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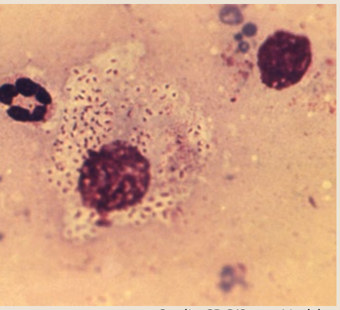

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Update: Osteoarthritis and Spondylosis, Active Component, U.S. Armed Forces, 2016–2020

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Osteoarthritis (OA) is the most common adult joint disease and accounts for significant morbidity burdens among U.S. civilian and military populations. During 2016–2020, the crude overall rates of incident OA and spondylosis diagnoses among U.S. active component service members were 630.9 per 100,000 person-years (p-yrs) and 958.2 per 100,000 p-yrs, respectively. Crude annual rates of both conditions decreased markedly from 2016 through 2020 with declines evident in all of the demographic and military subgroups examined. Compared to their respective counterparts, crude overall rates of OA diagnoses were highest among male service members, those aged 35 or older, non-Hispanic Black service members, Army members, and those working in health care occupations. Crude overall rates of spondylosis diagnoses were highest among those aged 30 or older, non-Hispanic White and non-Hispanic Black service members, Army members, and those in health care and communications/intelligence occupations. More than two-thirds of all incident OA diagnoses involved the knee (38.8%) or shoulder (28.4%). Differences in anatomic site-specific rates of OA were apparent by sex, race/ethnicity group, service, and military occupation. Additional research to identify military-specific equipment and activities that increase the risk of acute and chronic damage to joints would be useful to develop, test, and implement practical and effective countermeasures against OA and spondylosis among military members in general and those in high-risk occupations specifically.

WHAT ARE THE NEW FINDINGS?

During 2016–2020, OA and spondylosis were diagnosed in 39,949 and 60,475 active component service members, respectively. Among those aged 25 or older, overall rates of both conditions were highest among Army and Marine Corps members. In all demographic and military subgroups examined, the knee joint was the anatomic site most frequently affected by OA. Overall rates of site-specific OA diagnoses varied by sex, race/ethnicity group, service, and military occupation.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

OA and spondylosis can result in significant pain, limitations in function, and progressive disability. As such, these conditions can affect medical readiness of service members through increased limited duty days, decreased deployability rates, and increased medical separation rates.

Osteoarthritis (OA), the most common adult joint disease, is primarily a degenerative disorder of the entire joint organ, including the subchondral bone, synovium, and periarticular structures (e.g., tendons, ligaments, bursae).[1,2] Although OA has traditionally been viewed as a degenerative disorder arising largely from wear and tear, increasing evidence suggests that excessive or abnormal joint loading also stimulates joint tissue cells to produce proinflammatory factors and proteolytic enzymes that mediate joint tissue destruction.[3,4] The swelling that generally occurs in early OA is the result of an increased production of proteoglycans which reflects the chondrocytes' (cartilage cells) efforts to repair articular cartilage damage.[5] However, this process is accompanied by the presence of proinflammatory cytokines which result in the deterioration of chondrocyte metabolism and limit self-regeneration of cartilage.[5] These processes form a positive feedback loop that is a key driver in the pathology of OA.[5] As OA progresses, proteoglycan levels fall causing the cartilage to soften and lose elasticity, which further compromises joint surface integrity.[2] Over time, microscopic flaking and splitting develop on the surface of the articular cartilage with loss of cartilage leading to a reduction in joint space.[2] In severe cases of OA, erosion of the damaged cartilage may progress until the underlying bone is exposed.[1] The destruction of articular cartilage and remodeling of subarticular bone associated with OA can result in significant pain, joint effusion (abnormal accumulation of fluid in or around a joint), limitations in function, and progressive disability.[6]

OA predominantly involves the weight-bearing joints, including the knees, hips, cervical and lumbosacral spine, ankles, and feet.[2] Other commonly affected joints include the shoulder, the wrist and the joints of the hand.[7]

Spondylosis, often referred to as OA of the spine, is characterized by degenerative changes in the vertebral discs, joints, and vertebral bodies.[8] The pathophysiology of spondylosis is not fully understood.[8] The sequence of changes seen in spondylosis generally begins with desiccation of the vertebral disc; the resultant decrease in disc height weakens the ligamentous outer portion of the intervertebral disc.[9] These changes lead to increased stress at key points which, in turn, results in osseous and ligamentous hypertrophy and osteophyte formation.[9,10] Individuals affected by spondylosis often report neck and back pain that is increased by motion and/or stiffness with limitation of motion.[8,9] In severe cases, spondylosis may cause pressure on nerve roots and spinal stenosis (narrowing of the spinal canal).[8–10]

Key risk factors for the development of OA include advancing age,[11] female sex,[12] family history,[11,13] obesity,[14] specific bone/joint shapes,[14] high bone density/mass,[15] repetitive joint loading,[16–22] and traumatic joint injury (e.g., during occupational or recreational activities).[23–25] OA is a leading cause of pain and functional impairment in working age adults and the elderly[26–28]; as such, OA accounts for significant morbidity burdens among U.S. civilian and military populations[29–33] and its management requires substantial health care resources and incurs considerable costs.[34,35] Between 2008 and 2014, the average annual per-person medical costs attributed to OA was $11,052;[35] annual all-cause costs (both direct and indirect) attributed to OA averaged $468 billion nationally during this period.[35]

Despite the significant morbidity and health care costs attributable to OA, there are relatively few published, U.S. population-based estimates of the incidence of this condition. Estimates of the incidence of OA vary depending on the definition of OA employed (e.g., symptomatic, radiographic, self-reported, or physician-diagnosed), the specific joint(s) evaluated, and study population.[14] Studies that have focused on estimating incidence rates of OA have typically generated estimates related to a single joint.[30,36–38] Moreover, relatively few studies have focused on the incidence of OA in younger and physically active populations. In a 2011 report, Cameron and colleagues estimated that, from 1999 through 2008, incidence rates of OA diagnoses were significantly higher among U.S. active duty service members than comparably aged Canadian civilians.[39] Likely causes, at least in part, for the relatively high rates of OA among military members include the physical stresses associated with military training (e.g., running in formation), operations (e.g., heavy load bearing, prolonged wearing of body armor), and occupations (e.g., drivers and crews of military vehicles, paratroopers, health care workers).[21,22, 30, 40–43] Given their potential exposure to repetitive joint loading activities and rigorous occupational tasks, active component U.S. service members are a high-risk population of epidemiologic interest in general and of military medical concern. Specifically, OA can affect readiness through increased limited duty days, decreased deployability rates, and increased medical separation rates.[31,32,41,44, 45]

In 2016, the *MSMR* reported on the incidence of OA and spondylosis among active component U.S. service members from 2010 through 2015.[46] The current analysis updates this earlier work by summarizing the numbers, rates, trends, and demographic and military characteristics of active component service members who were diagnosed with OA or spondylosis during 2016–2020.

METHODS

The surveillance population consisted of all individuals who served in the active component of the U.S. Army, Navy, Air Force, or Marine Corps at any time between 1 January 2016 and 31 December 2020. Records of both inpatient and outpatient health care encounters documented in the Defense Medical Surveillance System (DMSS) were searched to identify cases of OA/spondylosis. Diagnoses were ascertained from administrative records of all inpatient and outpatient encounters of individuals who received medical care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System (MHS) or civilian facilities

TABLE 1. ICD-10 codes used to identify osteoarthritis and spondylosis

Condition	ICD-10
Osteoarthritis	
Polyosteoarthritis (multiple sites)	M15.0, M15.3, M15.4, M15.8, M15.9
Hip	M16.*
Knee	M17.*
Hand	M18.*; M19.04*, M19.14*, M19.24*
Shoulder	M19.01*, M19.11*, M19.21*
Elbow	M19.02*, M19.12*, M19.22*
Wrist	M19.03*, M19.13*, M19.23*
Ankle and foot	M19.07*, M19.17*, M19.27*
Site unspecified	M19.9*, M19.29
Spondylosis	
Anterior spinal and verterbral artery compression syndromes	M47.01*
Vertebral artery compression syndromes	M47.02*
Other spondylosis with myelopathy	M47.1*
Other spondylosis with radiculopathy	M47.2*
Other spondylosis without myelopathy or radiculopathy	M47.81*
Other spondylosis	M47.89*
Spondylosis unspecified	M47.9
Spinal stenosis	M48.0*
Ankylosing hyperostosis	M48.1*
Kissing spine	M48.2*
Traumatic spondylopathy	M48.3*
Spondylopathy, unspecified	M48.9

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD-10, International Classification of Diseases, 10th Revision.

in the purchased care system documented in the DMSS. Data on care provided in deployed settings were not included in this analysis.

An incident case of OA or spondylosis was defined by a record of a hospitalization or records of at least 2 outpatient medical encounters within 2 years that included any of the case-defining International Classification of Diseases, 10th Revision (ICD-10) codes in any diagnostic position **(Table 1)**. The incidence date was the date of the first case-defining hospitalization or outpatient medical encounter that included a diagnosis of OA or spondylosis. An individual could be counted as a case of OA or spondylosis once per lifetime. Each individual could be diagnosed as an incident case of OA and an incident case of spondylosis only 1 time each during the surveillance period; that is, incident cases of OA could be diagnosed as spondylosis cases and vice versa. Prevalent cases (i.e., individuals with incident encounters prior to the surveillance period) were excluded from the analysis. ICD-9 codes for OA and spondylosis (715.* and 721.*, respectively) were used to exclude prevalent cases.

Incidence rates were calculated as incident OA or spondylosis diagnoses per 100,000 person-years (p-yrs) of active component service. Crude overall incidence rates for both conditions were computed for each year of the surveillance period and stratified by key demographic and military characteristics (age group, sex, race/ethnicity group, branch of military service, rank and military occupation). Multivariable negative binomial regression models were used to compute adjusted incidence rate ratios (AIRRs) of OA and spondylosis for the military occupation categories with pilot/air crew as the reference group. Multivariable models were adjusted for age group (reference group=20–24 years), sex (reference group=male), race/ethnicity group (reference group=non-Hispanic White), and service branch (reference group=Marine Corps). All analyses were carried out using SAS/STAT software, version 9.4 (2014, SAS Institute, Cary, NC).

Site-specific ICD-10 codes were used to summarize the anatomical locations of OA **(Table 1)**; if an individual received more than 1 OA diagnosis, site-specific diagnoses (e.g., shoulder, knee) were prioritized over non-site-specific diagnoses (site unspecified); polyosteoarthritis (multiple sites) was prioritized over site unspecified diagnoses. If multiple diagnosis codes of the same specificity occurred during the surveillance period, the earliest occurring site-specific code was selected. If multiple diagnosis codes of the same specificity occurred in the same earliest encounter, diagnoses were prioritized by diagnostic position (diagnosis 1 > diagnosis 2, etc.). To examine counts and percentages of OA cases with 2 or more diagnoses of different specified anatomic sites during the surveillance period, diagnoses for site unspecified and polyosteoarthritis were excluded. OA cases with 2 or more diagnoses of different specified anatomic sites were categorized as having OA diagnoses of 2, 3, or 4 different specified sites.

