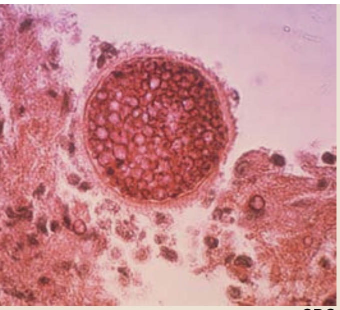
APRIL 2018

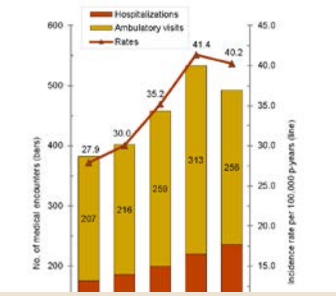
Volume 25
Number 4

MSMR

MEDICAL SURVEILLANCE MONTHLY REPORT



CDC



A publication of the Armed Forces Health Surveillance Branch

Coccidioidomycosis, Active Component, U.S. Armed Forces, 2007–2017

Valerie F. Williams, MA, MS; Shauna Stahlman, PhD, MPH; Gi-Taik Oh, MS

During 2007–2017, there were 574 incident cases of coccidioidomycosis among active component service members, with an overall unadjusted incidence rate of 3.9 cases per 100,000 person-years (p-yrs). Compared to their respective counterparts, the overall rates were highest among those aged 40 years or older, Navy members, enlisted service members, and those in healthcare occupations. Overall incidence rates were similar for males and females. Within race/ethnicity groups, the overall rates of coccidioidomycosis were highest among Asian/Pacific Islanders and lowest among non-Hispanic whites. During the surveillance period, crude annual incidence rates decreased from a high of 5.2 cases per 100,000 p-yrs in 2007 to a low of 2.3 cases per 100,000 p-yrs in 2017. Of the total U.S. cases (n=547), the vast majority (85.0%) were associated with locations within states in the southwestern U.S. with *Coccidioides*-endemic areas, including California (47.3%), Arizona (32.5%), Texas (4.6%), and New Mexico (0.5%). Providers of health care to U.S. military members should consider coccidioidomycosis as a potential cause of febrile respiratory infectious illnesses, particularly when the individual has a history of recent travel to an endemic area (especially those who work or participate in activities where dust is generated).

Coccidioidomycosis, also called "Valley Fever," is an infectious disease caused by fungi of the genus *Coccidioides* (*C. immitis* and *C. posadasii*).[1] The vast majority of infections are caused by inhalation of spores, although direct contact through broken skin has been occasionally reported.[1–3] *Coccidioides* spp. are endemic to arid regions of the southwestern U.S. (Arizona, California, Nevada, New Mexico, Texas, and Utah), northern Mexico, and several desert regions of Central and South America.[1] The organism tends to grow in sandy soil 10–30 cm below the surface, where in wet conditions it grows in mold form.[4] In dry conditions, the thread-like filaments (hyphae) of the fungi desiccate to form spores that are dispersed by aerosolization when the soil is disturbed.[4]

Approximately 60% of infected individuals are asymptomatic.[5] After an incubation period of 1–3 weeks, symptomatic individuals most often experience self-limited influenza-like symptoms including fever, cough, malaise, fatigue, dyspnea, and headache.[1] In those individuals who do not clear the infection, granulomatous lung disease may develop with dissemination to skin, bone, and meninges (coccidioidal meningitis) occurring in a small fraction of infected individuals.[6] Those at increased risk for severe disease include pregnant women, older adults, and persons with compromised immune systems.[6] In addition, those of African or Filipino descent disproportionately develop disseminated disease with greater frequency than whites.[7]

The risk for coccidioidomycosis among military personnel who are assigned to or train in endemic areas is well recognized.[8,9] Previous *MSMR* analyses have examined trends in the incidence of coccidioidomycosis among U.S. active component service members during 2000–2012/2013 and have shown that the overall incidence rates peaked in 2006, after which rates declined slightly.[10,11] The current analysis updates and expands upon previous work by examining incidence rates, trends, and correlates of risk of coccidioidomycosis among active component members during 2007–2017. Locations of the incident cases at the time of diagnosis are also presented.

METHODS

The surveillance period was 1 January 2007 through 31 December 2017. The surveillance population consisted of active component service members of the Army, Navy, Air Force, or Marine Corps who served at any time during the surveillance period and who accessed care through either a military medical facility/provider or a civilian facility/provider (if paid for by the Military Health System). Diagnoses were ascertained from administrative records of all such medical encounters which are maintained in the electronic database of the Defense Medical Surveillance System (DMSS). In-theater diagnoses of coccidioidomycosis were identified from medical records of service members deployed to Southwest Asia/Middle East and whose healthcare encounters were documented in the Theater Medical Data Store (TMDS). It is Department of Defense policy that cases of certain specified medical conditions and events of public health importance shall be reported electronically through military health channels for surveillance purposes.[12] Conditions covered by this policy, including diagnosed cases of coccidioidomycosis, are referred to as reportable medical events (RMEs). The content of such electronic reports is stored in the databases of the DMSS. In addition, laboratory-confirmed cases of *Coccidioides* infection (coccidioidomycosis) were identified from Navy and Marine Corps Public Health Center (NMCPHC) records of serologic tests or fungal cultures. Specific laboratory tests documented as positive were serology (including enzyme immunoassay, immunodiffusion, and complement fixation positive in any titer) and culture or direct visualization (i.e., smear or microscopy) of *Coccidioides* in any body fluid or tissue sample.

A case of coccidioidomycosis was defined as an individual with 1) one positive laboratory test; 2) a reportable medical event record of confirmed coccidioidomycosis; 3) a hospitalization record with a primary diagnosis of coccidioidomycosis; or 4) two or more outpatient (or TMDS) encounters within 14 days of each other (but not on the same day) that included the ICD-9 code 114.* or ICD-10 code B38.* in the primary diagnostic position.[13]

The incident date was considered the date of the first positive laboratory test, RME or medical encounter that included a qualifying diagnosis. An individual could be counted as a case of coccidioidomycosis once per lifetime. Service members diagnosed as a case prior to the start of the surveillance period were excluded from the analysis. Incidence rates were calculated as incident coccidioidomycosis diagnoses per 100,000 person-years (p-yrs) of active component service.

