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# MSMR

## MEDICAL SURVEILLANCE MONTHLY REPORT


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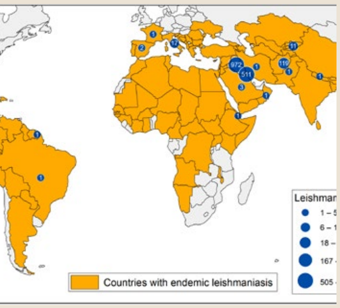



CDC/Carl Washington, MD, Emory Univ. School of Medicine; Mona Saraiya, MD, MPH



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# Incident Diagnoses of Leishmaniasis, Active and Reserve Components, U.S. Armed Forces, 2001–2016

*Shauna Stahlman, PhD, MPH; Valerie F. Williams, MA, MS; Stephen B. Taubman, PhD*

During the surveillance period, there were 2,040 incident diagnoses/reports of leishmaniasis among members of the U.S. Armed Forces. Cutaneous leishmaniasis accounted for more than three-fifths (61.0%) of the total diagnoses/reports among active component service members and for less than half (48.0%) of the total cases among reserve component members. The visceral form of leishmaniasis represented 1.2% of the total cases. Approximately two-fifths (40.6%) of the total diagnoses/reports were classified as "unspecified" with respect to the type of leishmaniasis. The lowest annual numbers of diagnoses/reports in the past decade were seen in 2011–2016 and reached a nadir of 11 cases in 2015. During the entire surveillance period, 71.7% of the total leishmaniasis cases were diagnosed or reported during the 7 months from early autumn to the beginning of spring (September–March) in the northern hemisphere. The majority of cases acquired in the Middle East (73.6%), South/Central America (87.5%), and other or unknown locations (64.5%) were diagnosed or reported during this 7-month interval.

Leishmaniasis is a zoonotic disease caused by protozoan parasites of the genus *Leishmania* that are transmitted to humans by the bites of infected female sandflies (*Lutzomyia* species in the Americas and *Phlebotomus* species in Europe, Africa, and Asia).[1-4] The disease is endemic in many regions of Africa, Mexico, South and Central America, southern Europe, Asia, and the Middle East.[1-5]

The clinical manifestations of leishmaniasis are varied and depend on the infecting species of protozoa as well as the immune status and immunoinflammatory responses of the host.[2,6] Cutaneous, mucosal, and visceral leishmaniasis, the three major clinical forms, result from infection of macrophages in the dermis, in the naso-oropharyngeal mucosa, and throughout the reticuloendothelial system, respectively. Cutaneous leishmaniasis is the most prevalent form of leishmaniasis and manifests as papules or nodules that may progress to ulcers and eventually heal spontaneously.[3,4,7] The mucosal form of leishmaniasis causes partial or total destruction of mucous membranes in the nose, mouth, and throat.[6] The manifestations of visceral leishmaniasis affect several internal organs (usually the spleen, liver and bone marrow) and can be life threatening. Affected people generally experience fever, hepatosplenomegaly, pancytopenia, hyperglobulinemia, and emaciation.[6-8]

Many leishmaniasis infections are asymptomatic, a reflection of the host immune system's ability to control the parasite.[2,8] Among people who do develop signs or symptoms of leishmaniasis, the time intervals from infection to first clinical manifestation generally range from a week to many months, with much longer periods (e.g., up to several years) for visceral infections.[2,6,8]

Leishmaniasis continues to be of military medical surveillance interest because of deployments to endemic areas of the Middle East (Iraq, Afghanistan, and Kuwait).[1,9-12] More U.S. service members were potentially exposed to leishmaniasis during their service in Operations Enduring Freedom, Iraqi Freedom, New Dawn, Inherent Resolve, and/or Freedom's Sentinel than at any other time since World War II. Previous *MSMR* articles (November/December 2004 and April 2007) reported on the frequencies, rates, and demographic characteristics of U.S. service members who were diagnosed/reported with leishmaniasis.[11,12] This report represents an update to these articles and expands the analysis to include information on the location of acquisition of leishmaniasis infection.

## METHODS

The surveillance period was 1 January 2001 through 31 December 2016. The surveillance population included active and reserve component members of the U.S. Armed Forces. The Defense Medical Surveillance System (DMSS) was searched to identify hospitalizations, reportable medical events, as well as outpatient and in-theater medical encounters that included diagnoses of leishmaniasis. A case of leishmaniasis was defined as one hospitalization or outpatient medical encounter documented with a qualifying ICD-code diagnosis in any diagnostic position (ICD-9: 085.0–085.9, ICD-10: B55), or a reportable medical event record of confirmed leishmaniasis. For these analyses, an individual was considered an incident case only once per lifetime. The incidence date was considered the date of onset documented in a reportable medical event, or the first hospitalization or outpatient medical encounter with a defining diagnosis of leishmaniasis. Incidence rates of leishmaniasis (per 100,000 person-years [p-yrs]) were calculated only for the active component. Deployment-related person-time was computed as time during deployment plus 180 days after deployment. All other person-time was considered non-deployment related. Because at the time of analysis person-time was available only through the end of October 2016, the person-time for calendar year 2016 was weighted by 1.2 to estimate the amount of complete person-time for that year.

Presumed locations of leishmaniasis acquisition were estimated using a hierarchical classification algorithm: 1) Cases that were identified in hospitalizations or ambulatory encounters in a country with endemic leishmaniasis[13] were considered acquired in that country; 2) reportable medical event case reports that listed exposures to leishmaniasis endemic countries were considered acquired in that country; 3) cases diagnosed among service members who were deployed or within 180 days of returning from a deployment to a leishmaniasis country were considered acquired in that country; and 4) all remaining cases were considered acquired in unknown locations. To be considered a "deployment-related" case, the incident case must have occurred while the service member was deployed to, or within 180 days of returning from deployment to a leishmaniasis country.

## RESULTS

During the 16-year surveillance period, there were 2,040 incident diagnoses/reports of leishmaniasis among members of the U.S. Armed Forces **(Table 1)**. Slightly more than three-quarters (77.7%) of the total incident diagnoses/reports were among service members in the active component. The affected active component service members were predominantly male (95.1%); white, non-Hispanic (68.6%); younger than 30 years old (65.9%); and in the Army (89.7%). The majority (73.0%) of total cases of leishmaniasis among active

**TABLE 1.** Leishmaniasis cases by type and selected demographic characteristics, active and reserve components, U.S. Armed Forces, 2001–2016

| | Total | | | | | |
|---|---|---|---|---|---|---|
| | Visceral | Cutaneous | Unspecified | Total | Rate per 100,000 person-years | % of total active component cases |
| **Active component** | | | | | | |
| Total | 19 | 968 | 599 | 1,586 | 7.2 | |
| **Service** | | | | | | |
| Army | 12 | 903 | 507 | 1,422 | 17.4 | 89.7 |
| Navy | 3 | 20 | 29 | 52 | 1.0 | 3.3 |
| Air Force | 4 | 33 | 35 | 72 | 1.3 | 4.5 |
| Marine Corps | 0 | 12 | 28 | 40 | 1.3 | 2.5 |
| **Sex** | | | | | | |
| Male | 18 | 936 | 555 | 1,509 | 8.1 | 95.1 |
| Female | 1 | 32 | 44 | 77 | 2.4 | 4.9 |
| **Age group** | | | | | | |
| <20 | 1 | 39 | 12 | 52 | 3.4 | 3.3 |
| 20–24 | 6 | 408 | 203 | 617 | 8.6 | 38.9 |
| 25–29 | 5 | 234 | 137 | 376 | 7.6 | 23.7 |
| 30–34 | 2 | 141 | 91 | 234 | 7.1 | 14.8 |
| 35–39 | 3 | 90 | 86 | 179 | 6.7 | 11.3 |
| 40–44 | 1 | 42 | 43 | 86 | 5.6 | 5.4 |
| 45–49 | 1 | 10 | 21 | 32 | 5.6 | 2.0 |
| 50+ | 0 | 4 | 6 | 10 | 5.0 | 0.6 |
| **Race/ethnicity** | | | | | | |
| White, non-Hispanic | 11 | 679 | 398 | 1,088 | 8.1 | 68.6 |
| Black, non-Hispanic | 7 | 137 | 99 | 243 | 6.5 | 15.3 |
| Hispanic | 0 | 85 | 56 | 141 | 5.6 | 8.9 |
| Other | 1 | 67 | 46 | 114 | 5.2 | 7.2 |
| **Deployment related** | | | | | | |
| Yes | 10 | 743 | 405 | 1158 | 39.0 | 73.0 |
| No | 9 | 225 | 194 | 428 | 2.3 | 27.0 |
| **Reserve component** | | | | | | |
| Total (no. of cases only) | 6 | 218 | 230 | 454 | --- | |
| Total active and reserve components | 25 | 1186 | 829 | 2,040 | | |

component service members were classified as deployment related **(Table 1)**.

More than half (58.1%) of the total diagnoses/reports of leishmaniasis were cases of cutaneous leishmaniasis **(Table 1)**. Cutaneous leishmaniasis accounted for more than three-fifths (61.0%) of the total diagnoses/reports among active component service members and for less than half (48.0%) of the total cases among reserve component members. More than three-quarters (76.8%) of the cases of cutaneous leishmaniasis among active component service members were deployment related. The visceral form of leishmaniasis represented 1.2% of the total cases (n=25). Nineteen of the 25 service members affected by visceral leishmaniasis were in the active component and six were in the reserve component. Among those in the active component, 10 (52.6%) were classified as deployment related **(Table 1)**.

Approximately two-fifths (40.6%) of the total diagnoses/reports were classified as "unspecified" with respect to the type of leishmaniasis. Among those in the active component, more than two-thirds (67.6%) of the unspecified cases were classified as deployment related **(Table 1)**. Notably, if the period of time after deployment to a leishmaniasis country was extended from 180 days to 730 days, an additional 539 cases would have been classified as deployment related. Cutaneous leishmaniasis accounted for more than two-fifths (41.4%) of these additional cases. More than half of these cases were classified as "unspecified" type and the remainder (1.4%) were classified as the visceral form of leishmaniasis **(data not shown)**.

As described in the April 2007 *MSMR*, numbers of diagnoses/reports of leishmaniasis increased sharply from 2002 to 2003, remained relatively high in 2004, and then decreased considerably in 2005.[12] The lowest annual numbers of diagnoses/reports during the subsequent period were seen in 2011–2016 and reached a nadir of 11 in 2015 **(Figure 1)**. The marked decline after 2004 is attributable to the decrease in numbers of leishmaniasis diagnoses/reports linked to Iraq, Kuwait, and Afghanistan **(data not shown)**.

During the surveillance period, the overall incidence rate of leishmaniasis among service members in the active component was 7.2 per 100,000 p-yrs **(Table 1)**. The overall incidence rate of leishmaniasis among active component service members in the Army was more than 10 times the rates among the other services. Annual incidence rates among active component service members during the 16-year period peaked at 40.6 diagnoses/reports per 100,000 p-yrs in 2003 and reached a low of 0.5 diagnoses/reports per 100,000 p-yrs in 2015 **(Figure 1)**.

As expected, during the surveillance period, the majority (86.6%) of total leishmaniasis cases were acquired in the Middle East **(Figure 2)**. Less than one-eighth (11.5%) of the total cases were acquired

**FIGURE 1.** Clinical diagnoses/reports of leishmaniasis and estimated leishmaniasis incidence rate, by year of clinical onset/diagnosis, by component, U.S. Armed Forces, 2001–2016