RESULTS

Osteoarthritis

During the 5-year surveillance period, a total of 39,949 active component service members received incident diagnoses of OA, for a crude (unadjusted) overall incidence rate of 630.9 per 100,000 p-yrs **(Table 2)**. The crude overall rate was higher among male compared to female service members (641.2 and 579.0 per 100,000 p-yrs, respectively) **(Table 2)**. The patterns of overall rates by age group were similar for both sexes through age 44; however, among those aged 45 or older, overall rates were higher among female compared to male service members **(data not shown)**. Overall rates of OA diagnoses increased markedly with increasing age, with the rate among service members aged 25–29 over 10 times the rate among those under age 20; rates doubled for each 5-year age interval from ages 20–24 through 35–39, but, thereafter, the increases by age group were approximately 80%, 50%, and 40%, respectively. Non-Hispanic Black service members had

TABLE 2. Incident cases and incidence rates of osteoarthritis, by demographic and military characteristics, active component, U.S. Armed Forces, 2016–2020

	Total 2016–2020	
	No.	Rate[a]
Total	39,949	630.9
Sex		
Male	33,894	641.2
Female	6,055	579.0
Race/ethnicity group		
Non-Hispanic White	22,565	633.5
Non-Hispanic Black	8,533	842.4
Hispanic	5,013	491.9
Other/unknown[b]	3,838	520.4
Age group (years)		
<20	132	26.8
20–24	2,284	109.8
25–29	4,250	284.1
30–34	6,021	594.0
35–39	10,231	1,442.7
40–44	8,846	2,554.5
45–49	5,498	3,820.5
50+	2,687	5,323.2
Service		
Army	19,671	868.3
Navy	6,439	401.5
Air Force	9,960	640.1
Marine Corps	3,879	427.7
Rank		
Junior enlisted (E1–E4)	4,162	148.1
Senior enlisted (E5–E9)	24,336	1,001.9
Junior officer (O1–O3; W1–W3)	3,974	563.1
Senior officer (O4–O10; W4–W5)	7,477	1,936.1
Occupation		
Combat-specific[c]	5,641	647.3
Motor transport	909	484.5
Pilot/air crew	1,477	647.6
Repair/engineering	10,400	551.7
Communications/ intelligence	9,916	734.5
Health care	4,336	788.1
Other/unknown	7,270	577.2

[a]Rate per 100,000 person-years.
[b]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
[c]Infantry, artillery, combat engineer, armor.

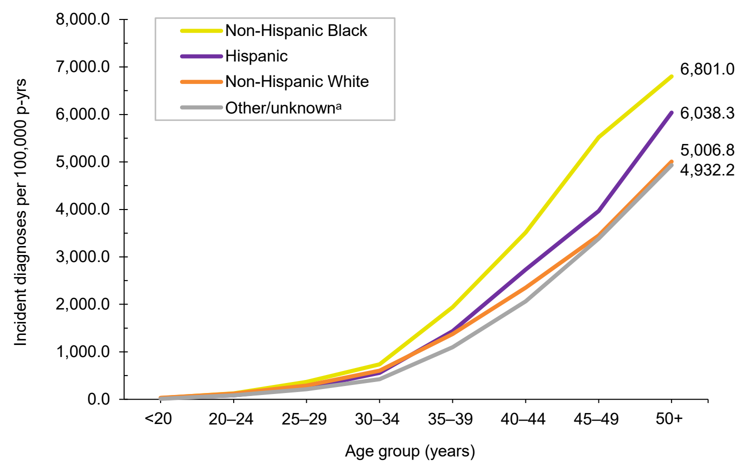
the highest crude overall rate of incident OA diagnoses (842.4 per 100,000 p-yrs) compared to those in other race/ethnicity groups **(Table 2)**. The lowest crude overall rate by race/ethnicity group was observed among Hispanic service members (491.9 per 100,000 p-yrs). Further stratification by age group showed that, among those 25 years or older, non-Hispanic Black service members had the highest overall rate of OA diagnoses and those in the other/unknown race/ethnicity group (includes American Indian/Alaska Native service members, Asian/Pacific Islander service members, and those of unknown race/ethnicity) had the lowest rate **(Figure 1)**.

Across the services, crude overall incidence rates of OA diagnoses were highest among Army members (868.3 per 100,000 p-yrs) and lowest among Navy members (401.5 per 100,000 p-yrs) **(Table 2)**. Examination by service and age group showed that, among those aged 25 or older, overall rates were highest among Army and Marine Corps members, respectively **(Figure 2)**. The overall rates of incident OA diagnoses among senior enlisted service members and senior officers were more than 6 and 3 times, respectively, those among their junior, and generally younger, counterparts **(Table 2)**. Crude overall incidence rates of OA diagnoses were highest among service members in health care and communications/intelligence occupations (788.1 and 734.5 per 100,000 p-yrs, respectively) and lowest among those working in motor transport (484.5 per 100,000 p-yrs). However, among service members 30 years or older, rates of OA diagnoses were higher among those in motor transport and combat-specific occupations than those in any other occupational group **(Figure 3)**. Moreover, among service members 45 years or older, rates of incident OA diagnoses were markedly higher among those working in motor transport than among those in any other occupational group. Of note, in all age groups 20 years or older, rates of OA diagnoses were lowest among service members working as pilots/air crew.

Multivariable regression analysis revealed that, compared to their respective counterparts working as pilots/air crew, service members in all other occupational groups showed significantly elevated rates of OA after adjusting for age group, sex, race/ethnicity group, and service branch **(data not shown)**. Rates of OA diagnoses were approximately 60% higher among those in combat-specific (AIRR=1.64; 95% CI: 1.51–1.77), motor transport (AIRR=1.60; 95% CI: 1.45–1.76), and repair/engineering occupations (AIRR=1.59; 95% CI: 1.47–1.71) compared with pilots and air crew members **(data not shown)**. Service members in communications/intelligence, other/unknown, and health care occupations had rates of OA that were 1.5, 1.4 and 1.3 times those of service members working as pilots/air crew, respectively **(data not shown)**.

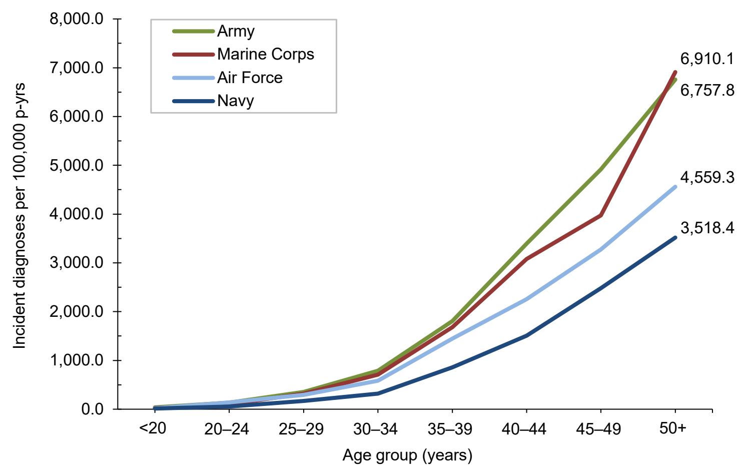
Over the course of the surveillance period, crude annual rates of incident OA diagnoses decreased from a high of 713.8 per 100,000 p-yrs in 2016 to a low of 476.4 per 100,000 p-yrs in 2020 (33.3% decrease), with the greatest decline occurring between 2019 and 2020 **(Figure 4)**. Throughout the 5-year period, crude annual incidence rates of OA diagnoses were consistently higher among male than female service members. Stratification by age group showed that rates of OA diagnoses remained relatively stable during the first 4 years of the surveillance period among those in the 3 oldest age groups (40 years or older), with pronounced decreases between 2019 and 2020 **(data not shown)**. Among service members aged 39 or younger, declines in OA rates were relatively steady over time **(data not shown)**. Over the surveillance period, crude annual rates of OA decreased among service members in all race/ethnicity groups with the most pronounced decreases among non-Hispanic Black (44.3%) and Hispanic service members (37.6%) **(Figure 5)**. Annual rates of incident OA diagnoses

FIGURE 1. Overall incidence rates of osteoarthritis diagnoses, by race/ethnicity group and age group, active component, U.S. Armed Forces, 2016–2020



[a]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
P-yrs, person-years.

FIGURE 2. Overall incidence rates of osteoarthritis diagnoses, by service and age group, active component, U.S. Armed Forces, 2016–2020

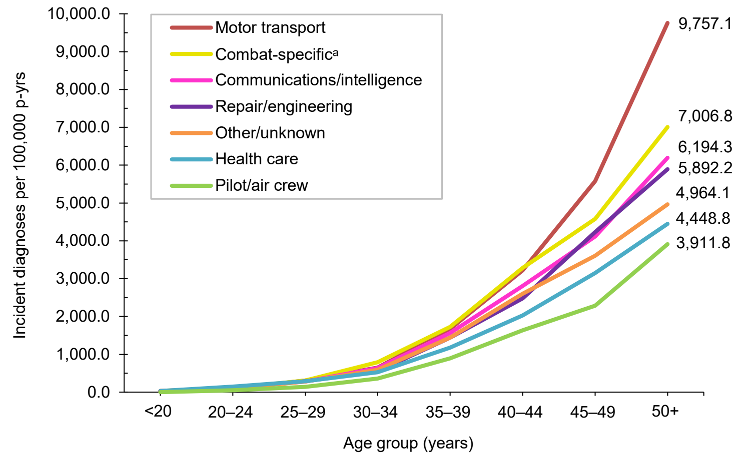


P-yrs, person-years.

decreased in all services with the greatest declines over time among members of the Air Force (38.9%) and Army (34.2%) **(Figure 6)**. Rates also decreased over the course of the 5-year period among service members in all occupational groups **(data not shown)**.

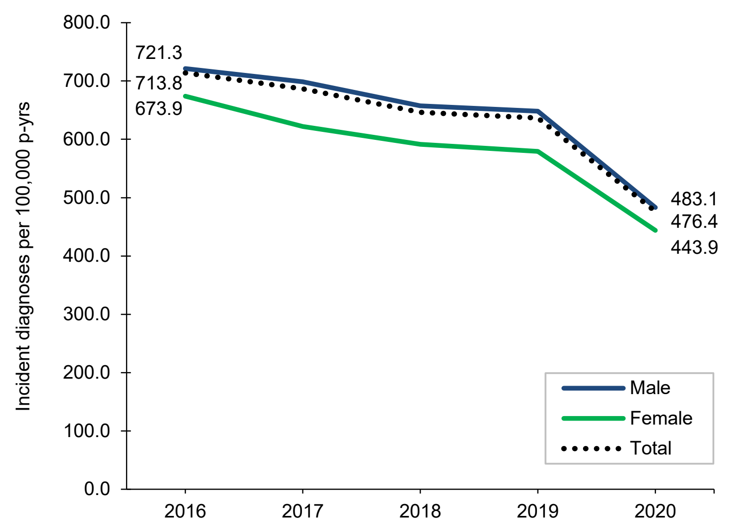
More than two-thirds of all incident OA diagnoses involved the knee (38.8%) or shoulder (28.4%) **(data not shown)**. Crude overall rates of incident diagnoses of OA of the knee, hip, hand, multiple sites, and unspecified sites were 10%–52% higher among female than male service members **(Figure 7)**. Among male service members, overall rates of diagnoses of OA of the elbow and shoulder were 4.4 and 2.3 times, respectively, those among female service members. Examination by sex and age group showed that the age at which several of these differences in rates became apparent varied by anatomic site. For example, the difference in overall rates of incident diagnoses of OA of the shoulder among male and female service members is apparent in those aged 25 or older while the difference in rates of diagnoses of OA of the hand are evident in those 35 years or older **(Figure 8)**. Further stratification by race/ethnicity group revealed that the overall incidence rates of diagnoses of OA of the knee and ankle/foot among non-Hispanic Black service members were 90.6% and 34.1% higher, respectively, than those among non-Hispanic White service members **(Figure 9)**. Across the services, overall rates of incident diagnoses of OA of all sites were highest among Army and Air Force members **(data not shown)**. Overall rates were lowest among Navy members for OA of all sites except the hand and wrist. Examination by occupational group revealed that the overall rates of diagnoses of OA of the knee among those working in health care and communications/intelligence occupations were at least 1.9 and 1.3 times, respectively, the rates among service members in other occupational groups **(Figure 10)**. In addition, the overall rate of incident diagnoses of OA of the hand among health care workers was 1.9 or more times those of service members in other occupational groups**.** The overall rate of shoulder OA among service members in combat-specific occupations was 9.4%–48.0% higher than rates among those in other occupational groups.