The new electronic health record for the Military Health System, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter and person-time data for individuals seeking care at one of these facilities during 2017 were not included in this analysis.

RESULTS

During 2007–2017, there were 574 incident cases of coccidioidomycosis among active component service members, with an overall crude (unadjusted) incidence rate of 3.9 cases per 100,000 p-yrs **(Table 1)**. Compared to their respective counterparts, the overall incidence rates were highest among those aged 40 years or older, Navy members, and enlisted service members. Overall incidence rates were similar for male and female service members (3.9 and 3.7 cases per 100,000 p-yrs, respectively). Within race/ethnicity groups, the overall rates of coccidioidomycosis were highest among Asian/Pacific Islanders (9.6 cases per 100,000 p-yrs) and lowest among non-Hispanic whites (3.2 cases per 100,000 p-yrs) **(Table 1)**. Across military occupations, overall incidence rates were highest among healthcare workers (4.7 cases per 100,000 p-yrs) and lowest among those working in infantry/artillery/combat engineering (1.7 cases per 100,000 p-yrs) and armor/motor transport (1.8 cases per 100,000 p-yrs) occupations. During the 11-year surveillance period, crude annual incidence rates decreased from a high of 5.2 cases per 100,000 p-yrs in 2007 to a low of 2.3 cases per 100,000 p-yrs in 2017 **(Figure 1)**.

A total of 547 incident cases of coccidioidomycosis occurred among service members associated with 25 U.S. states and the District of Columbia. Twelve of these states and the District of Columbia were associated with four or more cases of coccidioidomycosis (n=528) during 2007–2017 and accounted for 96.5% of the total number of U.S. cases **(Figure 2)**. Thirteen states were associated with fewer than four cases of coccidioidomycosis. Of the total U.S. cases, the vast majority (n=465; 85.0%) were associated with locations within states in the southwestern U.S. with *Coccidioides*-endemic areas, including California (n=259; 47.3%), Arizona (n=178; 32.5%), Texas (n=25; 4.6%), and New Mexico (n=3; 0.5%). However, some U.S. locations outside of the endemic areas also were associated with relatively high numbers of cases (Hawaii, n=16; Georgia, n=9; Washington, n=7; Maryland, n=7; Virginia, n=6; Florida, n=5) **(Figure 2)**.

The medical treatment facilities at four military installations diagnosed more than half (53.1%) of the total incident coccidioidomycosis cases and included Naval Medical Center San Diego, CA (n=95), Naval Health Clinic Lemoore, CA (n=89), Raymond W. Bliss Army Health Center Fort Huachuca, AZ (n=64), and Davis-Monthan Air Force Base, AZ (n=57). There were 12 incident coccidioidomycosis cases among service members assigned outside the U.S., in Germany (n=7), Japan (n=3), and South Korea (n=2) **(data not shown)**. Information on location of diagnosis was missing for a relatively small number of cases (n=15).

TABLE 1. Incident counts and incidence rates of coccidioidomycosis, by demographic and military characteristics, active component, U.S. Armed Forces, 2007–2017

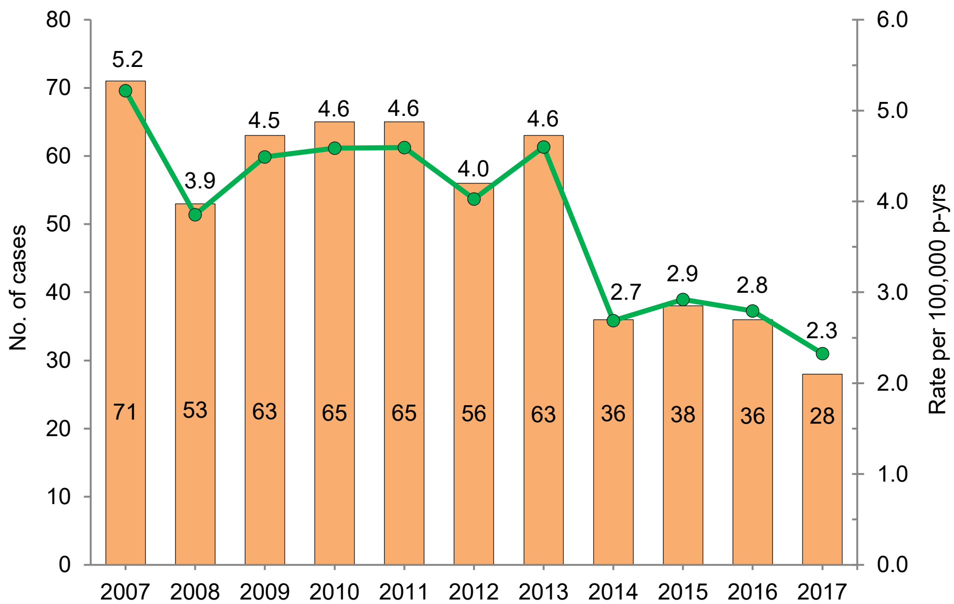
	No.	Rate[a]
Total	574	3.9
Sex		
Male	492	3.9
Female	82	3.7
Race/ethnicity		
Non-Hispanic white	287	3.2
Non-Hispanic black	106	4.4
Hispanic	78	4.1
Asian/Pacific Islander	53	9.6
Other/unknown	50	4.9
Age group (years)		
<20	25	2.6
20–29	277	3.3
30–39	174	4.3
40–49	87	6.1
50+	11	7.6
Service		
Army	149	2.6
Navy	212	6.1
Air Force	157	4.4
Marine Corps	56	2.6
Rank		
Enlisted	499	4.0
Officer	75	3.0
Occupation		
Combat-specific[b]	35	1.7
Armor/motor transport	10	1.8
Healthcare	60	4.7
Other	469	4.3

[a]Rate per 100,000 person-years
[b]Infantry/artillery/combat engineering

EDITORIAL COMMENT

In the U.S. general population, approximately 10,000 coccidioidomycosis cases are reported annually through reportable disease surveillance, and the substantial year-to-year fluctuation that occurs likely reflects varying environmental conditions, numbers of susceptible people exposed to

FIGURE 1. Incident diagnoses and annual incidence rates of coccidioidomycosis, active component, U.S. Armed Forces, 2007–2017



Coccidioides (because of travel or relocation to endemic areas), and testing and reporting practices.[14-16] The vast majority of U.S. coccidioidomycosis cases are reported from Arizona and California.[14] In 2016, a marked increase in annual coccidioidomycosis incidence was observed in California, compared with previous years.[17] Annual incidence rates in California and Arizona generally followed similar trends; however, Arizona reported a decrease in the rate between 2015 and 2016.[18-21] In contrast, during this same period, crude annual incidence rates among active component service members remained relatively stable.