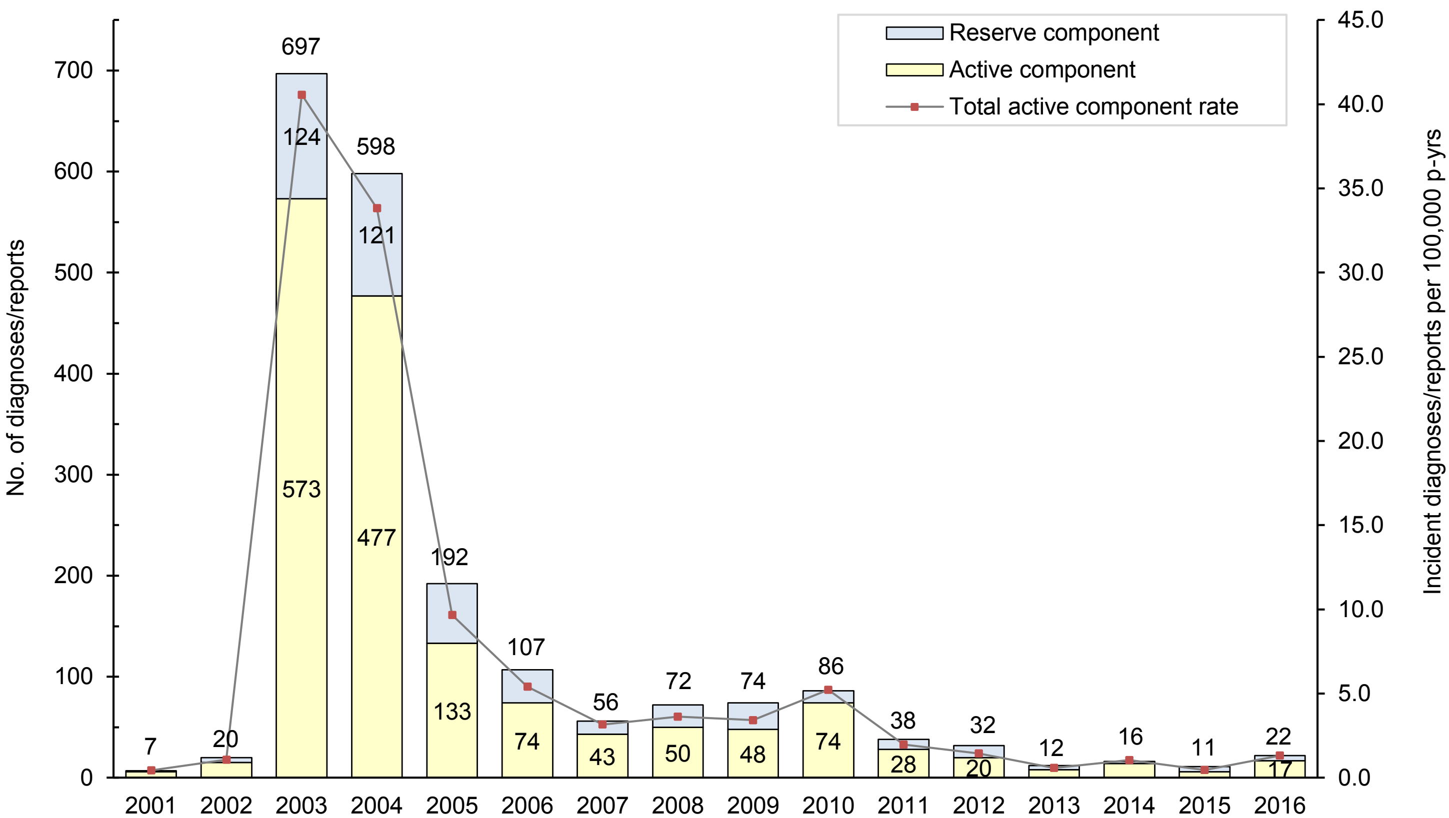
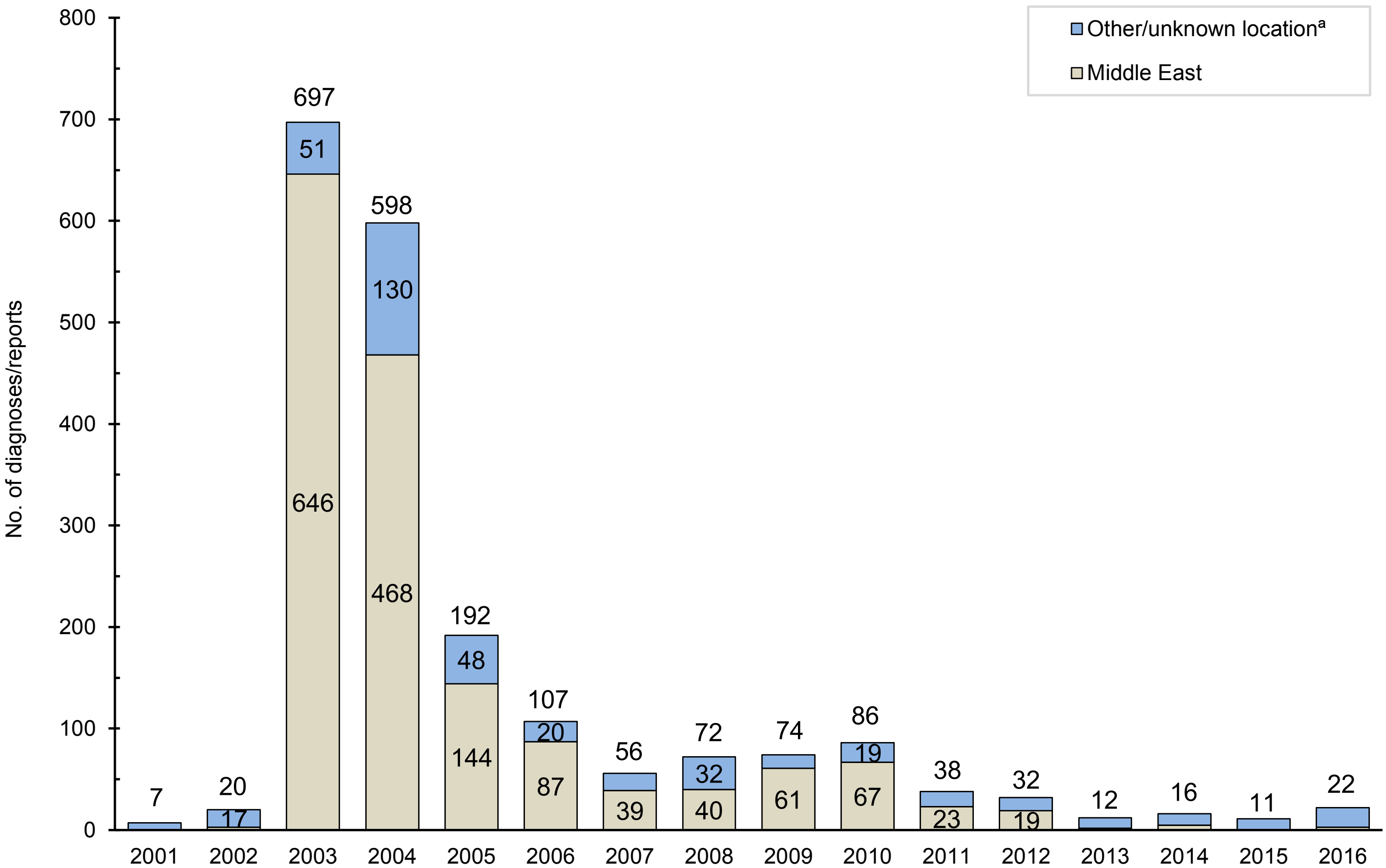


**FIGURE 2.** Clinical diagnoses/reports of leishmaniasis, by year of clinical onset/diagnosis, by geographical location of acquisition, active and reserve components, U.S. Armed Forces, 2001–2016




[a] "Other" includes locations in Europe (n=20), Asia (n=13), South/Central America (n=8), and Africa (n=1).

in unknown locations. Approximately 2% of the cases were acquired in "other" locations, which included Europe (n=20), Asia (n=13), South/Central America (n=8), and Africa (n=1). Of the cases acquired in the Middle East, approximately three-fifths (60.5%) were acquired in Iraq; close to one-third (31.8%) were acquired in Kuwait; and 7.4% were acquired in Afghanistan. Less than 1% of cases were acquired in other locations within the Middle East, including Saudi Arabia (n=3), Oman (n=1), and Iran (n=1) **(data not shown)**. The vast majority of total deployment-related cases were acquired in the Middle East **(data not shown)**. **Figure 3** displays the geographical distribution of the countries in which leishmaniasis cases were acquired during the surveillance period and depicts the number of cases for each.

During the entire period of 2001–2016, 71.7% (1,463 of 2,040) of the total leishmaniasis cases were diagnosed or reported during the 7 months from early autumn to the beginning of spring (September–March) in the northern hemisphere **(Figure 4)**. However, in 2016, 54.5% (12 of 22) of leishmaniasis cases among U.S. service members were diagnosed or reported during September–March. During the past 16 years, 73.6% of cases acquired in the Middle East (1,182 of 1,607), 87.5% of cases acquired in South/Central America (7 of 8), and 64.5% of cases acquired in other or unknown locations (274 of 425) were diagnosed or reported during this 7-month interval **(data not shown)**. For the purposes of the latter statement, "other" included locations in Europe (n=20), Asia (n=13), and Africa (n=1).

## EDITORIAL COMMENT

Since January 2001, approximately 2,000 U.S. service members were diagnosed/reported with leishmaniasis. However, the actual number of those affected was probably much higher. Consider, for example, that some infected service members likely had no or minor clinical manifestations of disease and did not seek evaluation; others who sought evaluation/treatment may not have been diagnosed with "leishmaniasis"; and others may have been diagnosed with leishmaniasis but their cases were not centrally reported (e.g., diagnoses were made outside of the Military Health System). For these reasons, it is likely that the numbers and rates of leishmaniasis reported here underestimate the actual numbers and

**FIGURE 3.** Total numbers of leishmaniasis diagnoses/reports by geographic location of acquisition, active and reserve components, U.S. Armed Forces, 2001–2016

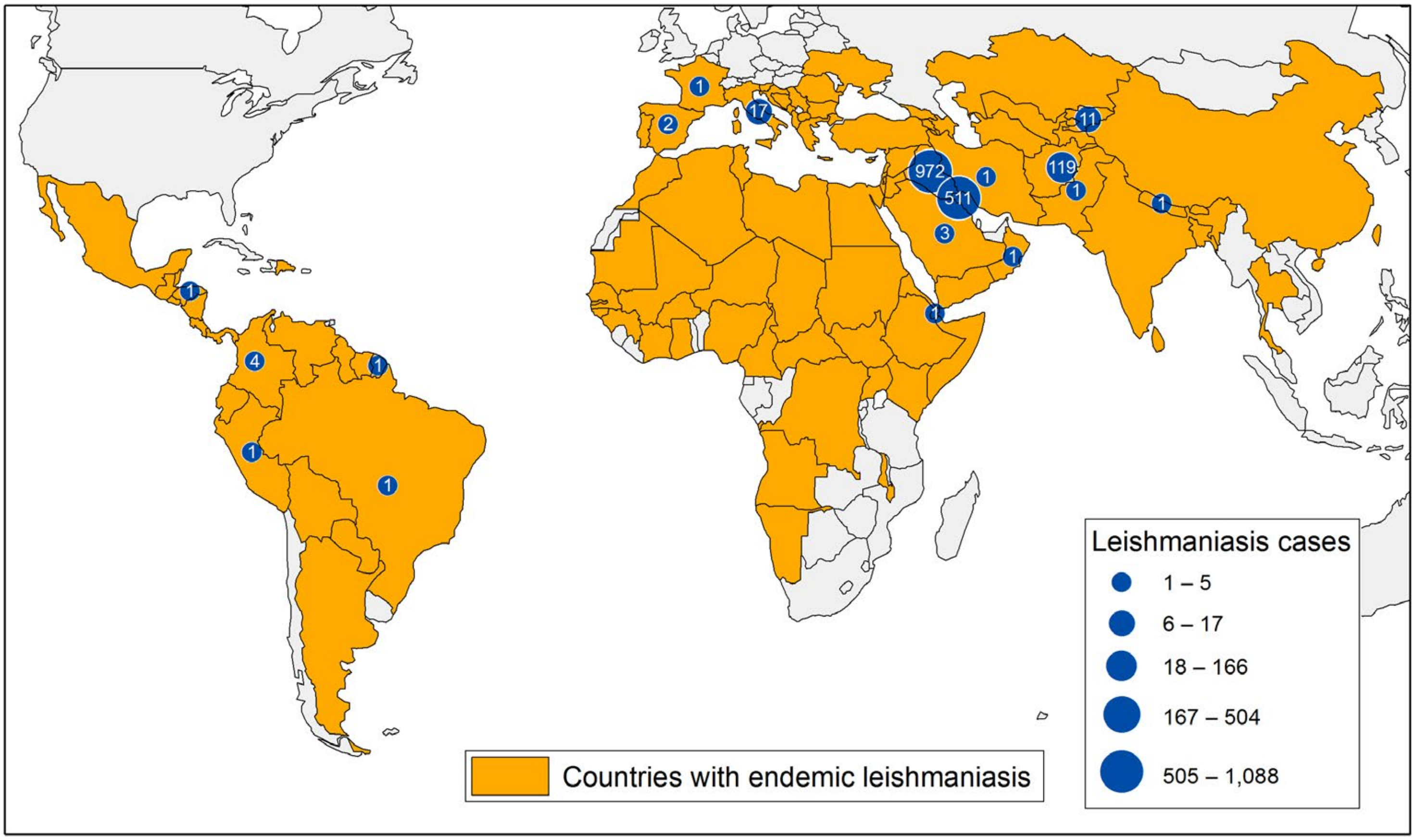
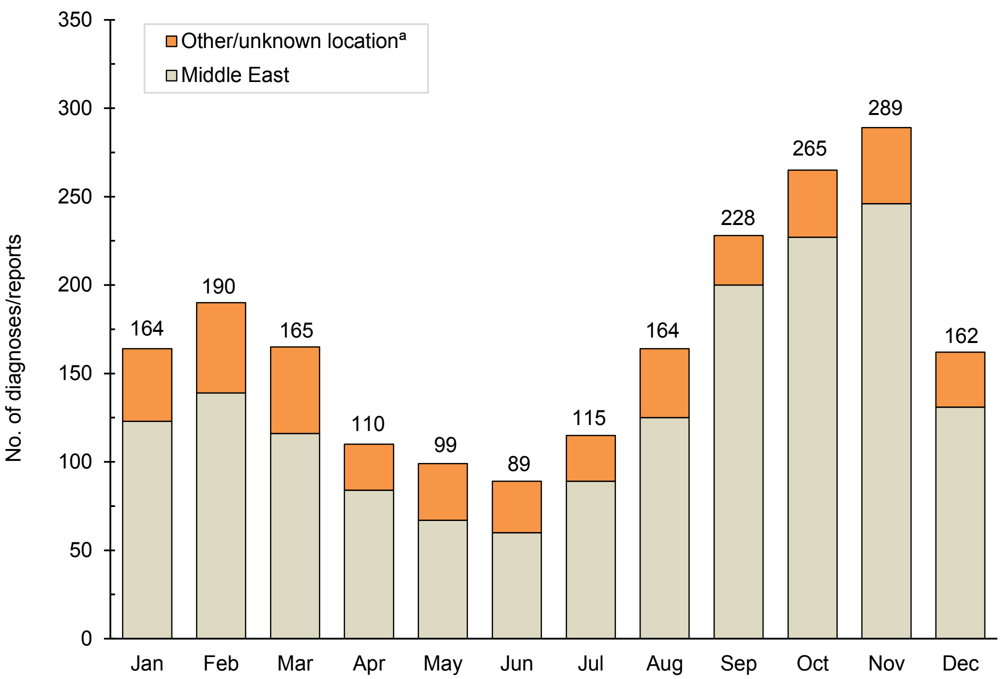



**FIGURE 4.** Diagnoses and reported cases of leishmaniasis, by location of acquisition of infection and cumulative month of clinical presentation/diagnosis, active and reserve components, U.S. Armed Forces, January 2001–December 2016




[a]"Other" includes locations in Europe (n=19), Asia (n=14), South/Central America (n=8), and Africa (n=1).

rates of leishmaniasis infections acquired during the surveillance period. It is also worth noting that there is often a significant lag between the date of the first clinical manifestation of leishmaniasis and the date of clinical diagnosis and reporting. Such a lag and the highly variable incubation periods of leishmaniasis, ranging from weeks to months and sometimes more than a year, are plausible explanations for the preponderance of cases diagnosed outside the warmer months of the peak sandfly biting season.[14,15] Given this, estimates of dates of infection should be considered imprecise estimates of actual infection times. Similarly, locations of acquisition are estimated using an algorithm and may not be representative of actual locations of acquisition. This is particularly true for leishmaniasis cases acquired during personal travel, which is not systematically documented in DMSS.

