vision in U.S. military members. In addition to the warfighter's improvement in quality of life, vision corrective surgeries are used frequently in the U.S. military due to the need and for improved preparedness and performance in operational tasks.[3–5] An Air Force study from 2020 reported the prevalence of myopia in 767 Air Force Basic Military Trainees. Among the trainees, 45% were found to have myopia classified as greater than -0.5 D, and 2% of trainees were found to have high myopia classified as greater than -6.0 D.[4] In 2019, Reynolds et al. reported that 51.1% of ocular care for service members during fiscal year 2018 was dedicated to refractive error-related disorders.[9] A study published in 2017 demonstrated the excellent and comparable vision outcomes of Wave-Front Guided and Wave-Front Optimized PRK on military members in regard to marksmanship, visual performance, threshold target identification, and contrast sensitivity.[10] These studies shed light on the importance of refractive surgery offered by the DoD.

FIGURE 1. Number of refractive surgery cases, by service from a Tri-Service Refractive Surgery Center, fiscal years 2000–2020



No., number.

FIGURE 2. Refractive surgery cases, by service and type of procedure performed at a Tri-Service Refraction Surgery Center, fiscal year 2020



No., number; PRK, photorefractive keratectomy; LASIK, laser assisted in situ keratomileusis; LASEK, laser epithelial keratomileusis; SMILE, small incision lenticule extraction, ILC, implantable collamer lens; RLE, refractive lens exchange.

When analyzing the effect of the COVID-19 pandemic, a decrease in the number of refractive surgery cases performed in the tri-service community was reported. Specifically, the total number of surgeries during fiscal year 2020 was comparable to the number of surgeries in fiscal year 2002, shortly after the procedures were first introduced. The pronounced decrease in the number of surgeries performed was undoubtedly due to factors related to the SARS-CoV-2 pandemic: shutdown of DoD Warfighter Refractive Surgery Centers, unavailability of TDY patients, pre-operative SARS-CoV-2 testing, difficulty with pre-operative virtual briefings, availability of N-95 masks, properly scheduling post-operative follow-up, and limitations on family members helping with patients after surgery. The reduced number of procedures observed in fiscal year 2020 is consistent with many published reports of reduced health care utilization during the COVID-19 pandemic.[11] One such report demonstrated initial reduced demand for refractive surgery which subsequently rebounded in 2021.[12]

In fiscal year 2020, the majority of cases were PRK followed by LASIK/LASEK and SMILE, respectively. A trend toward PRK surgery in the military has been prevalent for years; however, there has been a shift towards LASIK especially among Navy surgery centers.[13,14] Various reasons exist for the preference of PRK, which include surgeon's comfort with performing PRK over LASIK, previous military policies that prohibited LASIK for special forces, and the risk of traumatic corneal flap lifting following LASIK that cannot be attended to in an environment that is not readily equipped with an ophthalmologist (e.g., deployment, training, austere environments).[15] With the introduction of SMILE in 2016 after the U.S. Food and Drug Administration approval, it has been increasingly implemented in the DoD.[16] SMILE has shown promise with comparable, if not better, visual outcomes than PRK and more predictable outcomes and similar corneal biomechanical stability when compared to LASIK.[17,18] The emergence of new refractive surgery techniques will continue to provide opportunity for advancement in military refractive surgery.

Limitations of this study include potential bias in data retrieval and documentation. Data were individually reported from each center and were not verified with medical coding. Additionally, refractive surgeries performed outside of Warfighter Refractive Surgery Centers were not captured in this analysis.

In summary, this report demonstrates the trend in refractive surgeries at the DoD Refractive Surgery Centers and reveals the decrease in refractive surgeries during the COVID-19 pandemic. Because of the instrumental role refractive surgery plays in gaining a strategic advantage for the U.S. military warfighter, surgical procedures still continued during this period and will most likely increase to pre-pandemic numbers as the COVID-related restrictions are lifted or conditions to handle COVID-related spread are improved. Future implications from the lessons learned during the COVID-19 pandemic will provide a framework on how to troubleshoot barriers to performing refractive surgery in the future.