Provisional data from the California Department of Public Health for January–February 2018 show a more than 200% increase in the number of reported coccidioidomycosis cases compared to the number of cases reported during the same period in 2017 and 2016.[22] Similarly, provisional data from the Arizona Department of Health Services for January–February 2018 indicate a more than 100% increase in the number of reported coccidioidomycosis cases relative to the number reported during the same period in 2017.[23] Parallel increases in the number of cases of coccidioidomycosis among U.S. military personnel can be expected given the numbers of non-immune service members stationed or training in these states.

The vast majority of the incident cases of coccidioidomycosis among active component service members occurred among those personnel assigned to *Coccidioides*-endemic regions of the southwestern U.S. It is important to note that the fungus was recently found in south-central Washington state, and that this area is now considered endemic by some sources.[24,25] In addition to the risk of living and working in an endemic area, more cases may be identified at these locations because clinicians may suspect and test for coccidioidomycosis more readily, thus identifying larger proportions of incident cases.

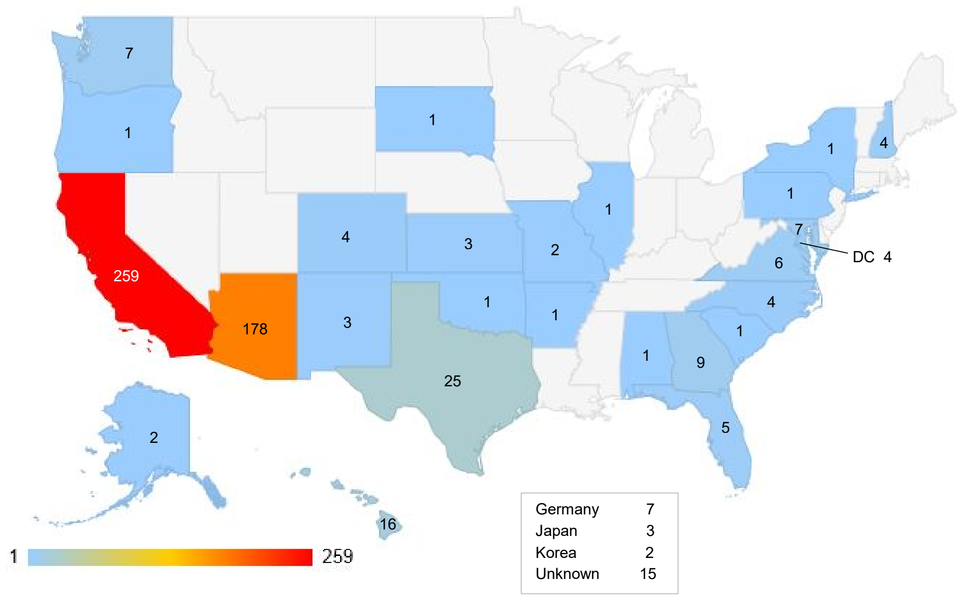
The results of this analysis are limited by the fact that the ascertainment of coccidioidomycosis cases is likely incomplete; some cases treated in deployed or non-U.S. military medical facilities may not have been reported or otherwise ascertained at the time of this analysis. In addition, because of the absence or mildness of symptoms, affected individuals may not seek medical attention. Furthermore, most infections with *Coccidioides* are of self-limited duration and would not be specifically identified in the absence of laboratory testing.

Because of the non-specific clinical manifestations of coccidioidomycosis and the delayed onset of symptoms, affected service members may present for care outside of endemic areas. Individuals with latent coccidioidal infection due to past exposure may experience reactivation of their infection and illness if they later develop immune compromise due to age, infection (e.g., HIV), cancer, autoimmune disease, or medical treatments.[6] Such reactivation may occur far from regions where coccidioidomycosis is endemic. In such situations, affected individuals may experience delays in testing, diagnosis, and treatment.[8] Because disease awareness is low among primary care providers outside of endemic areas, disease detection and timely treatment are significant challenges.[26,27] Providers of health care to U.S. military members should consider coccidioidomycosis as a potential cause of febrile respiratory infectious illnesses, particularly when the individual has a history of recent travel to an endemic area (especially those who work or participate in activities where dust is generated).

REFERENCES

1. Saubolle MA, McKellar PP, Sussland D. Epidemiologic, clinical, and diagnostic aspects of coccidioidomycosis. *J Clin Microbiol.* 2007;45(1):26–30.
2. Garcia Garcia SC, Salas Alanis JC, Flores MG, Gonzalez Gonzalez SE, Vera Cabrera L, Ocampo Candiani J. Coccidioidomycosis and the skin: a comprehensive review. *An Bras Dermatol.* 2015;90(5):610–619.
3. Russell DH, Ager E, Wohltman W. Cutaneous coccidioidomycosis masquerading as an epidermoid cyst: case report and review of the literature. *Mil Med.* 2017;182(1):e1665–e1668.
4. Brown J, Benedict K, Park BJ, Thompson GR 3rd. Coccidioidomycosis: epidemiology. *Clin Epidemiol.* 2013;5:185–197.
5. Smith CE, Whiting EG, Baker EE, Rosenberger HG, Beard RR, Saito MT. The use of coccidioidin. *Am Rev Tuberc.* 1948;57(4):330–360.
6. Galgiani JN, Ampel NM, Blair JE. Coccidioidomycosis. *Clin Infect Dis.* 2005;41(9):1217–1223.
7. Louie L, Ng S, Hajjeh R, et al. Influence of host genetics on the severity of coccidioidomycosis. *Emerg Infect Dis.* 1999;5(5):672–680.
8. Crum-Cianflone NF. Coccidioidomycosis in the U.S. military: a review. *Ann N Y Acad Sci.* 2007;1111:112–121.
9. Armed Forces Health Surveillance Center. Historical perspective: coccidioidomycosis in the U.S. military and military-associated populations. *MSMR.* 2012;19(12):5–6.
10. Armed Forces Health Surveillance Center. Brief

FIGURE 2. Number of incident diagnoses of coccidioidomycosis, by state, active component, U.S. Armed Forces, 2007–2017



report: coccidioidomycosis, active component, U.S. Armed Forces, January 2000–June 2012. *MSMR*. 2012;19(9):10.