Several factors likely contributed to the sharp decrease in numbers and rates of cases of diagnosed/reported leishmaniasis since 2003. For example, since 2003, there have been substantial improvements in tents and buildings (e.g., air conditioning, sandfly-proof windows) on many U.S. installations in Iraq and Afghanistan, and security needs often mandated sleeping in hardened structures. In addition, sandfly populations near U.S. military troop concentrations have been actively controlled and strict compliance with personal protective measures to prevent sandfly bites has been emphasized.[16-18] Lastly, in recent years, U.S. forces have not been deployed in large numbers in the vicinity of the Iran-Iraq border where the estimated case rate exceeded 200 per 1,000 deployed persons in 2003.

Visceral leishmaniasis is endemic in Iraq and Afghanistan. Sandflies that are competent vectors of visceral leishmaniasis are prevalent in areas where U.S. forces operate. Yet, fewer cases of visceral leishmaniasis have been diagnosed/reported among participants in military operations during the surveillance period than the first Gulf War. Visceral leishmaniasis can be clinically inapparent for long periods, and its first clinical manifestation can be a nonspecific febrile illness.[6,8] Physicians and other primary care providers should include leishmaniasis among possible diagnoses among veterans of military service in the Middle East and other endemic areas who have exposure histories and clinical presentations compatible with cutaneous or visceral leishmaniasis. In November 2016, the Infectious Diseases Society of America and the American Society of Tropical Medicine and Hygiene released updated guidelines for the diagnosis and clinical management of leishmaniasis.[7]

For prevention of leishmaniasis, no vaccines or chemoprophylaxis currently are available. Infection confers protection for at least several years against reinfection with similar species of *Leishmania*.[19] Leishmanization (intentional skin infection with *L. major*) has been effectively used to prevent infections in Israel, Iran,[20] Uzbekistan,[21] and the former Soviet Union.

All military personnel who serve in leishmaniasis-endemic areas should be informed of the nature of the risks and measures to counter them. Specifically, all service members who are at risk of leishmaniasis should be trained, equipped, supplied, and supervised to ensure compliance (especially from dusk to dawn) with indicated personal protective measures, including the consistent and proper wear of permethrin-treated uniforms; use of military-issued, DEET-containing insect repellent on exposed skin; and use of permethrin-treated bednets to prevent sandfly bites.[22]

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# Incidence Rates of Malignant Melanoma in Relation to Years of Military Service, Overall and in Selected Military Occupational Groups, Active Component, U.S. Armed Forces, 2001–2015

*John F. Brundage, MD, MPH (COL, USA, Ret); Valerie F. Williams, MA, MS; Shauna Stahlman, PhD, MPH; Mark G. McNellis, PhD*

During the 15-year surveillance period, there were 2,233 incident diagnoses of malignant melanoma among members of the active component of the U.S. military (unadjusted incidence rate 1.08 cases per 10,000 person-years [p-yrs]). Unadjusted incidence rates were highest in the fixed-wing pilot/crew group (2.45 per 10,000 p-yrs); lowest in the infantry, special operations, combat engineer group (0.77 per 10,000 p-yrs); and intermediate among healthcare providers (1.33 per 10,000 p-yrs) and all others (1.07 per 10,000 p-yrs). During the 15-year period, rates of malignant melanoma diagnoses among U.S. military members overall increased in an exponential fashion in relation to years of active service. However, this relationship varied across occupational groups. Most notably, after several years of service, rates of melanoma diagnoses increased relatively rapidly among pilots and the crews of fixed-wing aircraft (e.g., fighters, bombers, cargo/personnel transporters) and those in occupations inherently conducted outdoors (e.g., infantry, special operations, combat engineers). In contrast, melanoma diagnosis rates increased relatively slowly among healthcare providers and those in "other" military occupations. The findings reiterate the importance of limiting, to the extent possible given mission requirements, exposures of military members to solar ultraviolet and cosmic ionizing radiation.

Malignant melanomas occur when the DNA of pigment-producing skin cells, called melanocytes, is damaged (as from solar ultraviolet or cosmic ionizing radiation) and cells so affected undergo malignant transformation. Because malignant melanomas can grow rapidly and spread widely, they can impair vital bodily functions and threaten the lives of those affected.

A recent *MSMR* report documented that, among U.S. military members, the incidence of non-melanoma skin cancers (e.g., basal cell, squamous cell) far exceeded that of all other cancer types, including melanomas.[1] However, from 2005 through 2014, other than non-melanoma skin cancers, malignant melanomas were the most frequently diagnosed cancer among U.S. military members overall and the second most frequently diagnosed cancer among males (after testicular cancer) and females (after breast cancer).[2] Thus, of all cancers, non-melanoma skin cancers are the most common. However, of all skin cancers, melanomas are the most lethal.

In general among U.S. military members, incidence rates of both melanoma and non-melanoma skin cancers sharply increase with age and are higher among white than other racial/ethnic group members. Also, rates of both melanoma and non-melanoma skin cancers are higher in the Air Force and Navy, and among healthcare and fixed-wing aviation-related military occupational group members, compared to their respective counterparts.[2,3]

Undoubtedly, much of the variation in rates across military and occupational groups reflects differences in the demographic characteristics of the groups (e.g., healthcare workers and fixed-wing aviators are generally older than their counterparts). Also, there likely are differences in the ascertainment and reporting of suspicious lesions as "melanomas." For example, healthcare workers may detect and seek assessments of suspicious lesions more expeditiously than others; and aviators may be examined more closely than others during mandatory, periodic flight physical examinations.

Three exposures inherent to specific military activities are potential risk factors for the development of malignant melanomas:

Cosmic ionizing radiation exposure is inherently associated with high-altitude aviation. Several studies have documented relatively high rates of melanoma in the pilots and crews of commercial airliners and military fixed-wing aircraft.[4-6]

Solar ultraviolet radiation is associated with exposure to direct sunlight. There is abundant and consistent evidence that ultraviolet radiation from the sun increases risk of malignant melanoma.[7-12] However, the natures and timing of solar ultraviolet exposures that contribute the most to the increased risk are not well understood.[12-20] Military members may have significant exposures to solar ultraviolet radiation during training and operations outdoors (e.g., infantry, special operations, combat engineers).

Ionizing radiation is inherent to many medical diagnostic and treatment procedures. As such, healthcare providers may be exposed to ionizing radiation in their workplaces. At least one study found increased rates of melanoma among radiologic technologists.[21] Currently, all healthcare workers who are occupationally exposed to ionizing radiation are monitored to ensure their exposures are below risk-associated thresholds. Still, by the natures of their duties, some military healthcare providers may have low-level exposures to ionizing radiation.

The objectives of the analyses in this report were to document, in U.S. military members overall and in selected occupational groups during a 15-year surveillance period, the frequencies, rates, and trends of incident diagnoses of malignant melanoma in relation to years of active military service. Results of the analyses enable comparisons across occupational groups of the natures, timing, and magnitudes of incidence rate changes in relation to years of service.

## METHODS

The surveillance period was 1 January 2001 through 31 December 2015. The surveillance population included all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps during the surveillance period and did not receive a diagnosis of malignant melanoma at any time prior to this period.

Endpoints of analyses were incident diagnoses of malignant melanoma while in active service. Incident cases were defined using the criteria specified by the Armed Forces Health Surveillance Branch (AFHSB) for routine surveillance and reporting of malignant melanoma incidence.[22] Briefly, incident cases were defined by at least two medical encounters (inpatient or outpatient) with "malignant melanoma" reported in any diagnostic position following at least one medical encounter with a relevant diagnostic procedure; or five or more medical encounters with "malignant melanoma" reported in any diagnostic position. An individual could be considered an incident case only once per lifetime.

The occupation-related exposures of particular interest for this report were:

*Solar ultraviolet radiation*: Infantry, special operations (e.g., Army Special Forces, Army Rangers, Navy SEALS), and combat engineers were considered highly exposed to solar ultraviolet radiation.

*Cosmic ionizing radiation*: Pilots and crews of fixed-wing aircraft were considered highly exposed to cosmic ionizing radiation.

*Ionizing radiation*: Physicians, physician assistants, nurses, and medical technicians were considered potentially exposed to ionizing radiation.

All service members not included in any of the above occupational groups were considered in the "all others" group.

For each occupational group and overall, person-time was distributed in relation to the number of years since first entering active military service. Melanoma diagnosis incidence rates were calculated by dividing the number of incident diagnoses that occurred during the 1st through 20th years of military service by the person-time during the respective years after first entering service.

For each military occupational group and overall, linear regressions and exponential curves were fitted to years of service-specific incidence rates using a simple trendline $R^2$ analysis in Microsoft Excel 2010.[23] The fit of the regression lines/exponential curves was assessed based on the $R^2$ values calculated using the trendline function. Of note, because there were no incident diagnoses of malignant melanoma among fixed-wing pilots/crews during 5 of the first 6 years after entry to service **(Table 1)**, the exponential trendline for this group was fit to the results from the 7th through 20th years only **(Figure 2)**.

## RESULTS

*Overall*: During the 15-year surveillance period, there were 2,233 incident diagnoses of malignant melanoma among members of the active component of the U.S. military. The crude (unadjusted) incidence rate during the period was 1.08 cases per 10,000 person-years (p-yrs). In regard to military occupational groups, crude (unadjusted) incidence rates were highest in the fixed-wing pilot/crew group (2.45 per 10,000 p-yrs); lowest in the infantry, special operations, combat engineer group (0.77 per 10,000 p-yrs); and intermediate among healthcare providers (1.33 per 10,000 p-yrs) and all others (1.07 per 10,000 p-yrs) **(Table 1)**.

Among military members overall, rates of malignant melanoma increased in an exponential fashion **(Figure 1)** from the 1st through 20th years of service. For those years, each additional year was associated with an approximately 12.8% increase in the rate of malignant melanoma diagnoses (estimated from the best-fitting exponential) **(Table 2)**. As a result, the rate of malignant melanoma diagnoses in the 20th years of service was more than 12 times greater than the rate in the 1st years of service **(Table 1)**.

*Fixed-wing pilots/crews*: Among pilots and the crews of military fixed-wing aircraft, rates of malignant melanoma diagnoses increased in an exponential fashion from the 7th through 20th years since entering service **(Figure 2)**. There was only one malignant melanoma diagnosis in a fixed-wing pilot/crewman with less than 7 years of service; however, from the 7th through 20th years, rates increased relatively rapidly. From the 7th through 20th years, each additional year was associated with an approximately 23.5% increase in the melanoma diagnosis rate (estimated from the best-fitting exponential) **(Table 2)**. As a result, the rate of malignant melanoma diagnoses in the 20th years of service was nearly 16 times greater than the rate in the 7th years of service **(Table 1)**.