FIGURE 3. Overall incidence rates of osteoarthritis diagnoses, by occupation and age group, active component, U.S. Armed Forces, 2016–2020



[a]Infantry/artillery/combat engineering/armor.
P-yrs, person-years.

FIGURE 4. Crude annual incidence rates of osteoarthritis diagnoses, by sex, active component, U.S. Armed Forces, 2016–2020



P-yrs, person-years.

Spondylosis

Between 2016 and 2020, a total of 60,475 active component service members received incident diagnoses of spondylosis, for a crude overall incidence rate of 958.2 per 100,000 p-yrs **(Table 3)**. The crude overall rates of incident spondylosis diagnoses were broadly comparable among male and female service members. Similar to OA, there was a marked rise in overall incidence rates of spondylosis diagnoses with increasing age. Further stratification by sex showed that the pattern of increase with advancing age was roughly linear for male service members and approximately exponential for female service members **(Figure 11)**. Overall incidence rates of spondylosis diagnoses among male service members aged 20–44 were higher than comparably aged female service members. However, among those aged 45–49, overall spondylosis rates were very similar for service members of both sexes; however, among those 50 or older, the rate of OA diagnoses was considerably higher among female than male service members.

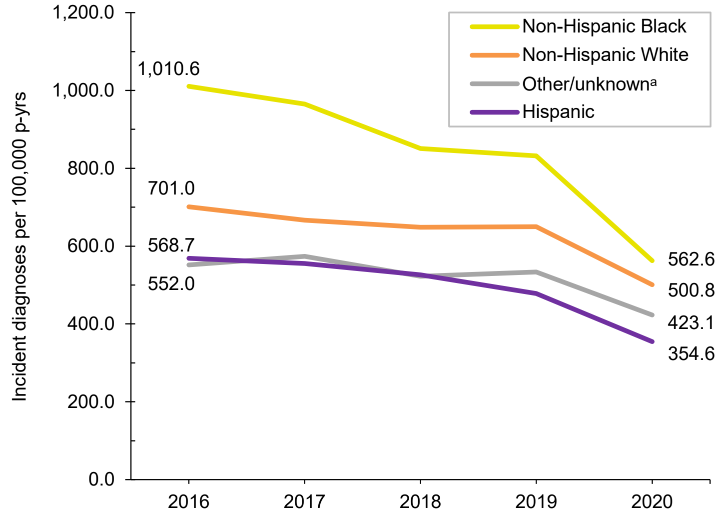
Crude overall rates of incident spondylosis diagnoses were markedly higher among non-Hispanic White (1,005.3 per 100,000 p-yrs) and non-Hispanic Black service members (1,000.6 per 100,000 p-yrs) compared to those among Hispanic service members (833.6 per 100,000 p-yrs) and those of other or unknown race/ethnicity (843.6 per 100,000 p-yrs) **(Table 3)**. Examination by race/ethnicity group and age group showed that the patterns of increase in rates with increasing age among non-Hispanic Black and Hispanic service members were similar through age 44 but then diverged, with non-Hispanic Black service members demonstrating markedly higher rates in the oldest 2 age groups (45 years or older) compared to Hispanic service members **(data not shown)**. The patterns of increasing overall rates of spondylosis with advancing age among non-Hispanic White service members and those in the other/unknown race/ethnicity group were broadly similar across all age groups **(data not shown)**.

Across the services, overall incidence rates of spondylosis diagnoses were highest among Army members (1,267.5 per 100,000 p-yrs) and lowest among Navy members (577.4 per 100,000 p-yrs) **(Table 3)**. Among those aged 25 or older, overall rates were highest among Army and Marine Corps members and intermediate among Air Force members; rates were lowest among Navy members in every age group **(Figure 12)**. The overall rates of incident spondylosis diagnoses among senior enlisted service members and senior officers were more than 4 and 2 times, respectively, those among their respective junior counterparts **(Table 3)**. Compared to those in other occupational groups, crude overall incidence rates of spondylosis diagnoses were highest among service members working in health care and communications/intelligence (1,161.6 and 1,102.0 per 100,000 p-yrs, respectively) occupations and lowest among those in the other/unknown occupational group (813.9 per 100,000 p-yrs). Further stratification by age group showed that, among service members 30 years or older, rates of spondylosis diagnoses were higher among those in combat-specific and motor transport occupations than among those in any other occupational groups; in all age groups 20 years or older, rates were lowest among pilots/air crew **(data not shown)**.

Results of multivariable regression analyses showed that, relative to pilots/air crew members, service members in all other occupational groups showed significantly elevated rates of spondylosis after adjusting for key covariates **(data not shown)**. Service members in motor transport (AIRR=1.64; 95% CI: 1.49–1.80), repair/engineering (AIRR=1.53; 95% CI: 1.41–1.65), and combat-specific (AIRR=1.52; 95% CI: 1.40–1.66) occupations had rates of spondylosis that were at least 1.5 times those of service members working as pilots/air crew **(data not shown)**. Service members in communications/intelligence, health care, and other/unknown occupations had rates of spondylosis that were 1.4, 1.4, and 1.3 times those of service members working as pilots/air crew, respectively **(data not shown)**.

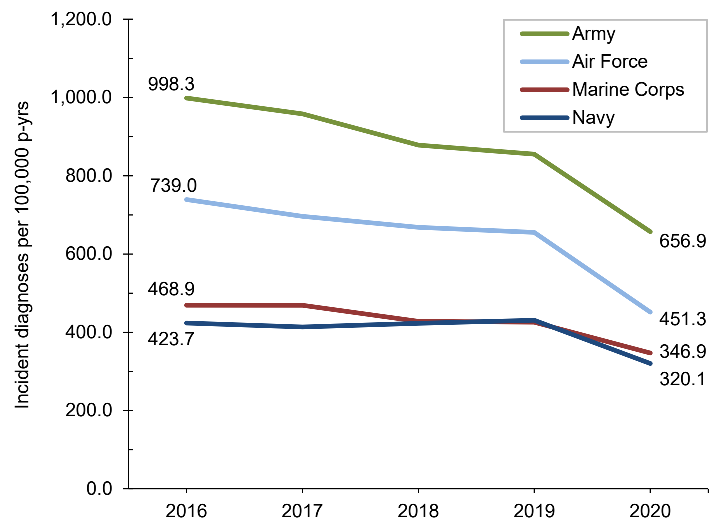
Between 2016 and 2020, crude annual rates of incident spondylosis diagnoses among active component service members decreased from a high of 1,101.6 per 100,000 p-yrs in 2016 to a low of 820.9 per 100,000 p-yrs in 2020 (25.5%) **(Figure 13)**. The greatest decline in incidence occurred between 2016 and 2018 after which the rate increased to 975.1 per 100,000 p-yrs in 2019 and then decreased to 820.9 per 100,000 p-yrs in 2020. Throughout the 5-year period, annual incidence rates of spondylosis diagnoses decreased in male and female service members with both sexes showing a similar pattern of change over time **(data not shown)**. Annual rates decreased among service members in all race/ethnicity groups with the greatest decrease (31.6%) among non-Hispanic Black service members **(data not shown)**. During the surveillance period, annual rates of incident spondylosis diagnoses decreased in all services with the greatest declines over time among members of the Air Force (37.7%) and Army (25.1%) **(Figure 13)**. Rates also decreased over the course of the 5-year period among service members in all occupational groups **(data not shown)**.

FIGURE 5. Crude annual incidence rates of osteoarthritis diagnoses, by race/ethnicity active component, U.S. Armed Forces, 2016–2020



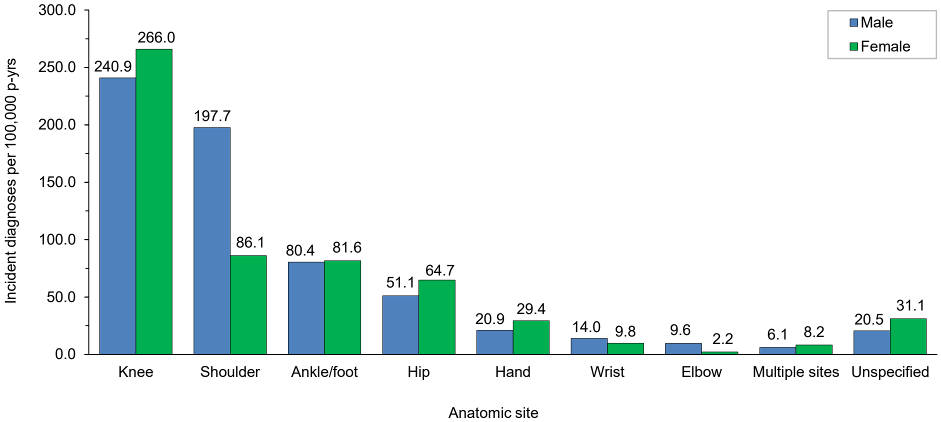
[a]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
P-yrs, person-years.

FIGURE 6. Crude annual incidence rates of osteoarthritis diagnoses, by service, active component, U.S. Armed Forces, 2016–2020



P-yrs, person-years.

FIGURE 7. Overall incidence rates of osteoarthritis diagnoses, by anatomic site and sex, active component, U.S. Armed Forces, 2016–2020



P-yrs, person-years.

EDITORIAL COMMENT

The results of the current study show that the crude annual incidence rates of OA and spondylosis diagnoses among active component service members decreased markedly (33.3% and 25.5%, respectively) from 2016 through 2020. During the 5-year period, annual rates of incident diagnoses of OA and spondylosis decreased in all of the demographic and military subgroups examined. These decreases in annual rates may be due, at least in part, to an overall decrease in combat operations during the study period and thus a possible decrease in the rates of extremity trauma. It is important to note that the drops in the incidence rates of diagnoses of both conditions between 2019 and 2020 may have been due, at least in part, to the COVID-19 pandemic. COVID-19 has led to decreases in the utilization of many types of health care,[47,48] ranging from preventive care to chronic disease management and emergency department visits.[49] Results of a web-based survey of a representative sample of U.S. adults aged 18 or older conducted in June 2020 showed that 40% of respondents reported having delayed or avoided seeking routine or emergent medical care because of the pandemic.[50]

The findings of this analysis re-emphasize the strong relationships between clinically significant OA and spondylosis and advancing age.[14] Across the age range of U.S. military members, rates of incident diagnoses of OA and spondylosis increased markedly with advancing age. This finding underscores the importance of accounting for the effects of age when assessing the effects of other potential risk factors.