11. Armed Forces Health Surveillance Center. Brief report: the geographic distribution of incident coccidioidomycosis among active component service members, 2000–2013. *MSMR*. 2014; 21(6):12–14.

12. Armed Forces Health Surveillance Branch [in collaboration with U.S. Air Force School of Aerospace Medicine, Army Public Health Center, and Navy and Marine Corps Public Health Center]. *Armed Forces Reportable Medical Events Guidelines and Case Definitions*. 17 July 2017. https://www.health.mil/Reference-Center/Publications/2014/04/01/Coccidioidomycosis.

13. Armed Forces Health Surveillance Branch. Surveillance Case Definition. Coccidioidomycosis. April 2017. https://www.health.mil/Reference-Center/Publications/2014/04/01/Coccidioidomycosis.

14. Centers for Disease Control and Prevention. Valley fever (coccidioidomycosis) statistics. https://www.cdc.gov/fungal/diseases/coccidioidomycosis/statistics.html. Accessed on 12 February 2018.

15. Gabe LM, Malo J, Knox KS. Diagnosis and management of coccidioidomycosis. *Clin Chest Med*. 2017;38(3):417–433.

16. Park BJ, Sigel K, Vaz V, et al. An epidemic of coccidioidomycosis in Arizona associated with climatic changes, 1998–2001. *J Infect Dis*. 2005;191(11):1981–1987.

17. Tabnak F, Knutson K, Cooksey G, Nguyen A, Vugia D. Epidemiologic summary of coccidioidomycosis in California, 2016. Sacramento, CA: California Department of Public Health, Center for Infectious Diseases, Division of Communicable Disease Control; 2017. https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/ CocciEpiSummary2016.pdf.

18. Cooksey GS, Nguyen A, Knutson K, et al. Notes from the field: increase in coccidioidomycosis—California, 2016. *MMWR Morb Mortal Wkly Rep*. 2017;66(31):833–834.

19. Increase in reported coccidioidomycosis—United States, 1998–2011. *MMWR Morb Mortal Wkly Rep*. 2013;62(12):217–221.

20. Office of Infectious Disease Services, Arizona Department of Health Services. Valley fever 2015 annual report. Phoenix, AZ: Arizona Department of Health Services, Office of Infectious Disease Services; 2016. http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/valley-fever/reports/valley-fever-2015.pdf.

21. Office of Infectious Disease Services, Arizona Department of Health Services. Rates of reported cases of selected notifiable diseases, by category, for each county, Arizona, 2016, per 100,000 population. Phoenix, AZ: Arizona Department of Health Services, Office of Infectious Disease Services; 2017. http://www.azdhs. gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/data-statistics-archive/2016/rates-by-county-2016.pdf.

22. California Department of Public Health, Center for Infectious Diseases, Division of Communicable Disease Control, Infectious Diseases Branch, Surveillance and Statistics Section. Coccidioidomycosis in California Provisional Monthly Report, January–February, 2018. https://www.cdph.ca.gov/Programs/CID/DCDC/CDPH%20Document%20Library/CocciinCAProvisionalMonthlyReport.pdf. Accessed on 22 February 2018.

23. Office of Infectious Disease Services, Arizona Department of Health Services. Summary of selected reportable diseases Jan–February, 2018. http://www.azdhs.gov/documents/preparedness/epidemiology-disease-control/disease-data-statistics-reports/data-statistics-archive/2018/2018-ytd-communicable-disease-summary.pdf. Accessed on 29 March 2018.

24. Marsden-Haug N, Goldoft M, Ralston C, et al. Coccidioidomycosis acquired in Washington State. *Clin Infect Dis*. 2013;56(6):847–850.

25. Litvintseva AP, Marsden-Haug N, Hurst S, et al. Valley fever: Finding new places for an old disease: *Coccidioides immitis* found in Washington State soil associated with recent human infection. *Clin Infect Dis*. 2015;60(1):e1–e3.

26. Tsang CA, Anderson SM, Imholte SB, et al. Enhanced surveillance of coccidioidomycosis, Arizona, USA, 2007–2008. *Emerg Infect Dis*. 2010;16(11):1738–1744.

27. Chen S, Erhart LM, Anderson S, et al. Coccidioidomycosis: knowledge, attitudes, and practices among healthcare providers—Arizona, 2007. *Med Mycol*. 2011; 49(6):649–656.

Update: Heat Illness, Active Component, U.S. Armed Forces, 2017

In 2017, there were 464 incident diagnoses of heat stroke and 1,699 incident diagnoses of heat exhaustion among active component service members. The overall crude incidence rates of heat stroke and heat exhaustion were 0.38 cases and 1.41 cases per 1,000 person-years, respectively. In 2017, subgroup-specific incidence rates of both heat stroke and heat exhaustion were highest among service members aged 19 years or younger, Asian/Pacific Islanders, Marine Corps and Army members, and those in combat-specific occupations. The rate of heat stroke was markedly higher among males than females. In contrast, the rate of heat exhaustion among females was similar to that among males. During 2013–2017, a total of 359 heat illnesses were documented among service members in Iraq and Afghanistan; 8.6% (n=31) were diagnosed as heat stroke. Commanders, small unit leaders, training cadre, and supporting medical personnel must ensure that military members whom they supervise and support are informed about risks, preventive countermeasures, early signs and symptoms, and first-responder actions related to heat illnesses.