*Infantry, special operations, combat engineers:* Among service members in selected occupations that are inherently conducted outdoors (i.e., infantry, special operations, combat engineers), rates of malignant melanoma diagnoses generally increased in an exponential fashion **(Figure 3)**. Among these service members, rates of malignant melanoma were low and relatively stable during the first several years of service, but they increased thereafter—particularly during the last 10 years of a 20-year service period **(Figure 3)**. In general, over 20 years of service, each additional

**TABLE 1.** Numbers and rates of incident diagnoses of malignant melanoma, by years of military service until initial diagnoses, in selected military occupational groups, active component, U.S. Armed Forces, January 2001–December 2015

| Primary exposure of concern | Military occupational group | | Year after entry to active military service: 1st | 2nd | 3rd | 4th | 5th | 6th | 7th | 8th | 9th | 10th | 11th |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | No. of incident diagnoses | 60 | 81 | 100 | 105 | 90 | 78 | 57 | 78 | 68 | 63 | 77 |
| | | Incidence rate | 0.25 | 0.35 | 0.47 | 0.56 | 0.68 | 0.73 | 0.64 | 0.98 | 0.98 | 1.00 | 1.33 |
| Cosmic ionizing radiation | Fixed-wing pilots, crews | No. of incident diagnoses | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 3 | 3 | 4 |
| | | Incidence rate | 0.00 | 0.00 | 0.75 | 0.00 | 0.00 | 0.00 | 0.42 | 0.43 | 1.29 | 1.36 | 2.01 |
| Solar ultraviolet radiation | Infantry, special operations, combat engineers | No. of incident diagnoses | 3 | 5 | 2 | 4 | 4 | 6 | 2 | 5 | 4 | 2 | 5 |
| | | Incidence rate | 0.12 | 0.16 | 0.07 | 0.17 | 0.29 | 0.58 | 0.23 | 0.67 | 0.64 | 0.36 | 0.99 |
| Health care | Physicians, nurses, physician assistants, health-care technicians | No. of incident diagnoses | 5 | 5 | 9 | 10 | 6 | 6 | 4 | 8 | 5 | 2 | 7 |
| | | Incidence rate | 0.50 | 0.46 | 0.90 | 1.12 | 0.86 | 1.08 | 0.85 | 1.98 | 1.44 | 0.63 | 2.35 |
| All others | All other military occupations | No. of incident diagnoses | 52 | 71 | 88 | 91 | 80 | 66 | 50 | 64 | 56 | 56 | 61 |
| | | Incidence rate | 0.25 | 0.38 | 0.51 | 0.60 | 0.74 | 0.75 | 0.68 | 0.98 | 0.97 | 1.07 | 1.28 |

| Primary exposure of concern | Military occupational group | | Year after entry to active military service: 12th | 13th | 14th | 15th | 16th | 17th | 18th | 19th | 20th | >20 years | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total | | No. of incident diagnoses | 112 | 113 | 113 | 123 | 134 | 147 | 122 | 104 | 109 | 299 | 2,233 |
| | | Incidence rate | 1.38 | 1.52 | 1.67 | 2.01 | 2.17 | 2.70 | 2.57 | 2.56 | 3.21 | 4.02 | 1.08 |
| Cosmic ionizing radiation | Fixed-wing pilots, crews | No. of incident diagnoses | 7 | 5 | 7 | 6 | 7 | 13 | 10 | 7 | 7 | 14 | 96 |
| | | Incidence rate | 2.68 | 1.88 | 2.90 | 2.76 | 3.61 | 7.75 | 6.97 | 5.83 | 6.94 | 6.40 | 2.45 |
| Solar ultraviolet radiation | Infantry, special operations, combat engineers | No. of incident diagnoses | 7 | 8 | 8 | 11 | 12 | 8 | 10 | 11 | 16 | 33 | 166 |
| | | Incidence rate | 1.35 | 1.58 | 1.71 | 2.51 | 2.40 | 1.73 | 2.46 | 3.09 | 5.34 | 4.06 | 0.77 |
| Health care | Physicians, nurses, physician assistants, health-care technicians | No. of incident diagnoses | 3 | 3 | 7 | 10 | 4 | 8 | 6 | 10 | 5 | 13 | 136 |
| | | Incidence rate | 0.76 | 0.80 | 2.04 | 3.20 | 1.26 | 2.79 | 2.46 | 4.84 | 2.82 | 2.73 | 1.33 |
| All others | All other military occupations | No. of incident diagnoses | 95 | 97 | 91 | 96 | 111 | 118 | 96 | 76 | 81 | 239 | 1,835 |
| | | Incidence rate | 1.36 | 1.54 | 1.59 | 1.86 | 2.15 | 2.61 | 2.43 | 2.25 | 2.87 | 4.03 | 1.07 |

year was associated with an approximately 22.0% increase in malignant melanoma diagnosis rates (estimated from the best-fitting exponential) **(Table 2).** As a result, the rate of malignant melanoma diagnoses in the 20th years of service was nearly 44 times greater than the rate in the 1st years of service **(Table 1).**

*Healthcare providers:* Among health-care providers (e.g., physicians, physician assistants, nurses, medical technicians), rates of malignant melanoma diagnoses increased in a roughly exponential fashion; of note, however, the best-fitting exponential was only a slightly better fit than the linear regression **(Figure 4)**. In general, over a 20-year service period, each additional year was associated with an approximately 9.0%

**TABLE 2.** Characteristics of best-fit exponential models of rates of incident diagnoses of malignant melanoma, by years of military service until initial diagnoses, in selected military occupational groups and overall, active component, U.S. Armed Forces, January 2001–December 2015

| | | Trendline results | | | |
|---|---|---|---|---|---|
| Primary exposure of concern | Sentinel military occupations | Trendline form | Formula | Goodness of fit ($R^2$) | % change of incidence rate per year |
| Total | | Exponential | Rate = $0.3128*e^{0.1206*(years)}$ | 0.97 | +12.8 |
| Cosmic ionizing radiation | Fixed-wing pilots, crews | Exponential | Rate = $0.4909*e^{0.2111*(years)}$ | 0.88 | +23.5 |
| Solar ultraviolet radiation | Infantry, special operations, combat engineers | Exponential | Rate = $0.0904*e^{0.1992*(years)}$ | 0.90 | +22.0 |
| Healthcare-related ionizing radiation | Physicians, nurses, physician assistants, healthcare technicians | Exponential | Rate = $0.5432*e^{0.0862*(years)}$ | 0.59 | +9.0 |
| All others | All except above | Exponential | Rate = $0.3426*e^{0.1117*(years)}$ | 0.95 | +11.8 |
| | | Linear | Rate = 0.1298x - 0.0196 | 0.95 | |

**FIGURE 1.** Overall incidence rates (and best-fitting exponential trendline) of diagnoses of malignant melanoma, by number of years of active U.S. military service, active component, U.S. Armed Forces, January 2001–December 2015


increase in melanoma diagnosis rates **(Table 2)**. As a result, the rate of malignant melanoma diagnoses in the 20th years of service was nearly 5 times greater than the rate in the 1st years of service **(Table 1)**.

*All other occupations*: Among service members with occupations other than those of special interest for this report, exponential and linear trendlines fit the observed incidence rates equivalently ($R^2$, exponential: 0.953; $R^2$, linear: 0.946) **(Figure 5)**. In general, over the period, each additional year was associated with an approximately 11.8% increase in the melanoma diagnosis rate (based on the best-fitting exponential) **(Table 2)**. As a result, the rate of malignant melanoma diagnoses in the 20th years of service was nearly 11 times greater than the rate in the 1st years of service **(Table 1)**.

## EDITORIAL COMMENT

Over a 15-year surveillance period, rates of malignant melanoma diagnoses among U.S. military members overall increased in an exponential fashion in relation to years of active service. However, there were significant differences across occupational groups in relationships between rates of malignant melanoma diagnoses and military service longevity. Most notably, after several years of service, rates of melanoma diagnoses increased relatively rapidly among pilots and the crews of fixed-wing aircraft (e.g., fighters, bombers, cargo/personnel transporters) and those in occupations inherently conducted outdoors (e.g., infantry, special operations, combat engineers). In contrast, melanoma diagnosis rates increased relatively slowly among healthcare providers and those in "other" military occupations.

The findings of the analyses are of interest for several reasons. First, in each occupational group and overall, rates of melanoma diagnoses were very low during the first several years of service. Although the frequencies, durations, and intensities of exposures to ultraviolet and cosmic radiation vary significantly among members of different occupational groups, rates of

**FIGURE 2.** Incidence rates (and best-fitting exponential trendline) of diagnoses of malignant melanoma among fixed-wing aviators and crews, by number of years of active U.S. military service, active component, U.S. Armed Forces, January 2001–December 2015

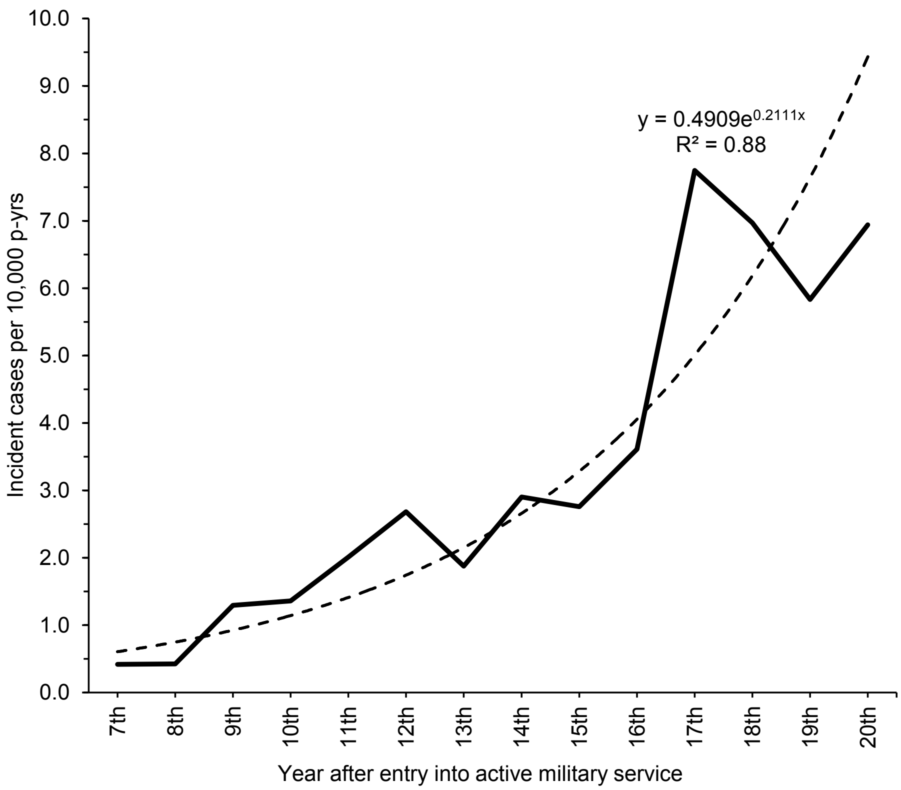
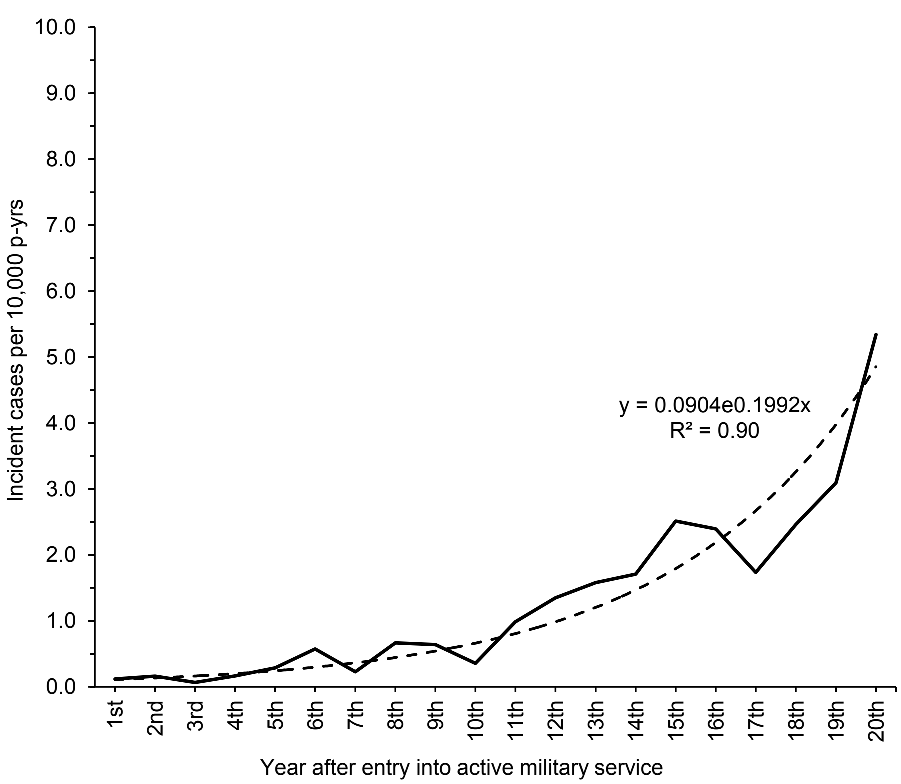



**FIGURE 3.** Incidence rates (and best-fitting exponential trendline) of diagnoses of malignant melanoma among infantry, special operations, and combat engineers, by number of years of active U.S. military service, active component, U.S. Armed Forces, January 2001–December 2015




melanoma diagnoses were very low among the junior and mid-career members of all occupation groups. The finding suggests that, in general, there are long lag times between the radiation exposures that damage cells and the clinical manifestations of malignant transformations of affected cells. The finding also suggests that reliable assessments of the risks associated with specific occupational exposures cannot be made during or within the first several years after the times of the exposures.

Second, consistent with the findings of other studies, through the first 8 and 12 years of active service for pilots and those in combat-related occupations, respectively, rates of diagnoses were relatively low among those with repeated exposures of long durations of respective exposure to cosmic and solar radiation. However, after 8 and 12 years of active service, respectively, diagnosis rates in these groups began to increase relatively rapidly. The finding suggests that, in healthy young adults such as these U.S. military members, the clinical manifestations of repeated and prolonged exposures to cosmic and ultraviolet radiation are generally delayed for many years after the times of the exposures.

Third, in the occupational groups of interest here and overall, diagnosis rates increased exponentially with increasing years of service. The finding reflects the effects of continuously increasing cumulative exposures to damaging radiation. Such effects include increasing numbers of genetically mutated melanocytes and decreasing immunoediting capabilities.[24,25] Eventually, radiation-induced damage may reduce the body's capacity to detect and eliminate all genetically modified melanocytes with tumorigenic potential.