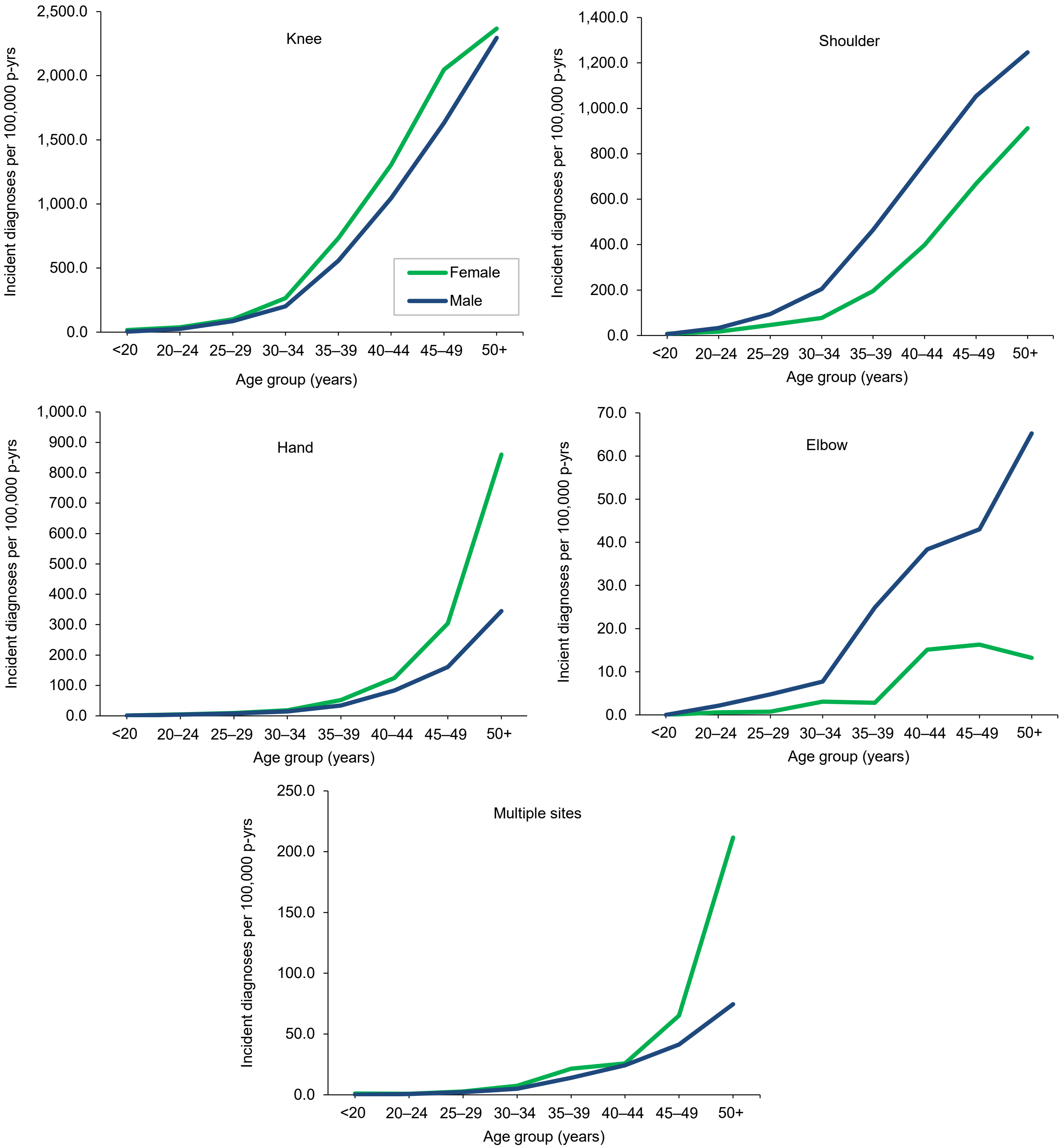
Subgroup analysis showed that male service members had a higher crude overall rate of incident OA diagnoses compared to female service members. This result is consistent with the results of the 2016 *MSMR* analysis;[46] however, Cameron and colleagues' study of active duty service members during 1999–2008 reported higher crude and age-adjusted incidence estimates among female than male service members.[39] The finding that, among individuals 45 years of older, rates of OA were higher among female than male service members is in line with many published studies of OA prevalence and incidence in the general U.S. population.[11,14,15] Compared to their respective counterparts, non-Hispanic Black service members, Army members, and those working in health care operations had the highest crude overall incidence rates of OA diagnoses. Stratification by age group showed that the highest overall rates of OA diagnoses were among non-Hispanic Black service members in those aged 20 or older, Army and Marine Corps members in those aged 25 or older, and those in motor transport and combat-specific occupations in service members aged 30 or older.

Cameron et al. described similar findings by race/ethnicity group among active duty U.S. military members between 1999 and 2008.[39] However, few other studies have examined the relationship between race and the occurrence of osteoarthritis in general. Analysis of 2010–2012 National Health Interview Study data indicated that, among individuals aged 18 or older, non-Hispanic Black adults had a prevalence of physician-diagnosed OA similar to that of non-Hispanic White adults.[29] Using data from the Johnston County (NC) Project, Nelson and colleagues reported that African Americans were more likely to develop multiple large-joint OA (knee, hip, spine) compared to those in other racial groups.[50] Scher et al. reported similar findings specific to OA of the hip among active duty U.S. service members during 1998–2006.[36] Results of several studies suggest that anatomic, neuromuscular, and biomechanical differences by race/ethnicity group (e.g., higher bone density/mass[51] and greater muscle mass[52]) may be linked to altered weight bearing and loading associated with joints in the lower extremity among non-Hispanic Blacks.

In all demographic and military subgroups examined, the knee joint was the anatomic site most frequently affected by OA. This finding is consistent with results of many studies of the occurrence of OA in U.S. general and military populations.[11,14,15,30,39] Differences were observed in anatomic site-specific rates of OA by sex, race/ethnicity, service, and military occupation. Crude overall rates of incident diagnoses of OA of the knee, hip and hand were higher among female than male service members; rates of OA of the shoulder and elbow were higher among male than female service members. Similar sex differences in the anatomic site-specific occurrence of OA have been reported from studies of the U.S. civilian population.[11,14,15] Overall incidence rates of diagnoses of OA of the knee and ankle/foot among non-Hispanic Black service members were markedly higher than those among non-Hispanic White service members. This finding of differences in OA site by race/ethnicity group mirrors results of studies of knee and hip OA in the general U.S. population.[14,25,54]

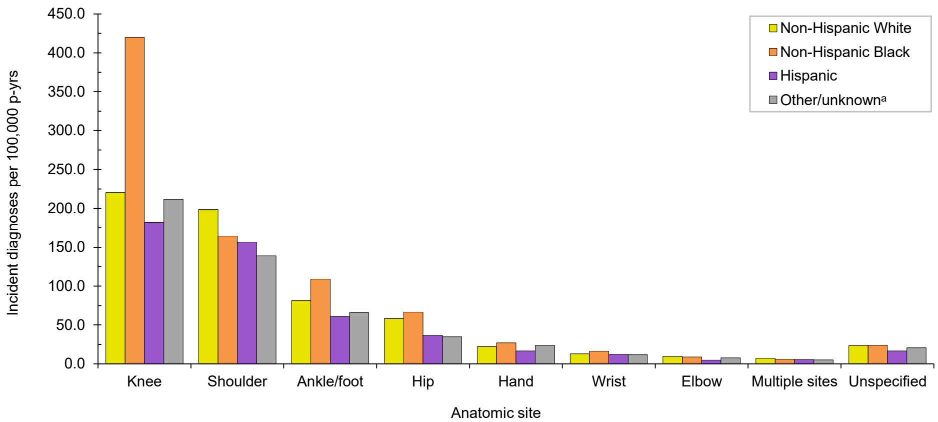
Across the services, overall rates of incident diagnoses of OA of all sites were highest among Army and Air Force members. The finding that crude and age-adjusted incidence rates of OA diagnoses were higher among Army members than among those in the other services is consistent with results described by Cameron et al. among active duty service members.[39] Scher and colleagues reported similar results for the incidence rate of primary hip OA among active duty service members.[36]

FIGURE 8. Overall incidence rates of osteoarthritis diagnoses, by anatomic site,[a] sex, and age group, active component, U.S. Armed Forces, 2016–2020



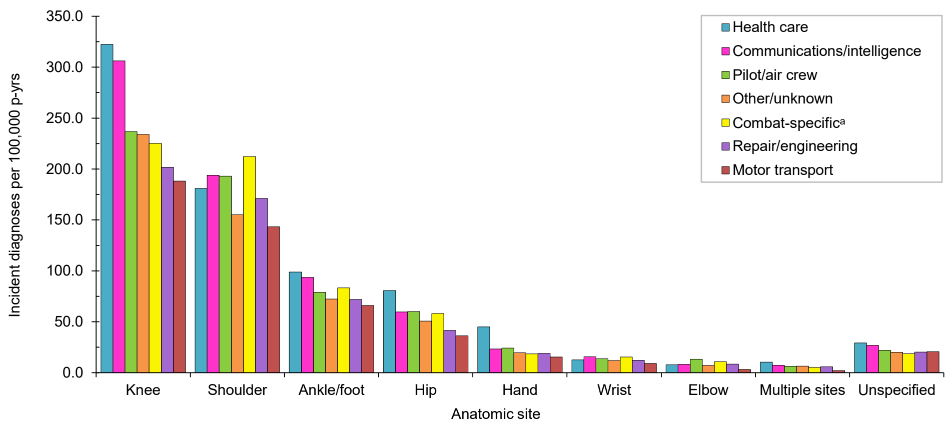
[a]Anatomic sites for which differences in overall rates by sex and age group are apparent.
P-yrs, person-years.

FIGURE 9. Overall incidence rates of osteoarthritis diagnoses, by anatomic site and race/ethnicity group, active component, U.S. Armed Forces, 2016–2020



[a]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
P-yrs, person-years.

FIGURE 10. Overall incidence rates of osteoarthritis diagnoses, by anatomic site and occupation, active component, U.S. Armed Forces, 2016–2020



[a]Infantry/artillery/combat engineering/armor.
P-yrs, person-years.

Differences in rates of incident OA diagnoses by military occupational group were apparent in both the crude and age-stratified results. The finding that, among service members aged 30 or older, those in the motor transport occupation category had the highest age-adjusted incidence rates of OA warrants additional study. Overall rates of diagnoses of OA of the knee among those working in health care and communications/intelligence occupations were markedly higher than rates among service members in other occupational groups. In addition, the overall rate of incident diagnoses of OA of the hand among health care workers was considerably higher than those of service members in other occupational groups. Service members in combat-specific occupations had the highest overall rate of shoulder OA compared to those in other occupational groups.

In the current analysis, service members working as pilots and other air crew had significantly lower crude and adjusted rates of incident diagnoses of both OA and spondylosis than those in all other occupational groups. AIRRs showed that, compared to their respective counterparts working as pilots/air crew, service members in all other occupational groups showed significantly elevated risk of OA and spondylosis after adjusting for key covariates. These findings for spondylosis were contrary to expectations given evidence that certain occupational conditions (e.g., helmets and headgear, awkward postures during

TABLE 3. Incident cases and incidence rates of spondylosis, by demographic and military characteristics, active component, U.S. Armed Forces, 2016–2020

	Total 2016–2020	
	No.	Rate[a]
Total	60,475	958.2
Sex		
Male	50,415	956.2
Female	10,060	967.9
Race/ethnicity group		
Non-Hispanic White	35,598	1,005.3
Non-Hispanic Black	10,229	1,000.6
Hispanic	8,458	833.6
Other/unknown[b]	6,190	843.6
Age group (years)		
<20	323	65.6
20–24	6,512	313.7
25–29	9,464	636.3
30–34	11,001	1,096.4
35–39	14,825	2,118.0
40–44	10,433	3,007.2
45–49	5,605	3,745.3
50+	2,312	4,107.0
Service		
Army	28,676	1,267.5
Navy	9,251	577.4
Air Force	15,659	1,013.6
Marine Corps	6,889	763.7
Rank		
Junior enlisted (E1–E4)	10,516	375.0
Senior enlisted (E5–E9)	36,801	1,526.2
Junior officer (O1–O3; W1–W3)	5,670	806.0
Senior officer (O4–O10; W4–W5)	7,488	1,907.0
Occupation		
Combat-specific[c]	8,791	1,011.3
Motor transport	1,577	843.0
Pilot/air crew	2,111	931.1
Repair/engineering	16,572	882.6
Communications/intelligence	14,820	1,102.0
Health care	6,362	1,161.6
Other/unknown	10,242	813.9

[a]Rate per 100,000 person-years.
[b]Includes American Indian/Alaska Native and Asian/Pacific Islander.
[c]Infantry, artillery, combat engineer, armor.

flight, flight accelerations, whole body vibrations) associated with flying may increase risk of degenerative changes in the cervical and lumbar spines of pilots.[55–57] However, other studies have found no relationships between musculoskeletal disorders experienced by pilots and job-related factors, especially regarding full-body vibration.[58,59] Results of the current analysis may reflect a tendency among military aviators and crewmen to seek care only for conditions that significantly interfere with their military occupational duties.