The term "heat illness" refers to a group of disorders that occur when the elevation of core body temperature surpasses the compensatory limits of thermoregulation.[1] Heat illness is the result of environmental heat stress and/or exertion and represents a set of conditions that exist along a continuum from less severe (heat exhaustion) to potentially life-threatening (heat stroke).

Heat exhaustion is caused by the inability to maintain adequate cardiac output due to strenuous physical exertion and environmental heat stress.[1,2] Acute dehydration often accompanies heat exhaustion but is not required for the diagnosis.[3] Clinical criteria for heat exhaustion include core body temperature greater than 100.5°F/38°C and less than 104°F/40°C at the time of or immediately after exertion and/or heat exposure; physical collapse at the time of or shortly after physical exertion; and no significant dysfunction of the central nervous system. If any central nervous system dysfunction develops (e.g., dizziness, headache), it is mild and rapidly resolves with rest and cooling measures (e.g., removal of unnecessary clothing, relocation to a cooled environment, and oral hydration with cooled, slightly hypotonic solutions).[1-4]

Heat stroke is a debilitating illness characterized clinically by severe hyperthermia (core body temperature of 104°F/40°C or greater), profound central nervous system dysfunction (e.g., delirium, seizures, coma), and additional organ and tissue damage.[1,4,5] The onset of heat stroke requires aggressive clinical treatments, including rapid cooling and supportive therapies such as fluid resuscitation to stabilize organ function.[1,5] The observed pathologic changes in several organ systems are thought to occur through a complex interaction between heat cytotoxicity, coagulopathies, and a severe systemic inflammatory response.[1,5] Multi-organ system failure is the ultimate cause of mortality due to heat stroke.[5]

Timely medical intervention can prevent milder cases of heat illness, such as heat exhaustion, from becoming severe (e.g., heat stroke) and potentially life threatening. However, even with medical intervention, heat stroke may have lasting effects, including damage to the nervous system and other vital organs and decreased heat tolerance, making an individual more susceptible to subsequent episodes of heat illness.[6-8] Furthermore, the continued manifestation of multiorgan system dysfunction after heat stroke increases patients' risk of mortality during the ensuing months and years.[9,10]

Strenuous physical activity for extended durations in occupational settings as well as during military operational and training exercises exposes service members to considerable heat stress due to high environmental heat and/or a high rate of metabolic heat production.[11] In some military settings, wearing needed protective clothing or equipment may make it biophysically difficult to dissipate body heat. The resulting body heat burden and associated cardiovascular strain limit exercise performance and increase the risk of heat-related illness.[11,12]

Over many decades, lessons learned during military training and operations in hot environments as well as a substantial body of literature have resulted in doctrine, equipment, and preventive measures that can significantly reduce the adverse health effects of military activities in hot weather.[13-19] Although numerous effective countermeasures are available, heat-related illness remains a significant threat to the health and operational effectiveness of military members and their units and accounts for considerable morbidity, particularly during recruit training in the U.S. military.[11,20]

In the Military Health System, the most serious heat-related illnesses are considered notifiable medical events. Notifiable cases of heat illness include heat exhaustion and heat stroke. All cases of heat illness that require medical intervention or result in change of duty status are reportable.[4]

This report summarizes not only reportable medical events of heat illnesses, but also heat illness–related hospitalizations and ambulatory visits among active component members during 2017 and compares them to the previous 4 years. Episodes of heat stroke and heat exhaustion are summarized separately.

METHODS

The surveillance period was 1 January 2013 through 31 December 2017. 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 the surveillance period. All data used to determine incident heat illness diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System) treatment facilities worldwide. In-theater diagnoses of heat illness were identified from medical records of service members deployed to Southwest Asia/Middle East and whose healthcare encounters were documented in the Theater Medical Data Store (TMDS). Because heat illnesses represent a threat to the health of individual service members and to military training and operations, the Armed Forces require expeditious reporting of these reportable medical events through one of the service-specific electronic reporting systems; these reports are routinely transmitted and incorporated into the DMSS.

For this analysis, a case of heat illness was defined as an individual with 1) a hospitalization or outpatient medical encounter with a primary (first-listed) or secondary (second-listed) diagnosis of heat stroke (ICD-9: 992.0; ICD-10: T67.0*) or heat exhaustion (ICD-9: 992.3–992.5; ICD-10: T67.3*–T67.5*); or 2) a reportable medical event record of heat exhaustion or heat stroke.[21] It is important to note that previous *MSMR* analyses included diagnosis codes for other and unspecified effects of heat and light (ICD-9: 992.8 and 992.9; ICD-10: T67.8* and T67.9*) within the heat illness category "other heat illnesses." These codes were excluded from the current analysis. If an individual had a diagnosis for both heat stroke and heat exhaustion during a given year, only one diagnosis was selected prioritizing heat stroke over heat exhaustion. Encounters for each individual within each calendar year then were prioritized in terms of record source: hospitalizations > reportable events > ambulatory visits.

For surveillance purposes, a "recruit trainee" was defined as an active component service member (grades E1–E4) who was assigned to one of the Services' nine recruit training locations (per the individual's initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his or her service. Recruit trainees were considered a separate category of enlisted service members in summaries of heat illnesses by military grade overall.

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if affected service members had at least one inpatient or outpatient heat illness medical encounter in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

The new electronic health record for the Military Health System, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter and person-time data for individuals seeking care at one of these facilities during 2017 were not included in this analysis.

RESULTS

In 2017, there were 464 incident cases of heat stroke and 1,699 incident cases of heat exhaustion among active component service members **(Table 1)**. The overall crude incidence rates of heat stroke and heat exhaustion were 0.38 cases and 1.41 cases per 1,000 person-years (p-yrs), respectively.