The findings of this report should be assessed in relation to several shortcomings. For example, the diagnoses used as endpoints of analyses were derived from clinical diagnoses that were coded and recorded in administrative records of relevant patient encounters. Such diagnoses may not be reliable indicators of confirmed cases of malignant melanoma. For example, in some cases, case-defining diagnoses in administrative records may indicate "suspected" or "rule out" diagnoses rather than confirmed diagnoses. To minimize

**FIGURE 4.** Incidence rates (and trendlines) of diagnoses of malignant melanoma among healthcare providers, by number of years of active U.S. military service, active component, U.S. Armed Forces, January 2001–December 2015

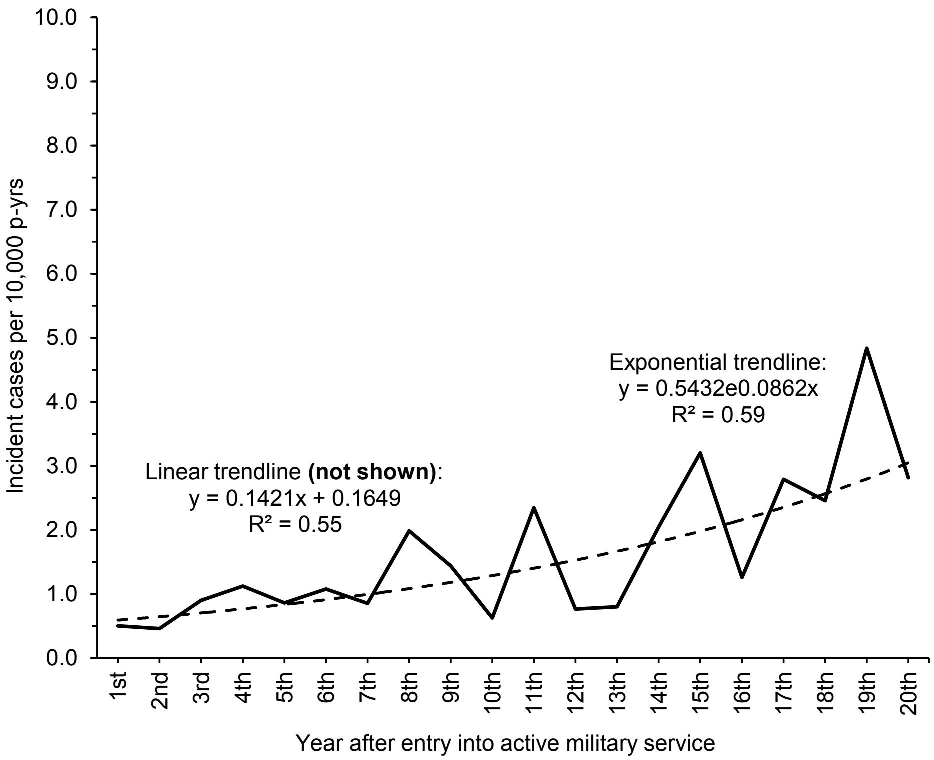
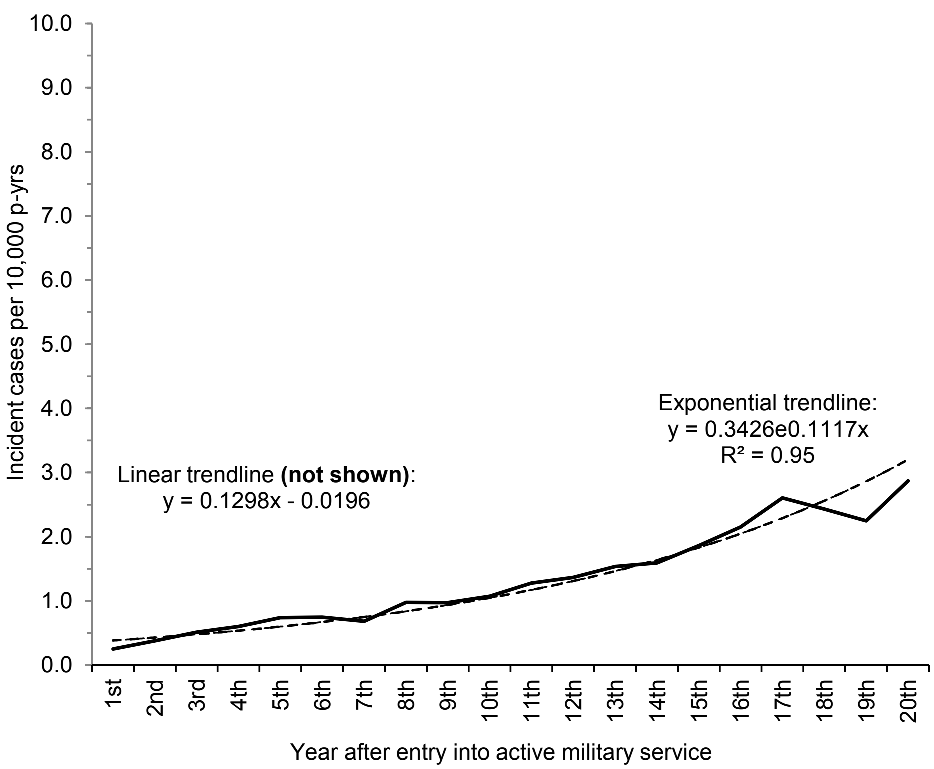



**FIGURE 5.** Incidence rates (and trendlines) of diagnoses of malignant melanoma among all others, by number of years of active U.S. military service, active component, U.S. Armed Forces, January 2001–December 2015




the likelihood of such misclassifications, the case definition for this analysis required malignant melanoma diagnoses as primary diagnoses during multiple patient encounters. It is also possible that some affected service members terminated their active military service before they had participated in multiple melanoma-related encounters; such circumstances would result in under ascertainment of true cases. However, because the case definition is so restrictive, there were likely few if any false positive cases included in the analysis; and because medical care is free to active service members, it seems unlikely that many service members left active service before receiving definitive diagnostic, treatment, and follow-up care for malignant melanomas. Hence, significant under ascertainment of cases seems unlikely.

In addition, for this analysis, military occupation was considered a categorical indicator of exposure levels to ultraviolet and cosmic radiation. Clearly, the occupational groups as defined are imprecise correlates of cumulative radiation exposure experiences. For example, during training and field operations, military members (including infantrymen and combat engineers) are often in buildings (e.g., classrooms), outdoor shelters (e.g., tents, bunkers), vehicles (e.g., troop carriers), and so on. Also, during the courses of their military careers, service members from all occupations have assignments that are almost entirely conducted indoors (e.g., military/civilian schooling, senior staff assignments). As such, there are large variations in exposures to ultraviolet radiation not only across but within military occupational groups.

Also, this report summarizes crude (unadjusted) rates of melanoma diagnoses in selected occupational groups and overall; however, there are differences in susceptibility to malignant melanoma in relation to age, gender, and skin pigmentation. Because the occupational groups considered here have different age, gender, and racial/ethnic distributions, direct comparisons of malignant melanoma rates across occupational groups, without accounting for the effects of such differences between the groups, are potentially misleading. Future studies of malignant melanoma in subgroups of military members should control for the confounding effects of age, gender, and race/ethnicity differences.

Furthermore, formal statistical tests were not conducted to assess the exponentiality of increasing incidence rates with increasing years of service. However, for all groups except the "all other occupations" group, exponential trendlines fit the observed experiences better than linear regression trendlines—particularly for the fixed-wing aviation and infantry/special operations/combat engineer groups, the groups presumably most intensely exposed to damaging radiation.

Finally, the analysis does not account for exposures to solar and cosmic radiation prior to military service or while off-duty. Service members may be exposed to damaging solar/cosmic radiation during activities unrelated to military service. As such, cases of melanoma that affect active military members or veterans should not be attributed unequivocally to military occupational exposures. In this regard, it is revealing that, during the first 8 years of service, rates of melanoma diagnoses were higher among those in "other" occupations than in those with inherently high radiation exposure levels (i.e., fixed-wing pilots/crews; infantry, special operations, combat engineers).

In summary, this report documents that, in general, rates of malignant melanoma diagnoses increase exponentially with increasing years of active military service. Also, among those in occupations that involve long periods of intense exposures to solar/cosmic radiation, melanoma diagnosis rates increase relatively rapidly beginning approximately 8 years after the beginning of military service. The findings reiterate the importance of limiting, to the extent possible given mission requirements, exposures of military members to solar ultraviolet and cosmic radiation. Of note, the finding of low rates of malignant melanoma among junior and mid-career service members while they are still in active service should not be considered evidence of low occupational risk of malignant melanoma. In this regard, future studies should assess whether malignant melanoma rates are relatively high and continue to accelerate with age among veterans who served in high-risk occupations during relatively short periods of active service (e.g., 3–7 years). Finally, because risk factors for melanoma and non-melanoma skin cancers are similar, policies and practices aimed at reducing rates of melanomas may be effective for preventing non-melanoma skin cancers.[1]

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# Medical Evacuations, Active and Reserve Components, U.S. Armed Forces, 2013–2015

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From 1 January 2013 through 31 December 2015, a total of 3,912 medical evacuations of service members from the U.S. Central Command area of responsibility were followed by at least one medical encounter in a fixed medical facility outside the operational theater. Overall, there were more medical evacuations for mental disorders than for any other category of illnesses or injuries. Among all service members, annual rates of medical evacuations attributable to battle injuries decreased from 3.4 per 1,000 deployed person-years (dp-yrs) in 2013 to a low of 0.7 per 1,000 dp-yrs in 2015. Annual rates of medical evacuations attributable to non-battle injuries and illnesses were relatively stable during 2013–2014 but decreased by 43.1% in 2015. The overall rate of medical evacuations was higher among females than males. Overall medical evacuation rates were highest among black, non-Hispanic and white, non-Hispanic service members and lowest among service members of "other" or unknown race/ethnicity. Compared to their respective counterparts, rates of evacuation were higher among deployers aged 40 years or older, in the Army or Marine Corps, in the reserve component, enlisted (junior or senior), and in armor/motor transport or combat-specific occupations. The majority of service members who were evacuated were returned to normal duty status following their post-evacuation hospitalizations or outpatient encounters.

Since the last *MSMR* report evaluating medical evacuations from 2001–2012, there has been a substantial reduction in combat operations taking place in the U.S. Central Command (CENTCOM) area of responsibility (AOR) in Southwest Asia.[1-3] However, the number of service members deployed to CENTCOM AOR after 2012 was still significant. From 1 January 2013 through 31 December 2015, there were more than 350,000 deployments in support of CENTCOM AOR operations, including Operation Enduring Freedom (OEF), Operation Freedom's Sentinel (OFS), Operation New Dawn (OND), and Operation Inherent Resolve (OIR). In the theaters of operations such as Afghanistan, most medical care is provided by deployed military medical personnel; however, some injuries and illnesses require medical management outside the operational theater. In these cases, such individuals are usually transported by air to a fixed military medical facility in Europe or the U.S. At the fixed facility, they receive the specialized, technically advanced, and/or prolonged diagnostic, therapeutic, and rehabilitative care required.

Medical air transports ("medical evacuations") are costly and generally indicative of serious medical conditions. Some serious conditions are directly related to participation in or support of combat operations (e.g., battle wounds); however, many others are unrelated to combat and may be preventable. The objectives of this report are to describe and compare the natures, numbers, rates, and trends of conditions for which male and female military members were medically evacuated from CENTCOM AOR operations during 2013–2015, a period of reduced numbers of service members on the ground in the region.

## METHODS

The surveillance period was 1 January 2013 through 31 December 2015. The surveillance population included all members of the active and reserve components of the U.S. Army, Navy, Air Force, and Marine Corps who were deployed as part of CENTCOM AOR operations during the period. The outcomes of interest in this analysis reflected individuals who were medically evacuated during the surveillance period from CENTCOM AOR (e.g., Afghanistan, Iraq) to a medical treatment facility outside the CENTCOM AOR. Evacuations were included in analyses if the affected service member had at least one inpatient or outpatient medical encounter in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after the evacuation date. Evacuations were included only if they occurred within 90 days of the time frame documented in a CENTCOM AOR deployment record as indicated by the Defense Manpower Data Center Contingency Tracking System in the Defense Medical Surveillance System (DMSS). Records of all medical evacuations conducted by the U.S. Transportation Command (TRANSCOM), maintained in the TRANSCOM Regulating and Command and Control Evacuation System (TRAC2ES), were also utilized. Access to this system is provided to the Armed Forces Health Surveillance Branch for health surveillance purposes via the Office of the Assistant Secretary of Defense for Health Affairs.

Medical evacuations included in the analyses were classified by the causes and natures of the precipitating medical conditions (based on information reported in relevant evacuation and medical encounter records). First, all medical conditions that resulted in evacuations were classified as "battle injuries" or "non-battle injuries and illnesses" (based on entries in an indicator field of the TRAC2ES evacuation record). Evacuations due to non-battle injuries and illnesses were subclassified into 18 illness/injury categories based on International Classification of Diseases (ICD-9/ICD-10) diagnostic codes reported on records of medical encounters after evacuation. For this purpose, all records of hospitalizations and ambulatory visits from 5 days before to 10 days after the reported date of each medical evacuation were identified. In most cases, the primary (first-listed) diagnosis for either a hospitalization (if one occurred) or the earliest ambulatory visit after evacuation was considered indicative of the condition responsible for the evacuation. However, if the first-listed diagnostic code specified the external cause (rather than the nature) of an injury (ICD-9 E-code/ICD-10 V-, W-, X-, Y-, or Z-code) or an encounter for something other than a current illness or injury (e.g., observation, medical examination, vaccination [ICD-9 V-codes/ICD-10 Z-codes other than those related to pregnancy]), then secondary diagnoses that specified illnesses and injuries (ICD-9: 001–999/ICD-10: A00–T88) were considered the likely reasons for the subject evacuations. If there was no secondary diagnosis, or the secondary diagnosis was also an external cause code, then the first-listed diagnostic code of a subsequent encounter was used.

Denominators for rates of medical evacuations were calculated by determining the length of each individual's deployment and summing the person-time of all deployers. If the deployment end date was missing, the end date was imputed based on average deployment times per service.