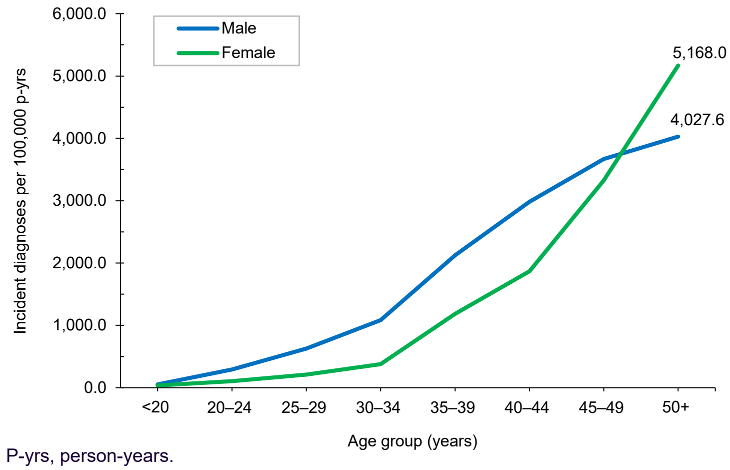
Many military occupations entail physically demanding work. Physical requirements of military service have been broadly characterized as climbing, digging, walking, marching and running, lifting and carrying, lifting and lowering, and pushing and pulling.[60] The preponderance of the published literature on the association between physically demanding work and OA has focused on OA of the hip and knee. Physically demanding jobs have been strongly associated with OA of both of these joints.[14,61–63] Recent reviews of the literature have found moderate to good evidence that heavy occupational lifting is associated with an increased risk of OA of the knee and the hip.[21,22] Moreover, results of some studies suggest that the combination of tasks that involve heavy lifting and kneeling[64] or squatting[65] further increases the risk of developing knee OA. In occupations that involve excessive squatting, this movement alone appears to be associated with knee OA.[21] The forces involved in squatting can have long-term adverse effects on both the mechanical functions of the knee joint and the structural integrity of the articular cartilage within the joint.[66] Activities that require knee bending or kneeling have also been associated with the development of knee OA.[21,22] A recent systematic review and synthesis of 69 occupational health and safety studies from 23 countries demonstrated moderate to strong evidence for no increased risk of hip or knee OA related to sitting, standing and walking, climbing ladders, or driving.[67]

Results of this same review and synthesis indicated that there was mixed or insufficient evidence related to work and OA of the hands, spine, and multiple joints.[67] Examination of studies focused on OA of the hands yielded moderate evidence for no effect of highly repetitive tasks on the development of wrist/hand/finger OA.[66] Evidence was mixed related to an association between lifting activities and physically demanding work and the development of spondylosis and OA in multiple joints, respectively.[67]

Physically demanding tasks such as carrying heavy loads, kneeling, and squatting are required elements of military training and many military occupations. Avoiding activities that require such tasks is not possible or desirable given that training must closely replicate expected combat/occupational actions.[54,59] Taking these constraints into account, prevention efforts could more reasonably be focused on minimizing initial injuries where possible,[7,68] ensuring complete rehabilitation of injuries when they do occur, achieving adequate strength around affected joints, and maintaining optimal body mass index.[69]

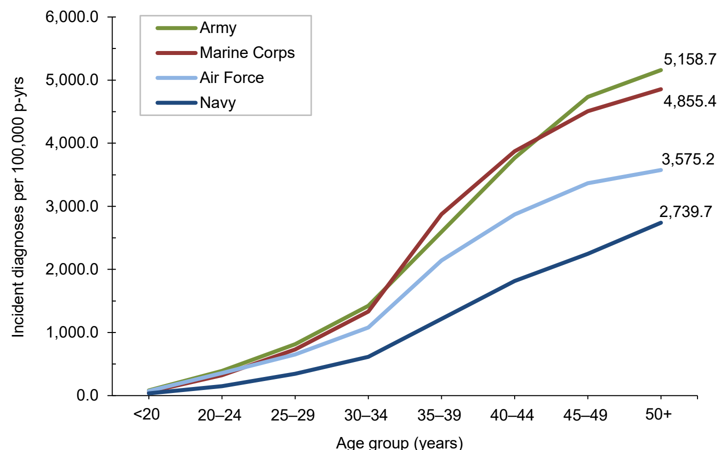
Several limitations should be considered when interpreting the results of this analysis. First, criteria for diagnosing OA

FIGURE 11. Overall incidence rates of spondylosis diagnoses, by sex and age group, active component, U.S. Armed Forces, 2016–2020



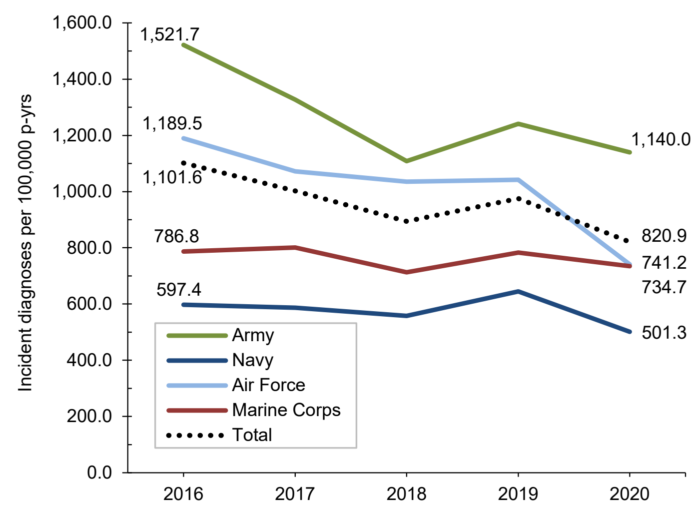
P-yrs, person-years.

FIGURE 12. Overall incidence rates of spondylosis diagnoses, by service and age group, active component, U.S. Armed Forces, 2016–2020



P-yrs, person-years.

FIGURE 13. Crude annual incidence rates of spondylosis diagnoses, by service, active component, U.S. Armed Forces, 2016–2020



P-yrs, person-years.

and spondylosis in active component service members may vary across health care providers and clinical settings, as well as in relation to the occupational duties of those affected. Some health care providers may diagnose these conditions based on symptoms alone, while others may require radiographic evidence of arthritic damage to the joints involved before reporting specific diagnoses in medical records. It is possible that the decline in incidence of both OA and spondylosis in the last year of the surveillance period may reflect the fact that some individuals with their first outpatient visits with qualifying diagnoses of OA or spondylosis in 2020 may not have had sufficient follow-up observation periods to have had second such visits, a necessary criterion to be counted as a case. In addition, this report summarizes diagnoses of OA and spondylosis that were reported on standardized records of hospitalizations and outpatient encounters in fixed U.S. military and civilian (i.e., purchased care) medical facilities if reimbursed through the MHS. Records of care received at civilian medical facilities outside the MHS but not reimbursed through the MHS were not available for this analysis. As a result, the numbers and rates of incident diagnoses reported here likely underestimate the actual numbers and rates of incident diagnoses of both conditions.

Also, there are limitations to the generalizability of the results because of the characteristics of the population. Active component service members are relatively young, healthy, physically active, and employed, and as such, may have unique risks (e.g., branch of service) and protective factors (e.g., lower body mass index). Also, military members have access to health care at no personal expense; as such, conditions such as OA and spondylosis could be diagnosed and medically documented more completely and earlier in their clinical courses than among many U.S. civilians. Thus, generalizations of the observed results should be limited to similar groups. Furthermore, it is difficult to determine differences in rates of degenerative OA versus post-traumatic OA, especially in the active component military population. However, a retrospective cohort study of U.S. Army soldiers from 2008 through 2012 demonstrated that soldiers who experienced knee joint trauma while on active duty were more than 5 times as likely to be diagnosed with OA of the knee during their military career compared to their respective counterparts with no knee joint injury.[70]

Additionally, this report summarizes the numbers and rates of incident (first time per person) diagnoses of the conditions of interest. As such, the results do not necessarily indicate the prevalences or military-operational impacts of the conditions in the Armed Forces. For example, service members with disabling OA or spondylosis may leave active military service earlier than their unaffected counterparts; if so, the continuous attrition from service of those affected would lower the prevalence, military operational impacts, and health care costs associated with the conditions among those who remain. Also, individuals who are unable to perform their occupation-specific duties due to OA or spondylosis may change occupations or separate from military service; if so, the prevalences of OA or spondylosis would be relatively higher in those occupations that retain service members with these conditions.

Finally, 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 through October 2019 were not included in the current analysis.

This report provides a descriptive summary of incidence rates of clinically significant OA and spondylosis among active component service members. Observed differences in incidence rates of OA diagnoses of specific anatomic sites by occupational group warrant further analysis to examine adjusted (e.g., by age, sex, race/ethnicity) incidence rates among service members within occupational groups. Findings also suggest a need for additional research to identify military-specific equipment and activities that significantly increase risk of acute and chronic damage to joints (particularly, the knees, shoulder, and back). Results of such research would be useful to develop, test, and implement practical and effective countermeasures against OA and spondylosis among military members in general and those in high-risk occupations specifically.

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Incident COVID-19 Infections, Active and Reserve Components, 1 January 2020–31 August 2021

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Between 1 January 2020 and 31 August 2021, a total of 189,239 service members were identified as confirmed or probable cases of COVID-19. The majority of cases were male (81.2%) and 57.3% were aged 20–29 years. Overall, 19.2% had a diagnosis of at least 1 of the pre-existing comorbidities of interest in the year prior to becoming a case. The most common pre-existing comorbidity was obesity or overweight (5.2%), followed by cardiovascular disease (4.2%), and substance use disorder including nicotine dependence (4.0%). Service members who were hospitalized for COVID-19 were twice as likely to have a diagnosis of any pre-existing comorbidity compared to those who were not hospitalized. There were a total of 1,760 hospitalizations (0.9%) and 45 deaths reported among service members. In addition, there were 11,899 cases observed among fully vaccinated individuals; however, only 0.4% of hospitalized cases were fully vaccinated and no service member deaths occurred among fully vaccinated individuals during the surveillance period, highlighting the importance of COVID-19 vaccination for force health protection.

WHAT ARE THE NEW FINDINGS?

This study describes the characteristics of COVID-19 cases among U.S. service members to date, including the prevalence of pre-existing comorbidities, vaccination status, and the proportion of cases hospitalized. This report also describes the characteristics of service members who died from COVID-19 during the surveillance period.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Detailed data on demographic characteristics, underlying medical conditions, and vaccination status can inform targeted communication to encourage persons in at-risk groups to practice preventive measures and promptly seek medical care if they become ill. Enhanced surveillance efforts can enable actions to prevent and control the current COVID-19 epidemic, which threatens the health of the force.