Crude (unadjusted) annual incidence rates of heat stroke increased steadily from 0.24 cases per 1,000 p-yrs in 2013 to 0.38 cases per 1,000 p-yrs in 2016 and 2017 **(Figure 1)**. In 2017, there were more heat stroke–related hospitalizations than in 2016 but similar numbers of ambulatory visits. Crude annual incidence rates of heat exhaustion ranged from a low of 1.12 cases per 1,000 p-yrs in 2014 to a peak of 1.43 cases per 1,000 p-yrs in 2016, after which the rate remained relatively stable at 1.41 cases per 1,000 p-yrs in 2017 **(Figure 2)**. During the 5-year surveillance period, the numbers of heat exhaustion–related hospitalizations and the proportions that they represented of the total heat exhaustion cases remained relatively stable (range 44–60; 2.6%–4.2%); however, the proportions of total heat exhaustion cases represented by ambulatory visits increased from 57.0% in 2013 to 80.8% in 2017.

In 2017, subgroup-specific incidence rates of heat stroke were highest among males and service members aged 19 years or younger, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations **(Table 1)**. The incidence rate of heat stroke was 38.2% higher among service members in the Marine Corps than among those in the Army; the Army rate was nearly 6-fold the Navy rate and 11-fold the Air Force rate; and the rate among females was 40.1% lower than the rate among males. There were only 18 cases of heat stroke reported among recruit trainees, but their incidence rate was more than one and a half times that of other enlisted members and officers.

In contrast to the heat stroke findings, the crude incidence rate of heat exhaustion among females was similar to that among males **(Table 1)**. In 2017, subgroup-specific

TABLE 1. Incident cases[a] and incidence rates[b] of heat illness, active component, U.S. Armed Forces, 2017

	Heat stroke		Heat exhaustion		Total heat illness diagnoses	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	464	0.38	1,699	1.41	2,163	1.79
Sex						
Male	416	0.41	1,430	1.41	1,846	1.82
Female	48	0.25	269	1.38	317	1.62
Age group						
<20	68	0.72	499	5.29	567	6.02
20–24	196	0.51	699	1.83	895	2.34
25–29	110	0.40	264	0.96	374	1.35
30–34	56	0.29	129	0.66	185	0.95
35–39	19	0.14	70	0.50	89	0.64
40+	15	0.12	38	0.31	53	0.43
Race/ethnicity						
Non-Hispanic white	269	0.39	947	1.37	1,216	1.76
Non-Hispanic black	81	0.41	325	1.63	406	2.04
Hispanic	66	0.35	252	1.35	318	1.71
Asian/Pacific Islander	28	0.59	101	2.11	129	2.70
Other/unknown	20	0.23	74	0.87	94	1.10
Service						
Army	265	0.60	961	2.19	1,226	2.80
Navy	29	0.10	109	0.39	138	0.50
Air Force	17	0.05	134	0.43	151	0.49
Marine Corps	153	0.84	495	2.70	648	3.54
Military status						
Recruit	18	0.61	306	10.45	324	11.07
Enlisted	368	0.38	1,279	1.33	1,647	1.71
Officer	78	0.36	114	0.52	192	0.88
Military occupation						
Combat-specific[c]	170	1.07	497	3.12	667	4.18
Armor/motor transport	8	0.19	66	1.58	74	1.77
Pilot/air crew	7	0.16	7	0.16	14	0.31
Repair/engineering	63	0.18	265	0.77	328	0.96
Communications/ intelligence	66	0.26	291	1.14	357	1.40
Health care	34	0.32	102	0.95	136	1.26
Other/unknown	116	0.45	471	1.84	587	2.29
Home of record[d]						
Midwest	97	0.44	307	1.40	404	1.85
Northeast	53	0.34	198	1.27	251	1.61
South	198	0.38	793	1.53	991	1.91
West	106	0.38	376	1.36	482	1.74
Other/unknown	10	0.25	25	0.63	35	0.88

[a]One case per person per year
[b]Number of cases per 1,000 person-years
[c]Infantry/artillery/combat engineering
[d]As self-reported at time of entry into service

incidence rates of heat exhaustion were notably higher among service members aged 19 years or younger, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations.

Heat illnesses by location

During the 5-year surveillance period, a total of 10,458 heat-related illnesses were diagnosed at more than 250 military installations and geographic locations worldwide. Less than 5% of the total heat illness cases occurred outside of the U.S. (n=440). Four Army installations accounted for close to one-third (32.8%) of all heat illnesses during the period (Fort Benning, GA [n=1,328]; Fort Bragg, NC [n=1,059]; Fort Campbell, KY [n=606]; and Fort Jackson, SC [n=442]); six other locations accounted for an additional one-quarter (25.3%) of heat illness events (Marine Corps Base Camp Lejeune/Cherry Point, NC [n=682]; Marine Corps Recruit Depot Parris Island/ Beaufort, SC [n=518]; Marine Corps Base Camp Pendleton, CA [n=432]); Fort Polk, LA [n=428]; NMC San Diego, CA [n=313]; and Okinawa, Japan [n=271]). Of the 10 locations with the most heat illness events, seven are located in the southeastern U.S. **(Table 2)**. The 17 locations with more than 100 cases of heat illness accounted for 71.4% of all active component cases during 2013–2017.

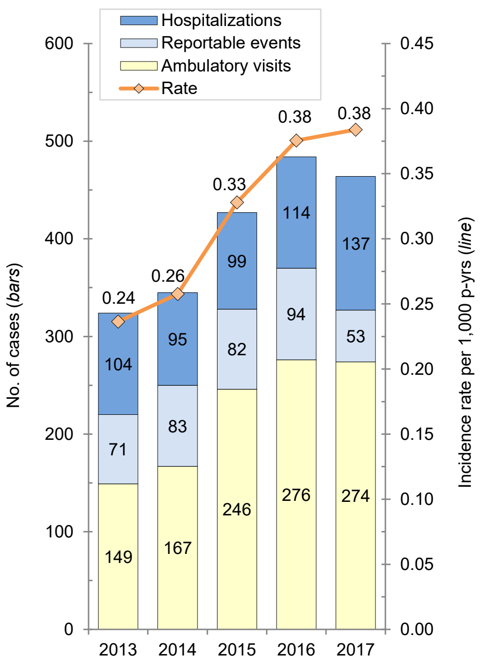
Heat illnesses in Iraq and Afghanistan

During the 5-year surveillance period, a total of 359 heat illnesses were diagnosed and treated in Iraq and Afghanistan **(Figure 3)**. Of the total cases of heat illness, 8.6% (n=31) were diagnosed as heat stroke. Deployed service members who were affected by heat illnesses were most frequently male (n=297; 82.7%); non-Hispanic white (n=215; 59.9%); aged 20–24 years (n=177; 49.3%); in the Army (n=206; 57.4%); enlisted (n=343; 95.5%); and in repair/engineering (n=123; 34.3%) or combat-specific (n=95; 26.5%) occupations **(data not shown)**. During the surveillance period, four service members were medically evacuated for heat illnesses from Iraq or Afghanistan; all of the evacuations took place in the summer months (May–September).