The disposition after each medical evacuation was determined by using the disposition code associated with the medical encounter that was used for determining the category of the medical evacuation. Inpatient disposition categories were: returned to duty (code: 01), transferred/discharged to other facility (codes: 02–04, 09, 21–28, 43, 61–66), died (codes: 20, 30, 40–42, 50, 51), separated from service (codes: 10–15), and other/unknown. Outpatient disposition categories were: released without limitation (code: 1), released with work/duty limitation (code: 2), immediate referral (code: 4), sick at home/quarters (codes: 3, S), admitted/transferred to civilian hospital (codes: 7, 9, A–D, U), died (codes: 8, G), discharged home (code: F), and other/unknown.

## RESULTS

During the 3-year surveillance period, a total of 3,912 medical evacuations of service members from CENTCOM AOR were followed by at least one medical encounter in a fixed medical facility outside the operational theater. Overall, there were more medical evacuations for mental disorders (n=750; 19.2% of all evacuations; rate: 3.9 per 1,000 deployed person-years [dp-yrs]) than for any other category of illnesses or injuries **(Table 1)**. In addition, rates of evacuation for non-battle injuries and poisonings (3.5 per 1,000 dp-yrs) and musculoskeletal system disorders (3.2 per 1,000 dp-yrs) were higher than the rate for battle injuries (2.4 per 1,000 dp-yrs). Among all service members, annual rates of medical evacuations attributable to battle injuries decreased by 78.0% from 3.4 per 1,000 dp-yrs (n=319) in 2013 to a low of 0.7 per 1,000 dp-yrs (n=28) in 2015. Annual rates of medical evacuations attributable to non-battle injuries and illnesses were relatively stable during 2013–2014 (19.2 per 1,000 dp-yrs and 20.9 per 1,000 dp-yrs, respectively) but decreased by 43.1% to 10.9 per 1,000 dp-yrs in 2015 **(data not shown)**. In general, the numbers of medical evacuations over the course of the period varied in relation to the numbers of deployed service members with the vast majority of medical evacuations associated with OEF and OFS (90.4% and 7.1%, respectively) **(data not shown)**. As expected, numbers of medical evacuations decreased considerably in the months leading up to 1 January 2015, when U.S. Forces-Afghanistan formally ended its combat mission, OEF, and commenced its new mission, OFS **(Figure)**.

During the surveillance period, three categories of illnesses and non-battle injuries accounted for more than half (52.0%) of all evacuations **(Table 1)**. Mental disorders (most frequently adjustment reactions, mood disorders, anxiety disorders, post-traumatic stress disorder (PTSD), and depressive disorder) accounted for close to one-fifth (19.2%) of evacuations; non-battle injuries (primarily sprains and fractures of extremities) accounted for approximately one in six (17.1%) evacuations; and musculoskeletal disorders (primarily affecting the back and knee) accounted for slightly more than one in seven (15.7%) evacuations **(Table 2)**.

### Demographic and military characteristics

Overall, more than six times as many males (n=3,398) as females (n=514) were medically evacuated; however, the rate of medical evacuations was 17.3% higher among females (23.6 per 1,000 dp-yrs) than males (20.1 per 1,000 dp-yrs) **(Table 3)**. The diagnoses most frequently associated with medical evacuations of male service members throughout the surveillance period were non-battle injuries (18.5%), mental disorders (18.2%), musculoskeletal disorders (16.0%), and battle injuries (13.0%). Among female service members during the period, the most frequent diagnoses were mental disorders (25.5%), musculoskeletal disorders (13.8%), "signs, symptoms, and ill-defined conditions" (12.3%), and non-battle injuries (7.8%) **(Table 1)**.

Compared to females, males had higher rates of evacuations for non-battle injuries/poisonings (females:males, risk ratio [RR]: 0. 49; rate difference [RD]: 1.9 per 1,000 dp-yrs), battle injuries (RR: 0.30; RD: 1.8 per 1,000 dp-yrs), disorders of the circulatory system (RR: 0.77; RD: 0.2 per 1,000 dp-yrs), disorders of the nervous system and sense organs (RR: 0.81;

**TABLE 1.** Numbers and rates of medical encounters after medical evacuation from theater, by ICD-9/ICD-10 diagnostic category, U.S. Armed Forces, 1 January 2013 through 31 December 2015

| | Total | | | Males | | | Females | | | Rate ratio | Rate difference |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | No. | % | Rate[a] | No. | % | Rate[a] | No. | % | Rate[a] | Female:Male | Female-Male |
| Diagnostic category (ICD-9/ICD-10) | | | | | | | | | | | |
| Mental disorders (290–319; F00–F99) | 750 | 19.2 | 3.9 | 619 | 18.2 | 3.7 | 131 | 25.5 | 6.0 | 1.64 | 2.3 |
| Non-battle injuries and poisonings (800–999; D78, S00–T88) | 670 | 17.1 | 3.5 | 630 | 18.5 | 3.7 | 40 | 7.8 | 1.8 | 0.49 | -1.9 |
| Musculoskeletal system (710–739; M00–M99) | 616 | 15.7 | 3.2 | 545 | 16.0 | 3.2 | 71 | 13.8 | 3.3 | 1.01 | 0.0 |
| Battle injuries (from TRAC2ES records) | 459 | 11.7 | 2.4 | 442 | 13.0 | 2.6 | 17 | 3.3 | 0.8 | 0.30 | -1.8 |
| Signs, symptoms, and ill-defined conditions (780–799; R00–R99) | 349 | 8.9 | 1.8 | 286 | 8.4 | 1.7 | 63 | 12.3 | 2.9 | 1.71 | 1.2 |
| Digestive system (520–579; K00–K93) | 209 | 5.3 | 1.1 | 188 | 5.5 | 1.1 | 21 | 4.1 | 1.0 | 0.87 | -0.1 |
| Nervous system and sense organs (320–389; G00–G99, H00–H95) | 180 | 4.6 | 0.9 | 163 | 4.8 | 1.0 | 17 | 3.3 | 0.8 | 0.81 | -0.2 |
| Circulatory system (390–459; I00–I99) | 144 | 3.7 | 0.8 | 131 | 3.9 | 0.8 | 13 | 2.5 | 0.6 | 0.77 | -0.2 |
| Genitourinary system (580–629, except breast disorders; N00–N99, except breast disorders) | 116 | 3.0 | 0.6 | 88 | 2.6 | 0.5 | 28 | 5.4 | 1.3 | 2.47 | 0.8 |
| Other (V01–V82, except pregnancy-related; Z00–Z76, except pregnancy related) | 95 | 2.4 | 0.5 | 77 | 2.3 | 0.5 | 18 | 3.5 | 0.8 | 1.81 | 0.4 |
| Neoplasms (140–239; C00–D49) | 70 | 1.8 | 0.4 | 48 | 1.4 | 0.3 | 22 | 4.3 | 1.0 | 3.56 | 0.7 |
| Skin and subcutaneous tissue (680–709; L00–L99) | 58 | 1.5 | 0.3 | 52 | 1.5 | 0.3 | 6 | 1.2 | 0.3 | 0.90 | 0.0 |
| Respiratory system (460–519; J00–J99) | 51 | 1.3 | 0.3 | 44 | 1.3 | 0.3 | 7 | 1.4 | 0.3 | 1.23 | 0.1 |
| Breast disorders (610–611; N60–N64) | 37 | 0.9 | 0.2 | 15 | 0.4 | 0.1 | 22 | 4.3 | 1.0 | 11.38 | 0.9 |
| Infectious and parasitic diseases (001–139; A00–B99) | 36 | 0.9 | 0.2 | 29 | 0.9 | 0.2 | 7 | 1.4 | 0.3 | 1.87 | 0.1 |
| Endocrine, nutrition, immunity (240–279; E00–E89, D80–D89) | 32 | 0.8 | 0.2 | 22 | 0.6 | 0.1 | 10 | 1.9 | 0.5 | 3.53 | 0.3 |
| Hematologic disorders (280–289; D50–D77) | 17 | 0.4 | 0.1 | 12 | 0.4 | 0.1 | 5 | 1.0 | 0.2 | 3.23 | 0.2 |
| Pregnancy and childbirth (630–679, relevant V-codes; O00–O99, relevant Z-codes) | 14 | 0.4 | 0.1 | . | . | . | 14 | 2.7 | 0.6 | . | . |
| Congenital anomalies (740–759; Q00–Q99) | 9 | 0.2 | 0.0 | 7 | 0.2 | 0.0 | 2 | 0.4 | 0.1 | 2.22 | 0.1 |
| Totals | 3,912 | | | 3,398 | | | 514 | | | | |

[a]Number of medical encounters after medical evacuations per 1,000 deployed person-years.

RD: 0.2 per 1,000 dp-yrs), disorders of the digestive system (RR: 0.87; RD: 0.1 per 1,000 dp-years), and disorders of the skin and subcutaneous tissue (RR: 0.90, RD: 0.03 per 1,000 dp-years). Females had higher evacuation rates for all other illness and injury categories. The largest relative differences in evacuation rates among females versus males were for breast disorders (RR: 11.38), neoplasms (RR: 3.56), endocrine, nutrition and immunity disorders (RR: 3.53), and hematologic disorders (RR: 3.23); however, the largest absolute differences in evacuation rates among females compared to males were for mental disorders (RD: 2.3 per 1000 dp-yrs) and "signs, symptoms, and ill-defined conditions" (RD: 1.2 per 1,000 dp-yrs) **(Table 1)**.

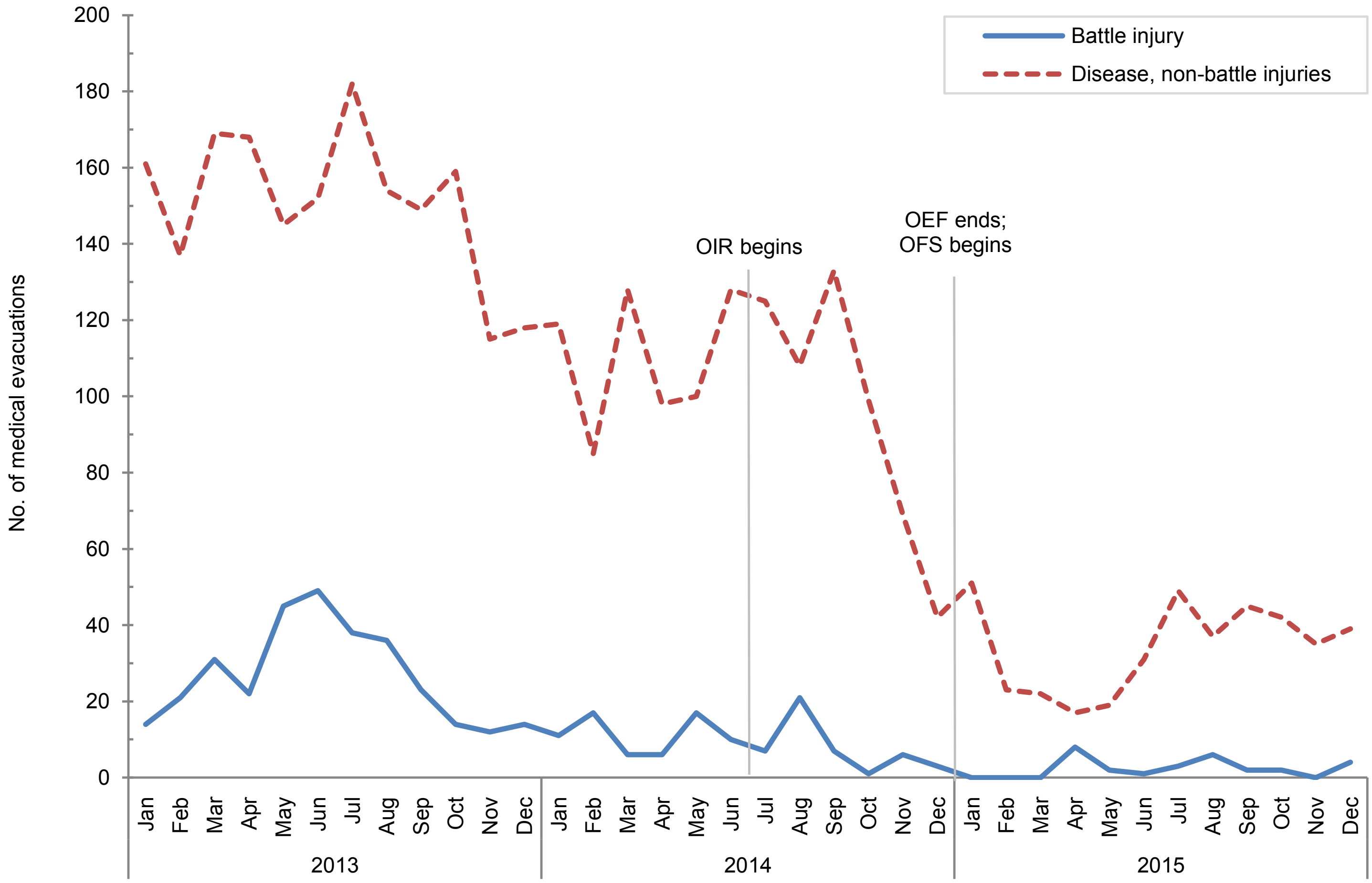
Overall, medical evacuation rates were highest among black, non-Hispanic (22.0 per 1,000 dp-yrs) and white, non-Hispanic (20.8 per 1,000 dp-yrs) service members and lowest among service members of "other" or unknown race/ethnicity (13.9 per 1,000 dp-yrs) **(Table 3)**. Rates of medical evacuation were lowest among the youngest (<20 years: 15.4 per 1,000 dp-yrs) and highest among those aged 40 years or older (40–44 years: 24.4 per 1,000 dp-yrs; ≥45 years: 27.0 per 1,000 dp-yrs). Compared to their respective counterparts, rates of evacuation were higher among deployers who were in the Army or Marine Corps, in the reserve component, enlisted (junior or senior), and in armor/motor transport or combat-specific occupations **(Table 3)**.