Since the beginning of the COVID-19 pandemic, there have been over 249 million COVID-19 cases and 5 million COVID-related deaths worldwide, including over 46 million cases and over 754 thousand deaths in the U.S.[1] Although most symptomatic cases of COVID-19 are mild, severe disease occurs in any demographic group.[2,3] Older individuals and those with underlying medical conditions are at higher risk of serious illness and death; this risk increases with advancing age.[3] The majority of COVID-19 deaths occur among adults aged 60 or older and among persons with serious underlying health conditions such as cancer, chronic kidney disease, chronic obstructive pulmonary disease (COPD), heart conditions (e.g., heart failure, coronary artery disease, cardiomyopathies), an immunocompromised state from solid organ transplant, and obesity (body mass index [BMI]=30–39.9 kg/m²).[4,5]

Two mRNA vaccines for COVID-19 (Moderna and Pfizer-BioNTech) were approved in December 2020 and an adenovirus-vectored vaccine (Janssen) was approved in late February 2021. Randomized clinical trials have shown that the current mRNA-based COVID-19 vaccines have high efficacies (94%–95%) for preventing COVID-19.[6,7] The Janssen adenovirus vectored vaccine also had moderately high efficacy against symptomatic COVID-19 (66%) and high efficacy against hospitalization for COVID-19 (93%).[8,9] Since these vaccines became available and used in the U.S., they have had substantial impacts on mitigating COVID-19 outbreaks and reducing risk of hospitalization and death.[10] Concerns were initially raised about the effectiveness of these vaccines against emerging new strains of SARS-CoV-2, including the Delta (B.1.617.2) variant, which became the predominant variant of the virus in the U.S. in July 2021.[12] There is currently very limited information about real-world effectiveness of the Janssen vaccine against the Delta variant. However, several studies have indicated moderate to high effectiveness of the Moderna and Pfizer-BioNTech vaccines against the Delta variant, particularly for preventing hospitalization and death.[12–14]

The Department of Defense (DoD) began COVID-19 vaccination in mid-December 2020. These vaccines were originally made available to service members on a voluntary basis according to occupational risk, but were made mandatory on 24 August 2021.[15] The objective of this study was to provide an update on the numbers of probable and confirmed COVID-19 cases among U.S. military service members in addition to describing demographics, prevalence of pre-existing comorbidities, hospitalization rates, and deaths.

METHODS

Since March 2020, the Armed Forces Health Surveillance Division (AFHSD) has maintained a case list of MHS beneficiaries with COVID-19. This list is updated daily and comprises Composite Health Care System (CHCS) Health Level 7 (HL7)-formatted and MHS Genesis laboratory positive test results extracted by the Navy and Marine Corps Public Health Center Epi Data Center (for all services), as well as medical event reports of laboratory confirmed and probable COVID-19 infection derived from the Disease Reporting System Internet (DRSi). AFHSD also maintains the Defense Medical Surveillance System (DMSS), a continuously expanding relational database of personnel and medical data.

For this analysis, cases of COVID-19 among active and reserve/guard component service members were included if the incident date occurred within 90 days of a personnel demographic record maintained in the DMSS. Beneficiary status (i.e., active or reserve/guard component) and branch of military service were determined based on the information recorded in the DMSS. The incident date for each COVID-19 case was defined as the earliest date of onset recorded in the DRSi, or the earliest collection date for the sample that tested positive via PCR or antigen laboratory testing.

In addition, DMSS data were used to identify hospitalizations for COVID-19 and for demographic information that was missing from the case list. DMSS data were also used to identify comorbidities from administrative records of inpatient and outpatient medical encounters, which included encounters from fixed military treatment facilities as well as outsourced care reimbursed by TRICARE. A hospitalization for COVID-19 was defined by having an inpatient record in DMSS occurring within 30 days after the first case record for COVID-19, with the International Classification of Diseases, 10th Revision (ICD-10) code U07.1 in the first or second diagnostic position, or a diagnosis of COVID-like illness in the first or second diagnostic position **(Table 1)**. An individual was considered to have a pre-existing comorbidity if there was an inpatient or outpatient encounter record containing an ICD-10 code for a comorbidity of interest within 365 days prior to the COVID-19 incident date **(Table 2)**.

Data on vaccination status at the time of the incident COVID-19 infection were derived from immunization records in the DMSS. An individual was considered fully vaccinated at the time of the case if the incident date occurred at least 14 days after the second dose of the Moderna (vaccine administered [CVX] code=207) or Pfizer-BioNTech (CVX code=208) vaccine, or at least 14 days after the first dose of the Janssen vaccine (CVX code=212). An individual was considered partially vaccinated if the individual had received at least 1 dose of vaccine but did not meet the aforementioned 14-day criteria for full vaccination.

COVID-19-related deaths occurring among service members were tracked and reported separately from cases of COVID-19. These deaths were identified via communication with the Armed Forces Medical Examiner System and via media reports, Director's Critical Information Requirement reports, the DRSi, and chart review of service members' electronic health record in the Armed Forces Health Longitudinal Technology Application (AHLTA). Information documented in these sources were used to describe pre-existing comorbidities and clinical course among those who died from COVID-19.

RESULTS

As of 31 August 2021, a total of 189,239 service members were identified as confirmed or probable cases of COVID-19 **(Table 3).** Of these cases, 19.2% had a medical encounter for at least 1 of the pre-existing comorbidities of interest in the year prior to becoming a case, and 6.9% had an encounter for 2 or more pre-existing comorbidities. There were a total of 1,760 hospitalizations (0.9%) and 45 deaths. Of the 42 deaths with past medical history data available for review, 17 (40.5%) had 1 pre-existing comorbidity of interest, 15 (35.7%) had 2 or more comorbidities and 10 (23.8%) had no comorbidities. A total of 111,801 cases occurred after COVID-19 vaccinations became available to the DoD on 11 December 2020. Among

TABLE 1. ICD-10 codes used to identify hospitalizations for COVID-19

Description	ICD-10
Coronavirus, unspecified	B34.2
SARS-associated coronavirus as the cause of disease classified elsewhere	B97.21
Other coronavirus as the cause of diseases classified elsewhere	B97.29
Acute nasopharyngitis; common cold	J00
Acute upper respiratory infection, unspecified	J06.9
Pneumonia due to SARS-associated coronavirus	J12.81
Other viral pneumonia	J12.89
Viral pneumonia unspecified	J12.9
Pneumonia due to other specified infectious organism	J16.8
Pneumonia in diseases classified elsewhere	J17
Bronchopneumonia, unspecified organism	J18.0
Lobar pneumonia, unspecified organism	J18.1
Other pneumonia, unspecified organism	J18.8
Pneumonia, unspecified organism	J18.9
Acute bronchitis due to other specified organisms	J20.8
Acute bronchitis, unspecified	J20.9
Unspecified acute lower respiratory infection	J22
Bronchitis, not specified as acute or chronic	J40
Acute respiratory distress syndrome	J80
Idiopathic interstitial pneumonia not otherwise specified	J84.111
Cough	R05
Dyspnea	R06.0
Dyspnea, unspecified	R06.00
Shortness of breath	R06.02
Acute respiratory distress	R06.03
Other forms of dyspnea	R06.09
Anosmia	R43.0
Ageusia	R43.2
Fever, unspecified	R50.9
2019-nCoV acute respiratory disease, COVID-19, virus identified	U07.1

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

TABLE 2. ICD-10 codes used to identify comorbidities

Description	ICD-10[a]
Hypertension	I10*–I16*, O10*–O16*
Any cardiovascular disease	I05*–I89*, Z95*
Chronic lower respiratory disease	J40*–J44*
Asthma	J45*
Any lung disease	J40*–J99*
Metabolic disease	E08*–E13*, O24*, Z794*, E00*–E07*, E50*–E64*, E88.81
Immune-compromising conditions	B20, D55*–D77*, D80*–D89*, Z94*, Z795*, L40*, M04*–M08*, K50*–K52*
Substance use disorders (including nicotine dependence)	F10*–F16*, F18*–F19*, F17*
Chronic liver disease	K70*–K77*, B18*
Chronic kidney disease	N03*–N16*, N18*–N19*
Chronic neurologic disorders	G10*–G40*
Neoplasms	C00*–D49*
Obesity or overweight	E66.0*, E66.1, E66.2, E66.3, E66.8, E66.9, Z68.3*, Z68.4*, Z68.25–Z68.29

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD-10, International Classification of Diseases, 10th Revision.

these cases, 83.7% (n=93,616) occurred among unvaccinated service members, 10.6% (n=11,899) cases occurred among fully vaccinated individuals, and 5.6% (n=6,286) occurred among partially vaccinated individuals. A total of 48 hospitalizations for COVID-19 occurred among fully vaccinated service members and there were 44 hospitalizations among partially vaccinated service members **(data not shown)**. No service member deaths occurred among vaccinated individuals, except for 1 active duty member who had received 1 dose of Pfizer vaccine 18 days prior to his death.

Service members who were hospitalized for COVID-19 were twice as likely to have a diagnosis of any comorbidity in the year prior to becoming a case compared to those who were not hospitalized, and almost 3 times as likely to have a diagnosis of multiple comorbidities **(Table 4)**. Of note, those who were hospitalized were 5 times as likely to have a prior diagnosis of chronic liver disease and almost 4 times as likely to have a prior hypertension diagnosis, compared to those who were not hospitalized. Of the 32 service member deaths with hospitalization data available, 24 (75.0%) were hospitalized at the time of death, 8 (25.0%) were found unresponsive at home or at an alternate site, and 1 died en route to the hospital.

The highest peak in the number of past 14-day incident COVID-19 cases among all service members occurred on 15 January 2021 with a total of 16,418 past 14-day cases, and was preceded by a peak on 11 December 2020 of 11,131 past 14-day cases **(Figure)**. Following the peak on 15 January 2021, there was another peak on 25 August 2021 of 9,875 past 14-day cases coinciding with the period of transmission of the Delta variant.

Active component

A total of 163,171 active component members had been infected with the SARS-CoV-2 virus as of 31 August 2021 **(Table 3)**. The largest demographic proportions of cases were among those who were male (81.6%), aged 20–24 (37.5%), non-Hispanic White (51.0%), and in the Army (42.0%). About one-fifth (19.9%) of the infected cases had a diagnosis of a pre-existing comorbidity in the year prior to becoming a case, and 7.0% were diagnosed with 2 or more comorbidities. Of the comorbidities that were assessed, the most commonly diagnosed were obesity or overweight (n= 8,690; 5.3%), substance use including nicotine dependence (n= 7,191; 4.4%), and cardiovascular disease (n= 6,840; 4.2%). A total of 1,504 active component members (0.9%) were hospitalized, with a median hospital stay of 4 days (interquartile range [IQR]=2–6). A total of 10,731 cases (11.1%) among the 96,539 cases that occurred after 11 December 2020 were fully vaccinated, and 5.6% (n=5,396) were partially vaccinated.