EDITORIAL COMMENT

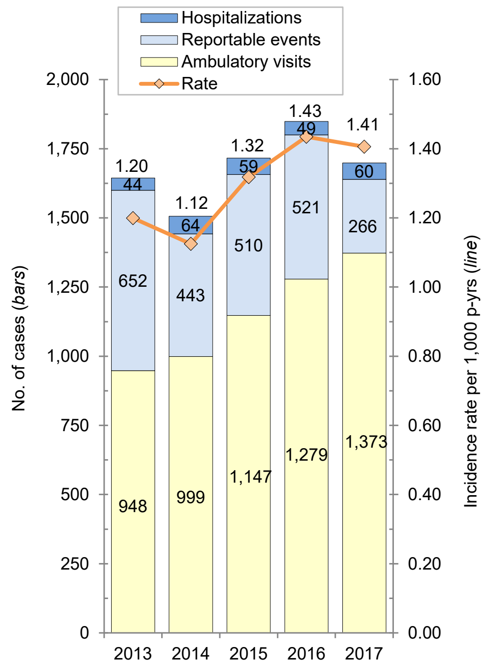
This annual update of heat illnesses among service members in the active component documented that the unadjusted annual incidence rates of heat stroke increased steadily between 2013 and 2016 with relatively little change in rates between

FIGURE 1. Incident cases[a] and incidence rates of heat stroke, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2013–2017



[a]Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits)

FIGURE 2. Incident cases[a] and incidence rates of heat exhaustion, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2013–2017



[a]Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits)

TABLE 2. Heat illness events,[a] by location of diagnosis/report, active component, U.S. Armed Forces, 2013–2017

Location of diagnosis	No.	% total
Fort Benning, GA	1,328	12.7
Fort Bragg, NC	1,059	10.1
MCB Camp Lejeune/ Cherry Point, NC	682	6.5
Fort Campbell, KY	606	5.8
MCRD Parris Island/ Beaufort, SC	518	5.0
Fort Jackson, SC	442	4.2
MCB Camp Pendleton, CA	432	4.1
Fort Polk, LA	428	4.1
NMC San Diego, CA	313	3.0
Okinawa, Japan	271	2.6
Fort Hood, TX	254	2.4
MCB Quantico, VA	239	2.3
Fort Stewart, GA	228	2.2
Fort Shafter, HI	172	1.6
NH Twentynine Palms, CA	168	1.6
Fort Leonard Wood, MO	166	1.6
JBSA-Lackland AFB, TX	166	1.6
Elgin AFB, FL	93	0.9
Fort Riley, KS	87	0.8
Fort Irwin, CA	85	0.8
All other locations	2,721	26.0
Total	10,458	100.0

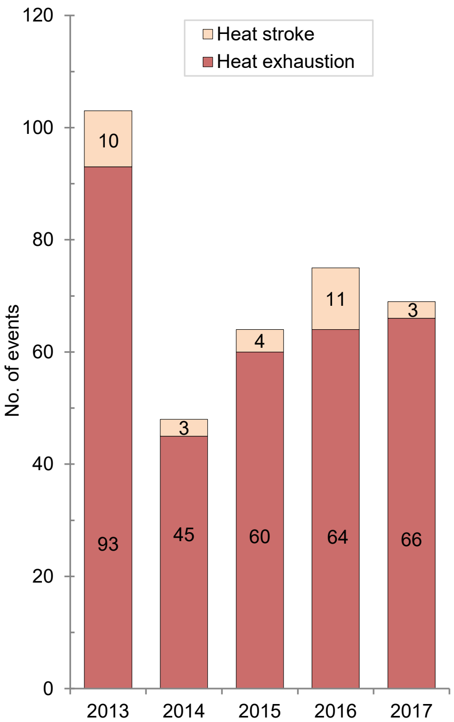
[a]One heat injury per person per year
MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NMC, Naval Medical Center; JBSA, Joint Base San Antonio; AFB, Air Force Base; NH, Naval Hospital

2016 and 2017. The crude annual incidence rate of heat exhaustion in 2017 was comparable to the rate in 2016.

There are significant limitations to this update that should be considered when interpreting the results. Similar heat-related clinical illnesses are likely managed differently and reported with different diagnostic codes at different locations and in different clinical settings. Such differences undermine the validity of direct comparisons of rates of nominal heat stroke and heat exhaustion events across locations and settings. Also, heat illnesses during training exercises and deployments that are treated in field medical facilities are not completely ascertained as cases for this report. In addition, it should be noted that the guidelines for mandatory reporting of heat illnesses were modified in the 2017 revision of the Armed Forces guidelines and case definitions for reportable medical events.[4] In this updated version of the guidelines and case definitions, the heat injury category was removed, leaving only case classifications for heat stroke and heat exhaustion. To compensate for such possible variation in reporting, the analysis for this update, as in previous years, included cases identified in DMSS records of ambulatory care and hospitalizations using a consistent set of ICD-9/ICD-10 codes for the entire surveillance period. However, it also is important to note that the exclusion of diagnosis codes for other and unspecified effects of heat and light (formerly included within the heat illness category "other heat illnesses") in the current analysis precludes the direct comparison of numbers and rates of cases of heat exhaustion to the numbers and rates of "other heat illnesses" reported in previous *MSMR* updates.