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Brief Report: Using Syndromic Surveillance to Monitor MIS-C Associated with COVID-19 in Military Health System Beneficiaries

Jamaal A. Russell, DrPH, MPH; Sarah N. Vick, MD, MPH (Col, MC, USAF)

SARS CoV-2 and the illness it causes, COVID-19, have exacted a heavy toll on the global community. Most of the identified disease has been in the elderly and adults. In April 2020, a rare hyperinflammatory syndrome called multisystem inflammatory syndrome in children (MIS-C) was reported in Europe in a number of children with SARS-CoV2 infections. The cluster was initially characterized as cases with symptoms compatible with Kawasaki's disease.[1] Cases presented with symptoms including systemic hyperinflammation, persistent fever, and multisystem organ dysfunction. In the U.S., cases of MIS-C have been disproportionately reported among Hispanic and non-Hispanic Black children 6 to 12 years old who presented with severe symptoms.[2] According to the Centers for Disease Prevention and Control (CDC), as of 3 May 2021, 3,742 cases of MIS-C were reported in the U.S., including 35 deaths.[3]

In an effort to detect potential cases of MIS-C in the Military Health System (MHS), the Armed Forces Health Surveillance Division (AFHSD) used the Electronic Surveillance System for the Early Notification of Community-based Epidemics (ESSENCE), a syndromic surveillance system which uses outpatient data to monitor trends and increases in health care encounters that may represent changes in the incidence of disease. Users of ESSENCE employ the system to analyze MHS clinical data sources in near real-time, including diagnosis codes, free text chief complaint or reason-for-visit data fields, reportable medical events (RME), laboratory and radiology data, and prescription drug information to develop a picture of disease syndromes based on health care encounters.[4,5]

The goal of this analysis was to ascertain if user-built ESSENCE queries applied to records of outpatient MHS health care encounters are capable of detecting MIS-C cases that have not been identified or reported by local public health departments.

METHODS

The AFHSD used ESSENCE to create a query based on the case definition of MIS-C developed by the CDC to identify potential MIS-C cases. The query included MIS-C-related International Classification of Diseases, 10th Revision (ICD-10) diagnosis codes and free text chief complaint and reason-for-visit data fields from records of outpatient medical encounters for health care beneficiaries of the MHS 20 years old or younger who sought care between 19 October 2020 and 12 March 2021. The query was adapted from the CDC-developed syndromic surveillance query, but the AFHSD query was modified to exclude those codes which are not present in AFHSD ESSENCE (Z86.16 [personal history of COVID-19] and Z20.822 [exposure to COVID-19 or SARS-CoV-2 infection]). The AFHSD-developed query selected ICD-10 codes in any diagnostic position in the electronic medical record for any outpatient encounter during the study period. Chief complaints were retrieved from patients' "reason for visit" free text field for each health encounter. The search criteria for ESSENCE's free text queries are built around Boolean logical operators and regular expressions which allow for a high level of customization.[6]

Four ICD-10 codes and 12 chief complaints were used to create the automated ESSENCE MIS-C query for searching records of all outpatient health encounters at nearly 400 military treatment facilities (MTFs) in real-time **(Tables 1, 2)**. Demographic and military variables, including age (in years), sex, race/ethnicity, ICD-10

TABLE 1. ICD-10 diagnostic codes used to identify possible cases of MIS-C

ICD-10 codes	Description
M30.3	Mucocutaneous lymph node syndrome [Kawasaki]
M35.81	Multisystem inflammatory syndrome
U07.1	COVID-19
B94.8	Sequelae of other specified infectious and parasitic diseases

ICD-10, International Classification of Diseases, 10th Revision; MIS-C, multisystem inflammatory syndrome in children.

TABLE 2. "List of reasons for visit" used to query the chief complaint field of ESSENCE to identify posible cases of MIS-C

Chief complaint
Kawasaki
Mucocutaneous lymph
Multisystem inflame
MIS-C
Toxic shock
Rash
Redness
Bloodshot eye
Oral change
Abdominal pain
Diarrhea
Red eye & lip

ESSENCE, Electronic Surveillance System for the Early Notification of Community-based Epidemics; MIS-C, multisystem inflammatory syndrome in children.

codes, patient identifiers, and location were extracted for analysis. All direct care outpatient encounters with 1 or more of the ICD-10 codes or chief complaints of interest were selected to create a list of potential cases. Data details were downloaded on a weekly basis, verified, and coded as confirmed MIS-C cases by registrars trained in infectious disease manual data abstraction associated with the Department of Defense (DoD) COVID-19 registry.