During the surveillance period, there were 17 deaths among active component COVID-19 cases **(data not shown)**. Past medical history was available in AHLTA for all of the active component service member deaths reviewed. COVID-specific case-related information, including clinical progression of illness, was available for review in 12 (70.6%) AHLTA records and 17 (100.0%) corroborative clinical reports and summaries, typically prepared by the services following a death. Of the active component deaths, 7 (41%) were Army, 7 (41%) were Navy, 2 (12%) were Air Force, and 1 (6%) was Marine Corps. The average age at death was 39 years. A majority (82.4%; n=14) of those who died had at least 1 comorbidity of interest and 52.9% (n=9) had a BMI that placed them in the overweight or obese category. The 2 most common pre-existing comorbidities among those who died were obesity (52.9%; n=9) and cardiovascular disease, primarily hyperlipidemia (23.5%, n=4). At the time of death, 11 service members were hospitalized, 4 were "found unresponsive" at home or at an alternative site and later pronounced dead in the emergency room, and 1 died en route to the hospital. Hospitalization data for 1 service member was not available. The clinical progression of illness for most hospitalized cases followed a standard pattern of deterioration: onset of symptomatic illness, increasing dyspnea (shortness of breath) with development of COVID pneumonia, ICU admission; onset of acute respiratory distress syndrome (ARDS) followed by intubation and mechanical ventilation, development of COVID-related complications (e.g., cardiogenic shock, myocarditis, deep vein thrombosis, disseminated intravascular coagulation, etc.) and death. None of the active component service members who died were fully vaccinated.

TABLE 3. COVID-19 confirmed and probable cases, active and reserve components, U.S. Armed Forces, 1 January 2020–31 August 2021

	Active component		Reserve/Guard component		Total	
	No.	%	No.	%	No.	%
Total	163,171	100.0	26,068	100.0	189,239	100.0
U.S. Census region						
Northeast	2,685	1.6	642	2.5	3,327	1.8
Midwest	14,015	8.6	3,751	14.4	17,766	9.4
South	93,857	57.5	16,828	64.6	110,685	58.5
West	39,968	24.5	3,365	12.9	43,333	22.9
Overseas	12,646	7.8	1,482	5.7	14,128	7.5
Sex						
Male	133,128	81.6	20,607	79.1	153,735	81.2
Female	30,043	18.4	5,461	20.9	35,504	18.8
Age group (years)						
<20	17,652	10.8	5,458	20.9	23,110	12.2
20–24	61,258	37.5	5,617	21.5	66,875	35.3
25–29	37,425	22.9	4,219	16.2	41,644	22.0
30–34	21,731	13.3	3,621	13.9	25,352	13.4
35–39	14,780	9.1	2,957	11.3	17,737	9.4
40–44	6,717	4.1	1,921	7.4	8,638	4.6
45–49	2,569	1.6	1,111	4.3	3,680	1.9
50+	1,039	0.6	1,164	4.5	2,203	1.2
Race/ethnicity group						
Non-Hispanic White	83,230	51.0	14,519	55.7	97,749	51.7
Non-Hispanic Black	30,681	18.8	4,440	17.0	35,121	18.6
Hispanic	33,232	20.4	4,826	18.5	38,058	20.1
Other[a]	13,480	8.3	1,975	7.6	15,455	8.2
Unknown	2,548	1.6	308	1.2	2,856	1.5
Sponsor service branch						
Army	68,495	42.0	17,948	68.9	86,443	45.7
Navy	33,878	20.8	1,704	6.5	35,582	18.8
Marine Corps	20,486	12.6	788	3.0	21,274	11.2
Air Force	39,005	23.9	5,580	21.4	44,585	23.6
Coast Guard	1,307	0.8	48	0.2	1,355	0.7
Comorbidities (1 year prior to infection)						
Hypertension						
Yes	4,482	2.7	833	3.2	5,315	2.8
No	158,689	97.3	25,235	96.8	183,924	97.2
Any cardiovascular disease						
Yes	6,840	4.2	1,079	4.1	7,919	4.2
No	156,331	95.8	24,989	95.9	181,320	95.8
Asthma						
Yes	1,637	1.0	211	0.8	1,848	1.0
No	161,534	99.0	25,857	99.2	187,391	99.0
Any lung disease						
Yes	2,998	1.8	412	1.6	3,410	1.8
No	160,173	98.2	25,656	98.4	185,829	98.2
Metabolic disease						
Yes	4,792	2.9	720	2.8	5,512	2.9
No	158,379	97.1	25,348	97.2	183,727	97.1
Immune compromising conditions						
Yes	5,568	3.4	552	2.1	6,120	3.2
No	157,603	96.6	25,516	97.9	183,119	96.8

TABLE 3 (cont). COVID-19 confirmed and probable cases, active and reserve components, U.S. Armed Forces, 1 January 2020–31 August 2021

	Active component		Reserve/Guard component		Total	
	No.	%	No.	%	No.	%
Substance use disorders (including nicotine dependence)						
Yes	7,191	4.4	381	1.5	7,572	4.0
No	155,980	95.6	25,687	98.5	181,667	96.0
Chronic lower respiratory disease						
Yes	414	0.3	81	0.3	495	0.3
No	162,757	99.7	25,987	99.7	188,744	99.7
Chronic liver disease						
Yes	577	0.4	110	0.4	687	0.4
No	162,594	99.6	25,958	99.6	188,552	99.6
Chronic kidney disease						
Yes	710	0.4	105	0.4	815	0.4
No	162,461	99.6	25,963	99.6	188,424	99.6
Chronic neurologic disorders						
Yes	841	0.5	97	0.4	938	0.5
No	162,330	99.5	25,971	99.6	188,301	99.5
Neoplasms						
Yes	5,327	3.3	884	3.4	6,211	3.3
No	157,844	96.7	25,184	96.6	183,028	96.7
Obese or overweight						
Yes	8,690	5.3	1,104	4.2	9,794	5.2
No	154,481	94.7	24,964	95.8	179,445	94.8
Any comorbidity						
Yes	32,534	19.9	3,731	14.3	36,265	19.2
No	130,637	80.1	22,337	85.7	152,974	80.8
Two or more comorbidities						
Yes	11,386	7.0	1,688	6.5	13,074	6.9
No	151,785	93.0	24,380	93.5	176,165	93.1
Hospitalized						
Yes	1,504	0.9	256	1.0	1,760	0.9
No	161,667	99.1	25,812	99.0	187,479	99.1
Median hospital stay in days (IQR)	4 (2-6)		4 (2.5-7)		4 (2-6)	
DoD occupation						
Combat-specific[b]	24,878	15.2	1,751	6.7	26,629	14.1
Motor transport	6,013	3.7	840	3.2	6,853	3.6
Pilot/air crew	4,888	3.0	796	3.1	5,684	3.0
Repair/engineering	45,662	28.0	4,679	17.9	50,341	26.6
Communications/intelligence	33,086	20.3	5,035	19.3	38,121	20.1
Health care	13,015	8.0	1,508	5.8	14,523	7.7
Other/unknown	35,629	21.8	11,459	44.0	47,088	24.9
Vaccination status						
Case occurred prior to 11 December 2020	66,632	40.8	10,806	41.5	77,438	40.9
Fully vaccinated	10,731	6.6	1,168	4.5	11,899	6.3
Partially vaccinated	5,396	3.3	890	3.4	6,286	3.3
Unvaccinated	80,412	49.3	13,204	50.7	93,616	49.5

[a]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
[b]Infantry, artillery, combat engineer, armor.
No., number.

Reserve/Guard component

A total of 26,068 COVID-19 cases were identified among reserve and guard service members **(Table 3)**. The largest proportions of cases were male (79.1%), aged 20–24 (21.5%), non-Hispanic White (55.7%), and in the Army (68.9%). About one-seventh (14.3%) of cases were diagnosed with a pre-existing comorbidity, and 6.5% were diagnosed with 2 or more comorbidities. Of the pre-existing comorbidities that were assessed, the most commonly diagnosed comorbidities were obesity or overweight (n=1,104; 4.2%), cardiovascular disease (n=1,079; 4.1%), and neoplasms (n=884; 3.4%). A total of 256 reserve/guard members (1.0%) were hospitalized, with a median hospital stay of 4 days (IQR=2.5–7). A total of 1,168 cases (7.7%) among the 15,262 cases that occurred after 11 December 2020 were fully vaccinated, and 5.8% (n=890) were partially vaccinated.

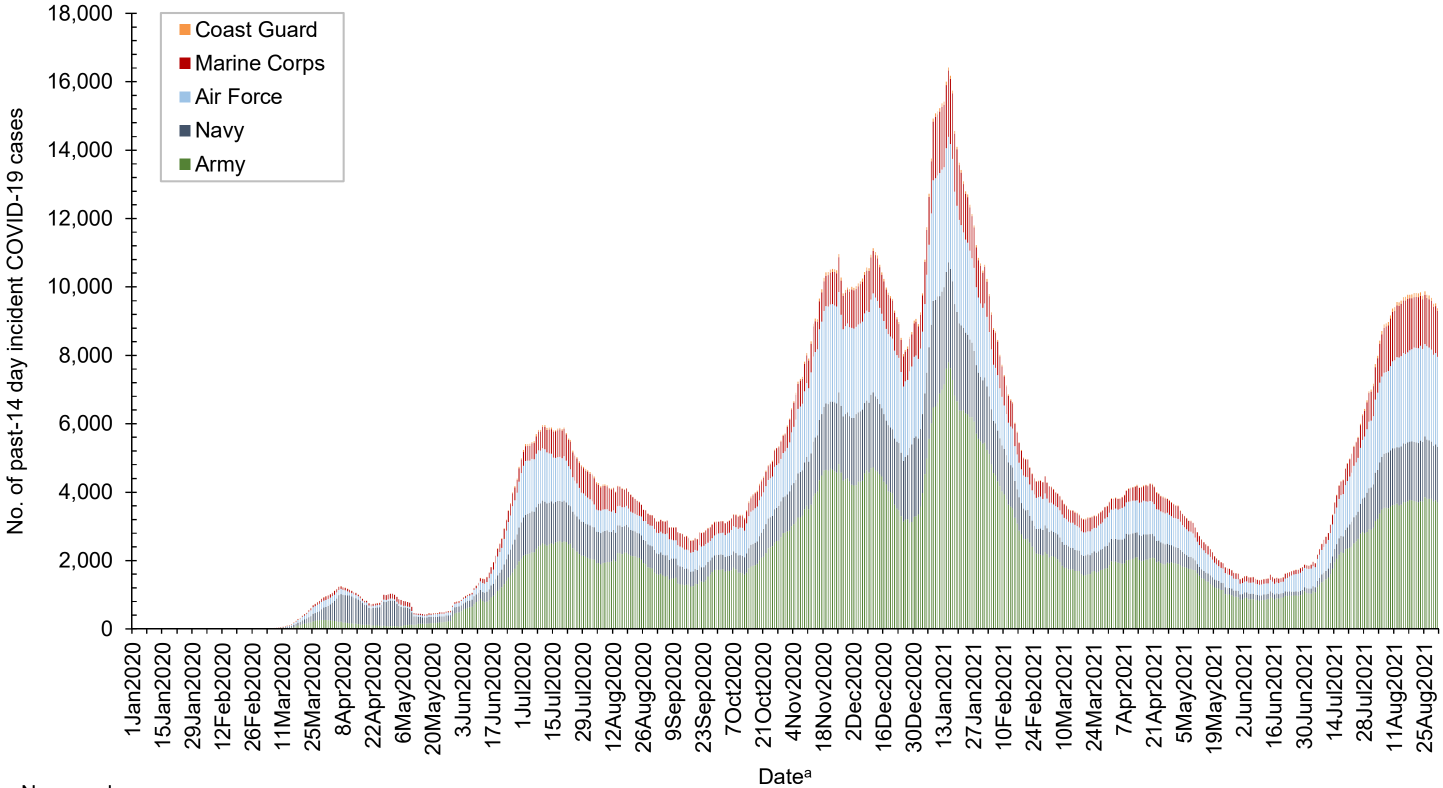
There were 28 deaths among reserve and guard COVID-19 cases; of these, 8 were on active duty status at the time of death **(data not shown)**. Past medical history was available in AHLTA for 25 (89.3%) of the reserve/guard deaths reviewed. COVID-specific case-related information, including clinical progression of illness, was available in AHLTA and corroborative clinical reports/summaries for all of the reserve/guard members who died while on active duty, but only available for 5 (25%) reserve/guard members who died while not on active duty. Similarly, vaccination status was available for all of the activated reserve/guard members who died, but only available for 11 (55%) of the inactivated reserve/guard members who died. Of the total reserve guard deaths, 19 (67.9%) were Army, 5 (17.9%) were Navy, and 4 (14.3%) were Air Force. The average age at death was 47 years. Of those with available data in AHLTA or in other sources, 15 (62.2%; 15/23) had at least 1 pre-existing comorbidity and 12 (54.5%; 12/22) had BMIs that placed them in the category of overweight or obese. Similar to the active component, the most common comorbidities among reserve/guard deaths were obesity (54.5%) and cardiovascular disease (25.0%; 6/24), with 4 having a diagnosis of hyperlipidemia. Of the 11 inactive reserve/guard