The vast majority of all medical evacuations (93.4%) were characterized as having routine precedence. The remaining 6.6% had priority (4.6%) or urgent (2.0%) precedence. All but 13 (0.3%) of the total medical evacuations were accomplished through military transport **(Table 3)**.

### Most frequent specific diagnoses

Among both males and females, "adjustment reaction" was the most frequent specific diagnosis (three-digit ICD-9/ICD-10 diagnosis code) during initial medical encounters after evacuations; the rate of adjustment disorder–related evacuations was 59.2% higher among females (3.5 per 1,000 dp-yrs) than males (2.1 per 1,000 dp-yrs) **(Table 2)**. Of the 20 diagnoses most frequently associated with evacuations of

**FIGURE.** Numbers of medical evacuations of U.S. service members, by type, by month, 1 January 2013 through 31 December 2015




OIR, Operation Inherent Resolve; OEF, Operation Enduring Freedom; OFS, Operation Freedom's Sentinel

males, six were fractures (extremities and spine) and six were musculoskeletal conditions (back and joints). In addition to "adjustment reaction," three other mental disorders ("episodic mood disorders," "anxiety, dissociative, and somatoform disorders," and "depressive disorder, not elsewhere classified") were among the 20 diagnoses most frequently associated with evacuations of male service members **(Table 2)**.

Of the 20 diagnoses most frequently associated with evacuations of female service members, five were mental disorders ("adjustment reaction," "episodic mood disorders," "anxiety, dissociative, and somatoform disorders," "depressive disorder, not elsewhere classified," and "reaction to severe stress, and adjustment disorders"); four were conditions that exclusively or primarily affect women ("other disorders of the breast," "non-inflammatory disorders of ovary, fallopian tube, and broad ligament," "normal pregnancy," and "pain/other symptoms associated with female genital organs"); and four were musculoskeletal conditions (back, joints, head, and neck) **(Table 2)**. Among all service members, the top five anatomic locations for non-battle injuries were the shoulder and upper arm, ankle, forearm, fingers, and the knee/leg. For both sexes, the leading non-battle-related injury type was fractures **(data not shown)**.

## Disposition

Of the 3,912 medical evacuations reported here, a total of 1,219 (31.2%) resulted in inpatient encounters. Nearly one-half (48.4%) of all service members who were hospitalized after medical evacuations were discharged back to duty. Half (50.5%) of service members who were hospitalized after medical evacuations were transferred or discharged to other facilities **(Table 4)**.

Return to duty dispositions were much more likely after hospitalizations for non-battle injuries (44.2%) than for battle injuries (20.0%). In addition, more than three-quarters (79.4%) of battle injury-related hospitalizations and a little more than half (55.1%) of non-battle injury-related hospitalizations, resulted in transfers/discharges to other facilities **(Table 4)**.

More than two-thirds (68.8%) of the total medical evacuations reported resulted in outpatient encounters only. Of the service members treated exclusively in outpatient settings after evacuations, the majority (82.6%) were discharged back

**TABLE 2.** Most frequent three-digit ICD-9 diagnoses from medical evacuations, by gender, U.S. Armed Forces, 1 January 2013 through 31 December 2015

| Males | | | | Females | | | |
|---|---|---|---|---|---|---|---|
| Three-digit ICD-9/ ICD-10 | ICD-9/ICD-10 description | No. | Rate | Three-digit ICD-9/ ICD-10 | ICD-9/ICD-10 description | No. | Rate |
| 309 | Adjustment reaction | 331 | 2.1 | 309 | Adjustment reaction | 73 | 3.5 |
| 722 | Intervertebral disc disorders | 116 | 0.7 | 296 | Episodic mood disorders | 24 | 1.2 |
| 296 | Episodic mood disorders | 112 | 0.7 | 611 | Other disorders of breast | 17 | 0.8 |
| 719 | Other and unspecified disorders of joint | 96 | 0.6 | 719 | Other and unspecified disorders of joint | 15 | 0.7 |
| 780 | General symptoms | 85 | 0.5 | 300 | Anxiety, dissociative and somatoform disorders | 13 | 0.6 |
| 724 | Other and unspecified disorders of back | 72 | 0.4 | 724 | Other and unspecified disorders of back | 13 | 0.6 |
| 300 | Anxiety, dissociative and somatoform disorders | 60 | 0.4 | 722 | Intervertebral disc disorders | 12 | 0.6 |
| 824 | Fracture of ankle | 56 | 0.3 | 789 | Other symptoms involving abdomen and pelvis | 10 | 0.5 |
| 813 | Fracture of radius and ulna | 53 | 0.3 | 780 | General symptoms | 10 | 0.5 |
| 840 | Sprains and strains of shoulder and upper arm | 52 | 0.3 | 729 | Other disorders of soft tissues | 10 | 0.5 |
| 727 | Other disorders of synovium tendon and bursa | 51 | 0.3 | 311 | Depressive disorder not elsewhere classified | 9 | 0.4 |
| 786 | Symptoms involving respiratory system and other chest symptoms | 49 | 0.3 | 784 | Symptoms involving head and neck | 9 | 0.4 |
| 550 | Inguinal hernia | 49 | 0.3 | 825 | Fracture of one or more tarsal and metatarsal bones | 8 | 0.4 |
| 311 | Depressive disorder, not elsewhere classified | 48 | 0.3 | 799 | Other ill-defined and unknown causes of morbidity and mortality | 8 | 0.4 |
| 816 | Fracture of one or more phalanges of hand | 44 | 0.3 | 785 | Symptoms involving cardiovascular system | 7 | 0.3 |
| 717 | Internal derangement of knee | 43 | 0.3 | 620 | Noninflammatory disorders of ovary, fallopian tube, and broad ligament | 7 | 0.3 |
| 823 | Fracture of tibia and fibula | 41 | 0.3 | V22 | Normal pregnancy | 7 | 0.3 |
| 339 | Other headache syndromes | 41 | 0.3 | F43 | Reaction to severe stress, and adjustment disorders | 6 | 5.7 |
| 805 | Fracture of vertebral column without mention of spinal cord injury | 39 | 0.2 | 625 | Pain/other symptoms associated with female genital organs | 5 | 0.2 |
| 815 | Fracture of metacarpal bone(s) | 38 | 0.2 | 426 | Conduction disorders | 5 | 0.2 |

TRAC2ES, U.S. Transportation Command Regulating and Command and Control Evacuation System

to duty; 10.9% were released with work/duty limitations; 5.0% were immediately referred; and less than 1% each were discharged to "home sick" for recuperation or admitted/transferred to a civilian hospital. Service members treated as outpatients after battle injury-related evacuations were more likely to be released without limitations (79.8%) and slightly less likely to have work/duty limitations (14.3%) than medical evacuees treated as outpatients for non-battle injuries (61.4% and 20.2%, respectively) **(Table 4)**.

## EDITORIAL COMMENT

This report documented that less than one-eighth of all medical evacuations during the surveillance period were associated with battle injuries. Rates of evacuations for battle injuries were considerably lower in the last year than the first year of the surveillance period, likely a reflection of both the reduction in troop levels that took place during this period and the change in mission away from direct combat. The majority of evacuations overall were associated with non-battle injuries and illnesses, more than two-thirds of which were attributed to mental disorders, non-battle injuries, musculoskeletal disorders, and "signs, symptoms, and ill-defined conditions." Overall rates of evacuation were slightly higher among females than males. Among the major diagnostic categories, rates of evacuation were noticeably higher among males than females only for non-battle injuries/poisonings and battle injuries. Examination of more specific illnesses and injuries revealed that evacuations for mental disorders and back and joint disorders were relatively common among deployers of both sexes, and fractures of extremities and vertebrae were less frequent among females than among males. The majority of service members who were evacuated were returned to normal duty status following their post-evacuation hospitalizations or outpatient encounters. However, less than three-eighths of those evacuated for battle injuries were returned to duty immediately after their initial healthcare encounters.

The relatively low likelihood of medical evacuation (20.5 evacuations per 1,000 dp-yrs for the entire surveillance period) suggests that most deployers were sufficiently healthy and fit, and received the

**TABLE 3.** Demographic and military characteristics of service members with medical evacuations with matched medical encounters, 1 January 2013 through 31 December 2015

| | No. medevaced | Rate[a] |
|---|---|---|
| Total | 3,912 | 20.5 |
| Sex | | |
| Male | 3,398 | 20.1 |
| Female | 514 | 23.6 |
| Race/ethnicity | | |
| White, non-Hispanic | 2,541 | 20.8 |
| Black, non-Hispanic | 679 | 22.0 |
| Hispanic | 441 | 19.5 |
| Asian/Pacific Islander | 131 | 19.6 |
| Other/unknown | 120 | 13.9 |
| Age group | | |
| <20 | 89 | 15.4 |
| 20–24 | 1,223 | 20.2 |
| 25–29 | 943 | 19.5 |
| 30–34 | 613 | 19.8 |
| 35–39 | 421 | 20.2 |
| 40–44 | 334 | 24.4 |
| 45+ | 289 | 27.0 |
| Service | | |
| Army | 3,252 | 25.8 |
| Navy | 161 | 15.7 |
| Air Force | 170 | 4.2 |
| Marine Corps | 329 | 23.5 |
| Component | | |
| Active | 2,864 | 19.6 |
| Reserve | 1,048 | 23.5 |
| Rank | | |
| Junior enlisted (E1–E4) | 1,735 | 21.7 |
| Senior enlisted (E5–E9) | 1,634 | 22.2 |
| Junior officer (O1–O4 [W1–W3]) | 312 | 12.7 |
| Senior officer (O1–O4 [W1–W3]) | 231 | 18.3 |
| Occupation | | |
| Combat-specific[b] | 1,126 | 29.3 |
| Motor transport | 277 | 32.6 |
| Repair/engineering | 844 | 16.5 |
| Communications/intelligence | 852 | 19.2 |
| Health care | 250 | 23.0 |
| Other | 563 | 15.0 |
| Precedence[c] | | % medical evacs |
| Routine | 3,654 | 93.4 |
| Priority | 178 | 4.6 |
| Urgent | 80 | 2.0 |
| Transport_mode_num[c] | | % medical evacs |
| Military | 3,899 | 99.7 |
| Commercial | 4 | 0.1 |
| Other | 9 | 0.2 |

[a]Rate per 1,000 deployed person-years

[b]Infantry, artillery, combat engineering, armor transport

[c]Data field within the U.S. Transportation Command Regulating and Command and Control Evacuation System

medical care in theater necessary, to successfully complete their assignments without having to be evacuated to receive medical care. Findings show that the changes in numbers of medical evacuations over the course of the surveillance period reflect the drawdown of U.S. troops from Afghanistan leading up to the end of OEF.[4] As OFS began, U.S. troop withdrawal slowed and leveled off by the end of 2015.[4]

There are several important limitations that should be considered when interpreting the results of this analysis. Direct comparisons of numbers and rates of medical evacuations by cause, as between males and females, can be misleading; for example, such comparisons do not account for differences between the groups in other characteristics (e.g., age, grade, military occupation, locations and activities while deployed) that are significant determinants of medical evacuation risk. Also, for this report, most "causes" of medical evacuations were estimated from primary (first-listed) diagnoses that were recorded during hospitalizations or initial outpatient encounters after evacuation. In some cases, clinical evaluations in fixed medical treatment facilities after medical evacuations may have "ruled out" serious conditions that were clinically suspected in the theater. For this analysis, the "causes" of such evacuations reflect diagnoses that were determined after evaluations outside of the theater rather than diagnoses—perhaps of severe disease—that were clinically suspected in the theater. To the extent that this occurred, the "causes" of some medical evacuations may seem surprisingly minor.

Overall, results highlight the need to tailor force health protection policies, training, supplies, equipment, and practices based on characteristics of the deployed force (e.g., combat vs. support; male vs. female) and the nature of the military operations (e.g., combat vs. humanitarian assistance). Finally, previous reports have documented that relatively large proportions of service members who are evacuated for illnesses (including musculoskeletal and mental disorders) during deployments had medical encounters for the same or closely related conditions

**TABLE 4.** Disposition after inpatient or outpatient encounter post–medical evacuation encounter, U.S. Armed Forces, 1 January 2013 through 31 December 2015

| Disposition | Total | | Battle injury | | Non-battle injury and poisoning | |
|---|---|---|---|---|---|---|
| | No. | % | No. | % | No. | % |
| Inpatient | 1,219 | | 340 | | 294 | |
| Returned to duty | 590 | 48.4 | 68 | 20.0 | 130 | 44.2 |
| Transferred/Discharged to other facility | 616 | 50.5 | 270 | 79.4 | 162 | 55.1 |
| Discharged home | 1 | 0.1 | 0 | 0.0 | 0 | 0.0 |
| Separated | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Died | 5 | 0.4 | 2 | 0.6 | 0 | 0.0 |
| Other | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Unknown | 7 | 0.6 | 0 | 0.0 | 2 | 0.7 |
| Outpatient | 2,693 | | 119 | | 376 | |
| Released w/o limitation | 2,224 | 82.6 | 95 | 79.8 | 231 | 61.4 |
| Released with work/duty limitation | 294 | 10.9 | 17 | 14.3 | 76 | 20.2 |
| Sick at home/quarters | 6 | 0.2 | 1 | 0.8 | 0 | 0.0 |
| Immediate referral | 134 | 5.0 | 5 | 4.2 | 66 | 17.6 |
| Admitted/transferred to civilian hospital | 5 | 0.2 | 1 | 0.8 | 2 | 0.5 |
| Died | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Discharged home | 1 | 0.0 | 0 | 0.0 | 1 | 0.3 |
| Other | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 |
| Unknown | 29 | 1.1 | 0 | 0.0 | 0 | 0.0 |

shortly before deploying.[1-3] Further analyses should identify conditions among male and female service members that are most likely to recur or worsen during, and require medical evacuation from, combat-related deployments.