The CDC case definition was used to confirm MIS-C cases. This definition includes an individual under 21 years old presenting with fever (>100.4 °F/38.0 °C) or report of subjective fever lasting 24 hours or longer), laboratory evidence of inflammation and a positive test for SARS-CoV-2 infection by RT-PCR, serology, or antigen test or COVID-19 exposure within the 4 weeks prior to the onset of symptoms in the clinical setting of severe inflammatory illness without other identifiable etiology.[3]

RESULTS

During the surveillance period, the AFHSD MIS-C ESSENCE query identified 60 encounters that met selection criteria. The month of February 2021 had the most MIS-C-related encounters with 15 (25%) occurring during this time **(data not shown)**. Out of 60 possible cases, 40 (66%) were males and 36 (60%) were 0–8 year olds (mean=8.5 years) **(data not shown)**. Half of the MIS-C-related encounters (n=30) were in the southeast region of the U.S., and 9 (15%) were in overseas military clinics **(data not shown)**. The most common ICD-10 code recorded was "M30.3-Mucocutaneous lymph node syndrome (Kawasaki)." Of the 60 records identified as possible cases by ESSENCE, 10 cases of MIS-C were confirmed by the DoD COVID-19 health records review process (17%). Four (40%) of the 10 confirmed cases were male and 4 were female (40%). Information on sex was not available for 2 of the confirmed cases. Half of the confirmed cases were 7–10 years old (mean=12 years; range=7–18 years).

EDITORIAL COMMENT

Monitoring disease progression of the COVID-19 pandemic for situational awareness has been the current focus of the syndromic surveillance. The emergence of MIS-C reported in military beneficiaries should widen the focus on how to monitor disease progression in diverse populations. Although MIS-C is a rare condition among children who have developed COVID-19, it is still of great concern to public health officials in the military health care system.[4] The ability to detect individual cases of disease was not originally how syndromic surveillance was designed to function. The main objective of syndromic surveillance is to detect a cluster or outbreak of disease before diagnosis.

There are some limitations to using ESSENCE to detect MIS-C encounters. A proportion of ESSENCE records that were received were deidentified; these records were not used in the analysis. In addition, records of purchased care encounters were not included in the analysis. Given these limitations, the findings of this analysis should not be construed as a complete representation of MIS-C cases in the surveyed population. Moreover, because the use of ESSENCE was limited to outpatient clinic data, the current analysis did not include the more severe cases seen in emergency departments and urgent care centers which are visible through the civilian form of ESSENCE.

The purpose of the analysis was to create a query that could identify possible outpatient cases of MIS-C. The MIS-C query was able to capture 10 cases of the rare condition of MIS-C during the surveillance period while minimizing the number of encounters (n=60) which met the selection criteria out of millions of encounters. ESSENCE has shown the ability to detect potential cases of MIS-C through health encounters at MTFs across the MHS. This capability will expand the biosurveillance efforts of AFHSD in response to future emerging infectious diseases and other threats of military interest. Furthermore, civilian surveillance systems may use this or similar queries to identify previously unreported cases of MIS-C in the civilian population.