TABLE 4. Pre-existing comorbidities by hospitalization status, active and reserve components, U.S. Armed Forces, 1 January 2020–31 August 2021

	Hospitalized (n=1,760)		Not hospitalized (n=187,479)	
	No.	%	No.	%
Hypertension				
Yes	180	10.2	5,135	2.7
No	1,580	89.8	182,344	97.3
Any cardiovascular disease				
Yes	213	12.1	7,706	4.1
No	1,547	87.9	179,773	95.9
Asthma				
Yes	39	2.2	1,809	1.0
No	1,721	97.8	185,670	99.0
Any lung disease				
Yes	80	4.5	3,330	1.8
No	1,680	95.5	184,149	98.2
Metabolic disease				
Yes	145	8.2	5,367	2.9
No	1,615	91.8	182,112	97.1
Immune compromising conditions				
Yes	128	7.3	5,992	3.2
No	1,632	92.7	181,487	96.8
Substance use disorders (including nicotine dependence)				
Yes	115	6.5	7,457	4.0
No	1,645	93.5	180,022	96.0
Chronic lower respiratory disease				
Yes	13	0.7	482	0.3
No	1,747	99.3	186,997	99.7
Chronic liver disease				
Yes	32	1.8	655	0.3
No	1,728	98.2	186,824	99.7
Chronic kidney disease				
Yes	23	1.3	792	0.4
No	1,737	98.7	186,687	99.6
Chronic neurologic disorders				
Yes	23	1.3	915	0.5
No	1,737	98.7	186,564	99.5
Neoplasms				
Yes	107	6.1	6,104	3.3
No	1,653	93.9	181,375	96.7
Obese or overweight				
Yes	214	12.2	9,580	5.1
No	1,546	87.8	177,899	94.9
Any comorbidity				
Yes	650	36.9	35,615	19.0
No	1,110	63.1	151,864	81.0
Two or more comorbidities				
Yes	345	19.6	12,729	6.8
No	1,415	80.4	174,750	93.2

No., number.

FIGURE. Past 14-day COVID-19 cases, active and reserve components, U.S. Armed Forces, 1 January 2020–31 August 2021



No., number.
[a]Date reflects the number of active cases on a given date.

service members with available COVID-specific case-related data, 8 (72.7%) were hospitalized at the time of death with a clinical progression of illness that followed the standard pattern outlined above and 3 (27.3%) were found unresponsive at home or at an alternate site and later pronounced dead in the emergency room. None of the reserve/guard service members who died were fully vaccinated.

EDITORIAL COMMENT

This report describes the demographic characteristics and prevalence of pre-existing comorbidities among service members with incident COVID-19 infection. Not surprisingly, cases among service members (including recruits) were most commonly diagnosed in young, non-Hispanic White males, which follows the expected demographic distributions of these groups. Overall, 19.2% had a medical encounter for at least 1 of the pre-existing comorbidities of interest in the year prior to becoming a case.

The most common pre-existing comorbidities in both hospitalized and non-hospitalized cases were obesity or overweight, followed by cardiovascular disease. These same pre-existing comorbidities were also common among service members who died from COVID-19.

For each of the comorbidities evaluated in this study, hospitalized COVID-19 cases were more likely than non-hospitalized cases to have had a medical encounter for the condition in the past year. Chronic liver disease, hypertension, and chronic kidney disease were among the comorbidities most likely to be previously diagnosed in the hospitalized cases compared to the non-hospitalized cases. The finding that chronic liver disease was more likely to be diagnosed in hospitalized compared to non-hospitalized cases is noteworthy because recent studies have suggested that chronic liver disease is not a significant comorbid condition for COVID-19.[16,17] However, other studies have indicated that cirrhosis increases risk for COVID-19 hospitalization and death among patients with chronic liver disease, and that cirrhosis may play a role in immune dysfunction.[18,19]

There were totals of 1,760 hospitalizations (0.9%) and 45 deaths among service members as of 31 August 2021. Although there were 11,899 cases of COVID-19 occurring among fully vaccinated individuals, only 0.4% of hospitalized cases were fully vaccinated and no service member deaths occurred among fully vaccinated individuals, highlighting the importance of COVID-19 vaccination for force health protection. In particular, 45 deaths corresponds to a cumulative case fatality ratio of about 0.02% (i.e., 1 death per 4,205 infected), which is much lower than the case fatality ratio of 1.6% observed in the general U.S. population.[20] This lower case fatality ratio is not surprising given that service members are on average younger and healthier compared to members of the general U.S. population.

It should be noted that the progression of illness followed a standard clinical course for a majority of service members who died from COVID-19 during the surveillance period.[21] However, there were a few individuals who experienced rapid deterioration after having been discharged from the hospital and some who died suddenly at home or at an alternate site with COVID symptoms or a previously diagnosed COVID-19 infection. Acute respiratory and thrombotic complications of COVID-19 have been previously reported as common causes of death, with many patients having comorbidities such as hypertension, ischemic heart disease, and obesity.[22] In patients who die suddenly, severe systemic inflammation, multi-organ dysfunction, and cardiovascular failure may also play a role.[23–25] It is important to note that, although service members are a generally young and healthy population experiencing few deaths due to COVID-19, they are still vulnerable to the harmful effects of this disease particularly if they have pre-existing comorbidities and are unvaccinated.

There are several limitations that should be considered when interpreting the results of this study. First, the prevalence of pre-existing comorbidities among all cases may be underestimated because medical encounter data were queried in the year prior to the incident date of the case. Individuals who did not seek medical care for these conditions during this time period would not be captured. However, comorbidities may also be overestimated because the case definition allowed for only a single medical encounter to qualify as a comorbidity; therefore, screening encounters that were miscoded using the diagnosis code for that condition may overestimate the occurrence of certain pre-existing comorbidities. Importantly, as the science evolves more is being learned about the types of medical conditions that place individuals at higher risk for severe illness from COVID-19. The list of comorbidities investigated in this analysis is not exhaustive and should be re-evaluated in subsequent investigations. Second, the expansion of MHS Genesis to military treatment facilities throughout most of the western U.S. presented challenges to linking MHS GENESIS laboratory records with case information in the DRSi and the CHCS. As a result, some cases may have been missed. Finally, the number of cases, vaccination information, and hospitalization status may have also been underestimated if individuals were seen for care outside of the MHS TRICARE network, which is most likely to occur among inactivated reserve/guard members.

The COVID-19 pandemic continues to have persistent person-to-person spread in the community worldwide and will require continuous monitoring as new variants of the SARS-CoV-2 virus emerge. Findings presented here draw attention to the necessity of building on present-day disease surveillance efforts to collect and analyze case prevalence data, and in particular data including vaccination status, hospitalization, death, and serious underlying health conditions. Continued surveillance of COVID-19 among service members remains an important part of force health protection efforts.

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Surveillance Snapshot: Donovanosis Among Active Component Service Members, U.S. Armed Forces, 2011–2020

Denise O. Daniele, MS; Thomas Wilkerson, MPH

Donovanosis, or granuloma inguinale, is an uncommon sexually transmitted infection (STI) that is much rarer than chlamydia, gonorrhea, and syphilis. Donovanosis is found mainly in tropical regions, and is highly correlated with populations affected by poverty and lack of access to hygiene and public health infrastructure. However, recent news reports have described donovanosis as a “flesh-eating” STI that may be increasing in incidence in developed countries.[1–3]

Donovanosis is a bacterial infection of the skin and mucous membranes in the genital region.[4–5] Early lesions are small, painless nodules that grow into characteristic “beefy red” highly vascular ulcers and progressively expand. Untreated cases can result in tissue destruction and scarring. Although clinical diagnosis is possible, ulcers may be hard to differentiate from those associated with syphilis, chancroid, HIV-associated herpes, amoebiasis, and carcinoma. For this reason, confirmation via staining of tissue or biopsies is recommended. The causative agent is *Klebsiella granulomatis*, a gram-negative intracellular bacillus, which produces characteristic Donovan bodies within mononuclear cells upon staining. Antibiotics such as azithromycin, doxycycline, erythromycin, ciprofloxacin, and trimethoprim-sulfamethoxazole are curative over a 3-week course or until sores have healed.

For this analysis, the Defense Medical Surveillance System was searched for records of inpatient and outpatient care for diagnoses of donovanosis. A case was defined by the recording of 1 inpatient or outpatient diagnosis of donovanosis (International Classification of Diseases, 9th Revision Clinical Modification [ICD-9-CM]: 099.2; ICD-10-CM: A58) in the primary diagnostic position. An individual could be counted as an incident case only once during the surveillance period (2011–2020). The surveillance population included all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during this period. During the 10-year period, there were 50 incident cases of donovanosis. Cases were split relatively evenly by sex (female service members: 54%; male service members: 46%) and most cases occurred in those aged 20–29 (56%) **(data not shown)**. The annual numbers of cases ranged from 3 to 10 with no discernable trend over time **(Figure)**.

Although the incidence of donovanosis has been very low among service members, it is important for health care providers to be aware of trends of emerging STIs particularly among young, sexually active individuals who may travel to endemic areas. As with other STIs, the best prevention of donovanosis is protected sex.

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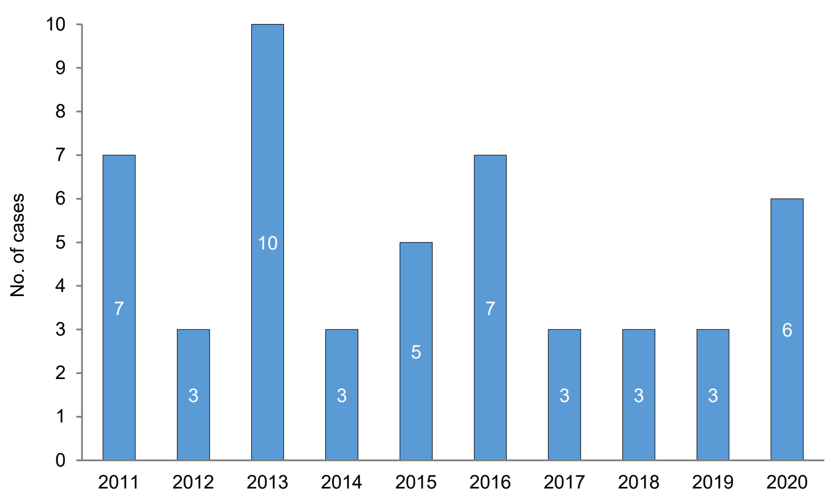
FIGURE. Cases of donovanosis among active component service members, U.S. Armed Forces, 2011–2020



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