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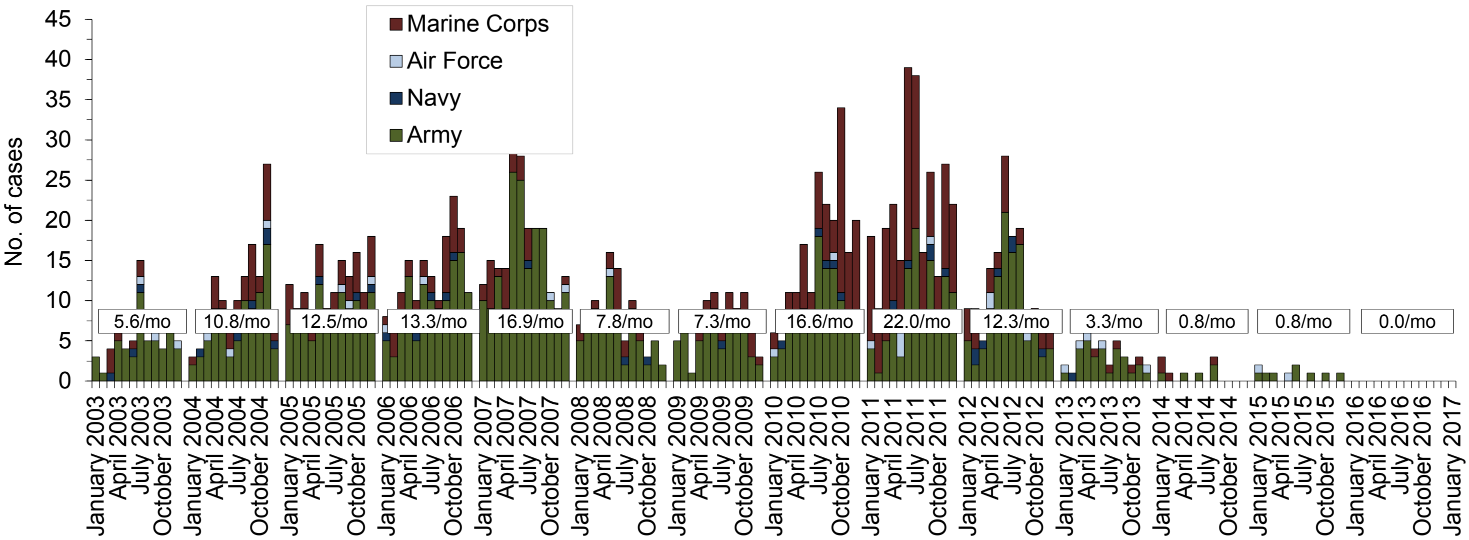
# Deployment-related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003–January 2017 (data as of 21 February 2017)

Amputations[a,b]

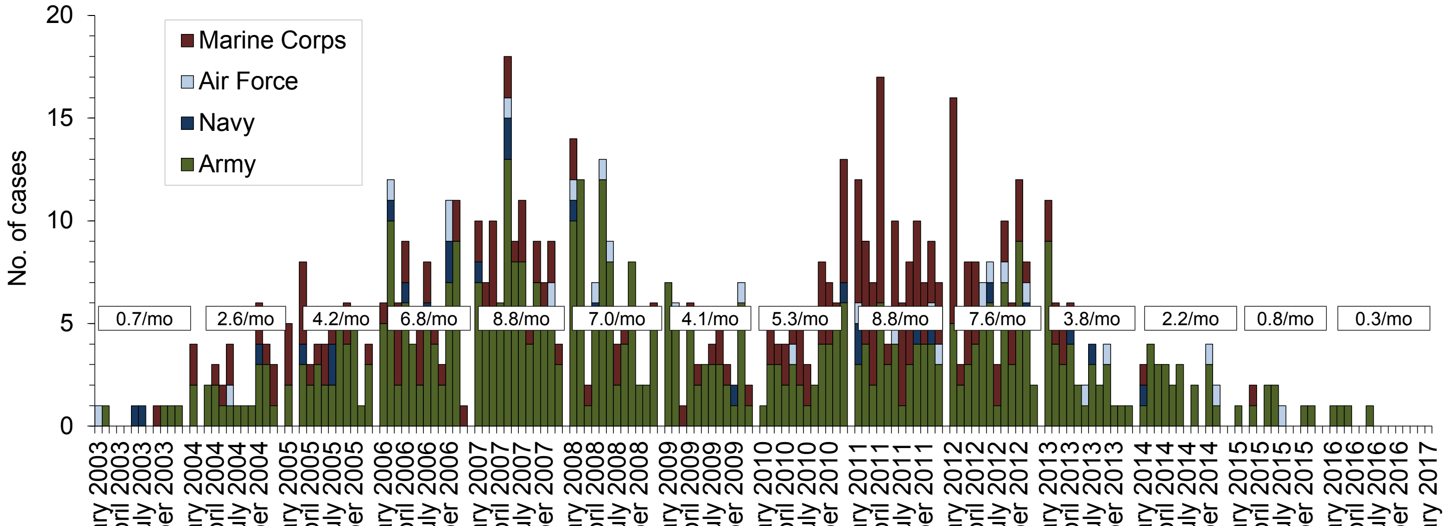



Reference: Army Medical Surveillance Activity. Deployment-related condition of special surveillance interest: amputations. Amputations of lower and upper extremities, U.S. Armed Forces, 1990–2004. *MSMR*. 2005;11(1):2–6.

[a]Amputations (ICD-10: S48, S58, S684, S687, S78, S88, S980, S983, S989, Z440, Z441, Z4781, Z891, Z892, Z8943, Z8944, Z895, Z896, Z899)

[b]Indicator diagnosis (one per individual) during a hospitalization while deployed to/within 365 days of returning from deployment.

Heterotopic ossification[a,b]



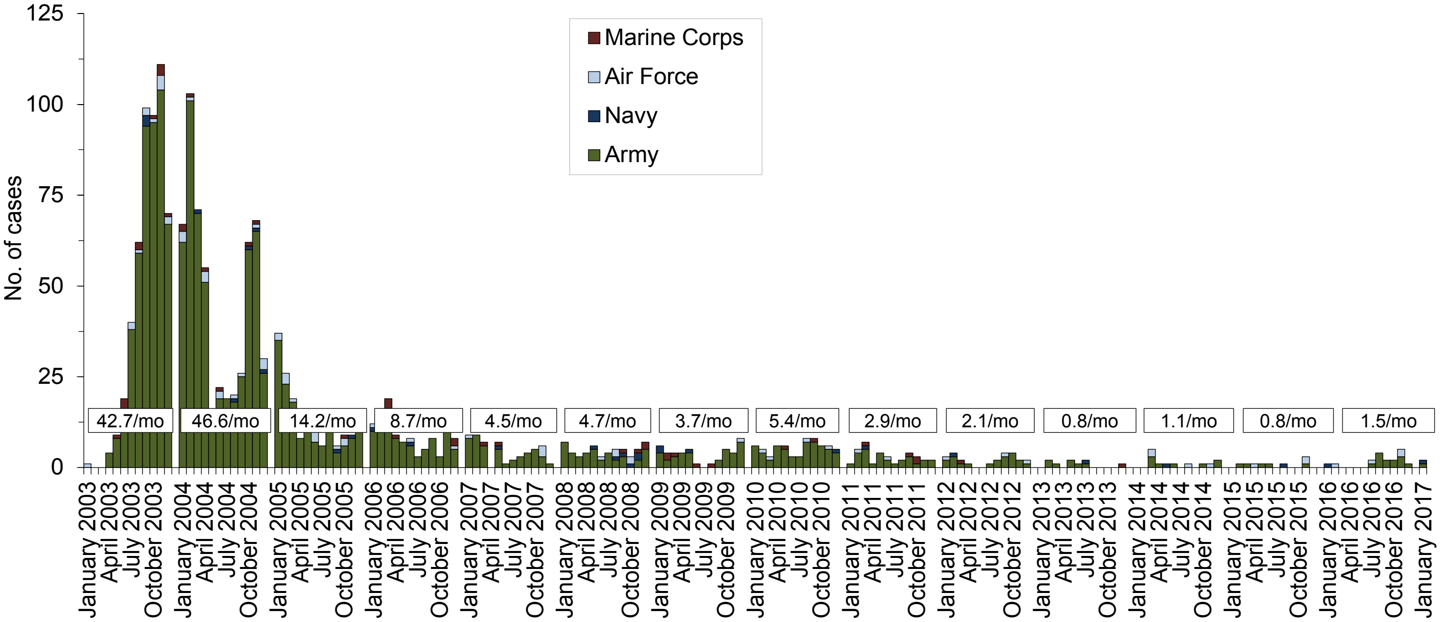

Reference: Army Medical Surveillance Activity. Heterotopic ossification, active components, U.S. Armed Forces, 2002–2007. *MSMR*. 2007;14(5):7–9.

[a]Heterotopic ossification (ICD-10: M610, M614, M615)

[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 365 days of returning from deployment.

# Deployment-related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003–January 2017 (data as of 21 February 2017)

Leishmaniasis[a,b]

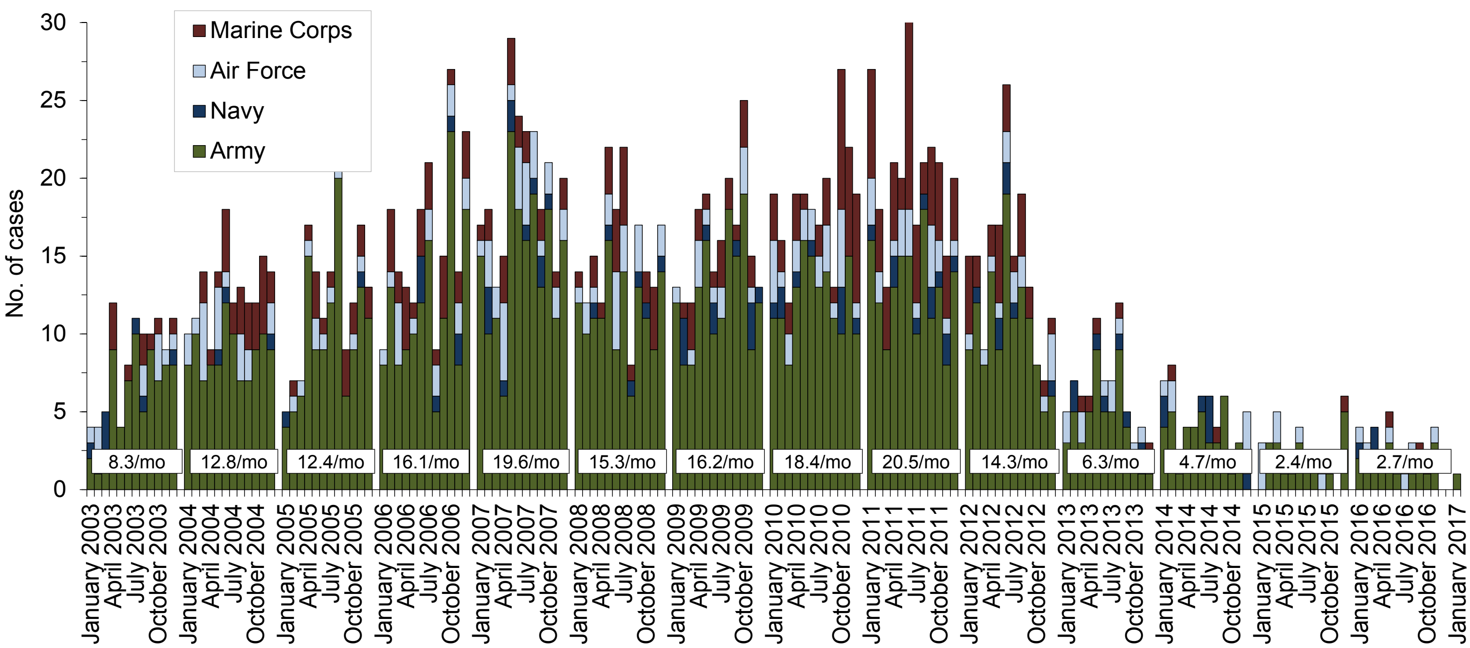



Reference: Army Medical Surveillance Activity. Deployment-related condition of special surveillance interest: leishmaniasis. Leishmaniasis among U.S. Armed Forces, January 2003–November 2004. *MSMR*. 2004;10(6):2–4.

[a]Leishmaniasis (ICD-10: B55, B550, B551, B552, B559)

[b]Indicator diagnosis (one per individual) during a hospitalization, ambulatory visit, and/or from a notifiable medical event during or after service in OEF/OIF/OND.

Deep vein thrombophlebitis/pulmonary embolus[a,b]




Reference: Isenbarger DW, Atwood JE, Scott PT, et al. Venous thromboembolism among United States soldiers deployed to Southwest Asia. *Thromb Res*. 2006;117(4):379–383.

[a]Deep vein thrombophlebitis/pulmonary embolus (ICD-10: I2601, I2609, I2690, I2699, I801–I803, I808, I809, I822–I824, I826, I82A1, I82B1, I82C1, I8281, I82890, I8290)

[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 90 days of returning from deployment.

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