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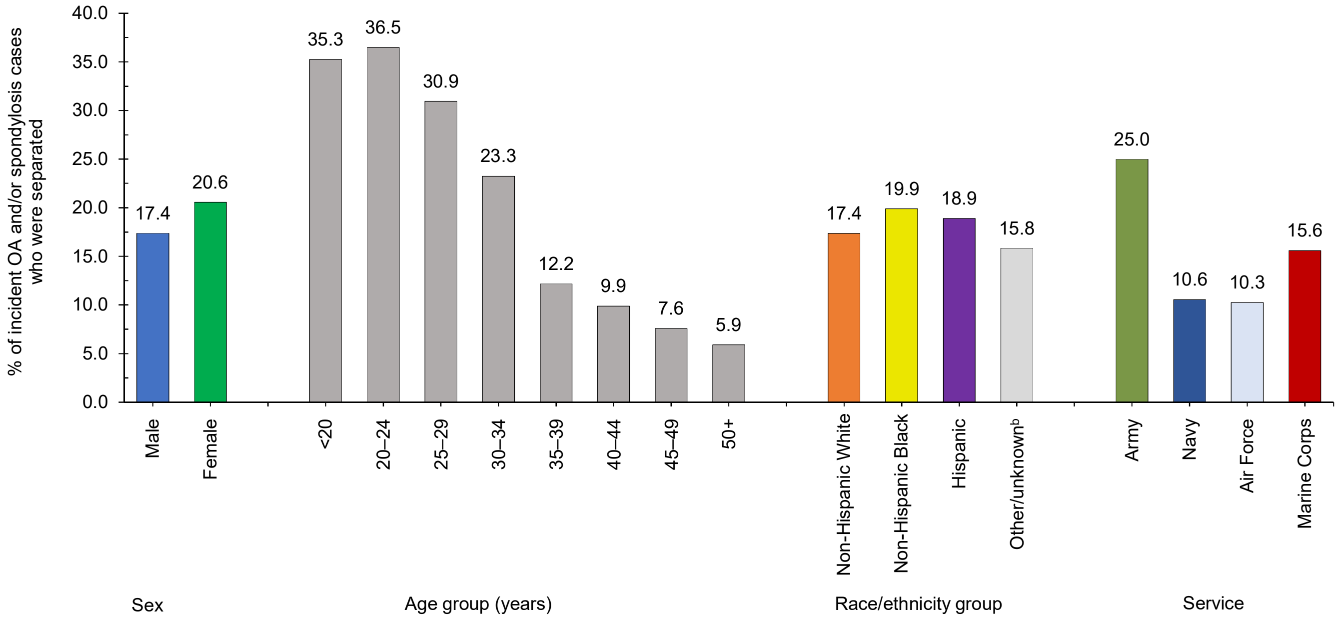
Surveillance Snapshot: Medical Separation from Service Among Incident Cases of Osteoarthritis and Spondylosis, Active Component, U.S. Armed Forces, 2016–2020

Valerie F. Williams, MA, MS; Saixia Ying, PhD; Shauna L. Stahlman, PhD, MPH

FIGURE. Percentages of service members with incident OA and/or spondylosis diagnoses during 2016–2020 who were medically separated from military service,[a] active component, U.S. Armed Forces



[a]Through 31 July 2021 (n=16,819).
[b]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.

Osteoarthritis (OA) is the most common adult joint disease and predominantly involves the weight-bearing joints.[1] This condition, including spondylosis (OA of the spine), results in significant disability and resource utilization and is a leading cause of medical separation from military service.[2] A recent *MSMR* analysis described the incidence of OA and spondylosis diagnoses among active component service members of the U.S. Armed Forces from 2016 through 2020.[3] During the 5-year surveillance period, crude overall rates of incident OA and spondylosis diagnoses were 630.9 per 100,000 person-years (p-yrs) and 958.2 per 100,000 p-yrs, respectively.[3] Anatomic site-specific rates of OA varied by sex, race/ethnicity group, service, and military occupation.[3]

In this analysis, the numbers and percentages of incident cases of OA and/or spondylosis with a medical separation after the incident diagnosis (through 31 July 2021) were stratified by selected demographic and military characteristics. Separations from service were categorized as having been for medical reasons using interservice separation (ISC) codes (1010, 1011, 1012, 1013, 1014, 2010, 2011, 2012, 2013).

Among a total of 94,036 unique individuals who qualified as incident cases of OA and/or spondylosis during 2016–2020, 17.9% (n=16,819) were medically separated from service by 31 July 2021 **(data not shown)**. The median time from incident OA and/or spondylosis diagnosis and separation from military service was 430 days (mean=506 days) **(data not shown)**. Median times to separation were broadly similar by demographic characteristics (sex, age group, and race/ethnicity group) with more pronounced differences apparent by service; the median time to separation was lowest for Army and Marine Corps members (392 days and 447 days, respectively) and highest for Air Force members (553 days) **(data not shown)**. The percentages of incident cases aged 34 years or younger (range=23.3%–36.5%) who were medically separated were higher than the percentages among those aged 35 or older (range=5.9%–12.2%) **(Figure)**. Army members with incident diagnoses of OA and/or spondylosis were more likely to be medically separated compared to their respective counterparts in the other services.

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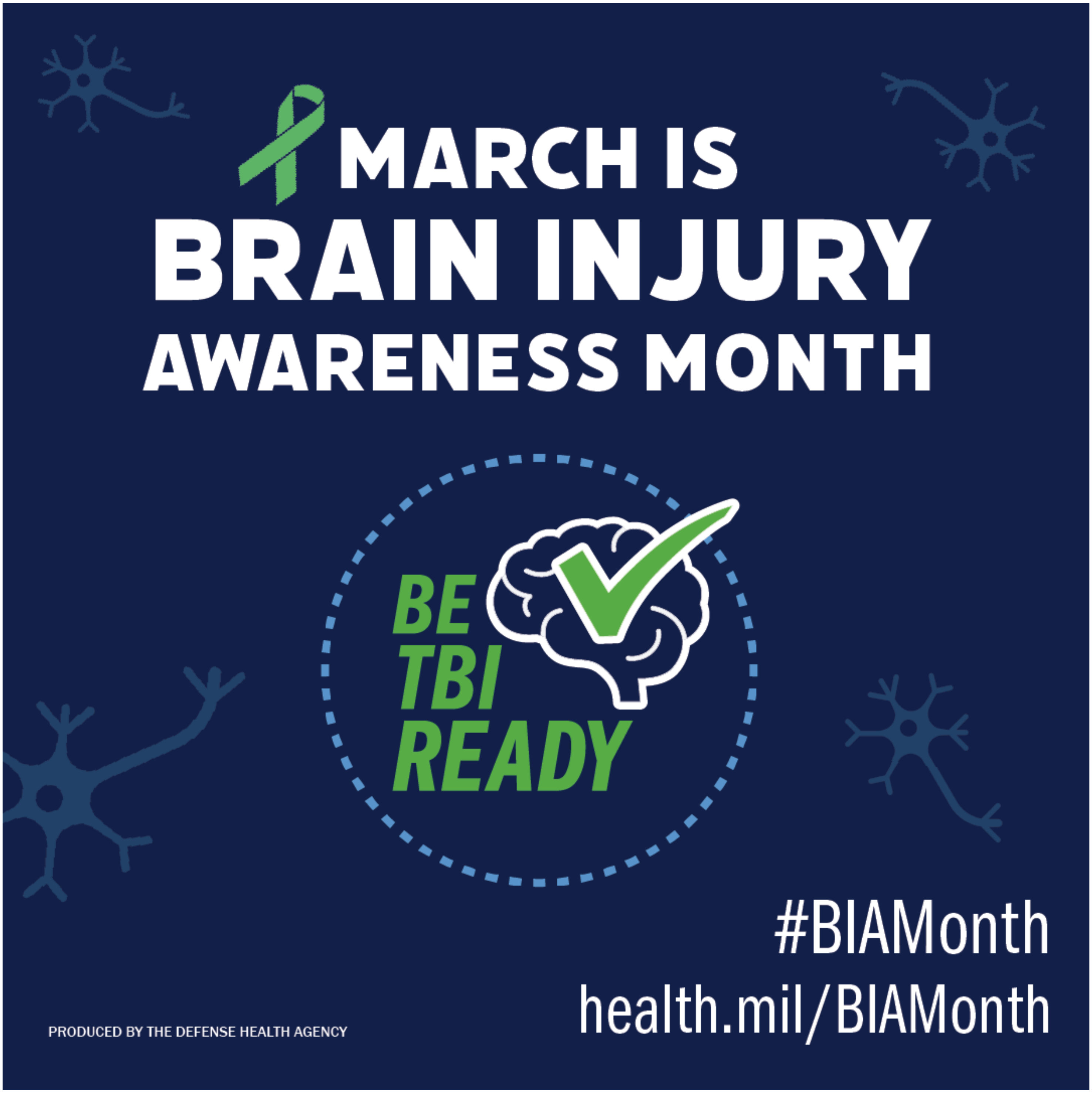
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