As has been noted in previous *MSMR* heat illness updates, results indicate that a sizable proportion of cases identified through DMSS records of hospitalizations and ambulatory visits did not prompt mandatory reports through the reporting system.[20] However, the record source prioritization rule (hospitalizations > reportable events > ambulatory visits) employed in this analysis imposes limitations as to what can be said about the true magnitude of the observed discrepancy in the numbers of reportable events and medical encounters for both types of heat illness. To address this limitation in future analyses, it will be important to ascertain the overlap between hospitalizations and reportable events and the overlap between reportable events and outpatient encounters. It is possible that cases of heat illness, whether diagnosed during an inpatient or outpatient encounter, were not reported as reportable medical events because treatment providers were not attentive to the criteria for reporting

FIGURE 3. Numbers of heat illnesses diagnosed in Iraq/Afghanistan, active component, U.S. Armed Forces, 2013–2017



or because of ambiguity in interpreting the criteria (e.g., the heat illness did not result in a change in duty status; for heat stroke, core body temperature measured during/immediately after exertion or heat exposure was not available). Underreporting is especially concerning for cases of heat stroke because it may reflect insufficient attentiveness to the need for prompt recognition of cases of this dangerous illness and for timely intervention at the local level to prevent additional cases.

In spite of its limitations, this report documents that heat illnesses are a significant and persistent threat to both the health of U.S. military members and the effectiveness of military operations. Of all military members, the youngest and most inexperienced Marines and soldiers (particularly those training at installations in the southeastern U.S.) are at highest risk of heat illnesses—including heat stroke, exertional hyponatremia, and exertional rhabdomyolysis (see the other articles in this issue of the *MSMR*).

Commanders, small unit leaders, training cadre, and supporting medical personnel—particularly at recruit training centers and installations with large combat troop populations—must ensure that military members whom they supervise and support are informed regarding risks, preventive countermeasures (e.g., water consumption), early signs and symptoms, and first-responder actions related to heat illnesses.[13–19] Leaders should be aware of the dangers of insufficient hydration on the one hand and excessive water intake on the other; they must have detailed knowledge of, and rigidly enforce countermeasures against, all types of heat illnesses.

Policies, guidance, and other information related to heat illness prevention and treatment among U.S. military members are available online here:

https://phc.amedd.army.mil/topics/discond/hipss/Pages/Heat-Related-Illness-Prevention.aspx

www.logcom.marines.mil/Centers/Special-Staff/I-E-and-Safety-Office/Installations/Heat-Prevention/

REFERENCES

1. Atha WF. Heat-related illness. *Emerg Med Clin North Am*. 2013;31(4):1097–1098.
2. Simon HB. Hyperthermia. *N Engl J Med*. 1993;329(7):483–487.
3. O'Connor F, Deuster P. Disorders due to heat and cold: Heat Illness. In: Goldman L, Schafer AI, eds. Goldman-Cecil Medicine E-Book. 25th ed. Philadelphia, PA: Elsevier Saunders; 2016:692–693.
4. Armed Forces Health Surveillance Branch [in collaboration with U.S. Air Force School of Aerospace Medicine, Army Public Health Center, and Navy and Marine Corps Public Health Center]. *Armed Forces Reportable Medical Events Guidelines and Case Definitions*. 17 July 2017. https://www.health.mil/Reference-Center/Publications/2017/03/01/Heat-Injuries.
5. Leon LR, Bouchama A. Heat stroke. *Compr Physiol*. 2015;5(2):611–647.
6. Epstein Y. Heat intolerance: predisposing factor or residual injury? *Med Sci Sports Exerc*. 1990;22(1):29–35.
7. O'Connor FG, Casa DJ, Bergeron MF, et al. American College of Sports Medicine roundtable on exertional heat stroke–return to duty/return to play: conference proceedings. *Curr Sports Med. Rep*. 2010;9(5):314–321.
8. Shapiro Y, Magazanik A, Udassin R, Ben-Baruch G, Shvartz E, Shoenfeld Y. Heat intolerance in former heatstroke patients. *Ann Intern Med*. 1979;90(6):913–916.
9. Dematte JE, O'Mara K, Buescher J, et al. Near-fatal heat stroke during the 1995 heat wave in Chicago. *Ann Intern Med*. 1998;129:173–181.
10. Wallace RF, Kriebel D, Punnett L, Wegman DH, Amoroso PJ. Prior heat illness hospitalization and risk of early death. *Environ Res*. 2007;104:290–295.
11. Carter R 3rd, Cheuvront SN, Williams JO, et al. Epidemiology of hospitalizations and deaths from heat illness in soldiers. *Med Sci Sports Exerc*. 2005;37(8):1338–1344.
12. Sawka MN, Cheuvront SN, Kenefick RW. High skin temperature and hypohydration impair aerobic performance. *Exp Physiol*. 2012;97(3):327–332.
13. Goldman RF. Ch 1: Introduction to heat-related problems in military operations. In *Textbook of Military Medicine: Medical Aspects of Harsh Environments (Volume 1)*. Borden Institute, Office of the Surgeon General, U.S. Army. Washington, DC. 2001:3–49.
14. Sonna LA. Ch 9: Practical medical aspects of military operations in the heat. In *Textbook of Military Medicine: Medical Aspects of Harsh Environments (Volume 1)*. Borden Institute, Office of the Surgeon General, U.S. Army. Washington, DC. 2001:293–309.
15. Headquarters, Department of the Army and Air Force. TB MED 507/AFPAM 48-152: Heat Stress Control and Heat Casualty Management, 2003. https://www.dir.ca.gov/oshsb/documents/Heat_illness_prevention_tbmed507.pdf. Accessed on 5 March 2018.
16. Headquarters, United States Marine Corps, Department of the Navy. MCO 6200.1E: Marine Corps Heat Injury Prevention Program, 2002. http://www.marines.mil/Portals/59/Publications/MCO%206200.1E%20W%20CH%201.pdf. Accessed on 5 March 2018.
17. Navy Environmental Health Center. NEHC-TM-OEM 6260.6A: Prevention and Treatment of Heat and Cold Stress Injuries, 2007. http://www.med.navy.mil/sites/nmcphc/Documents/nepmu-6/Environmental-Health/Disease-Prevention/Technical-Manual-NEHC-TM-OEM-6260-6A.pdf. Accessed on 3 March 2017.
18. Webber BJ, Casa DJ, Beutler AI, Nye NS, Trueblood WE, O'Connor FG. Preventing exertional death in military trainees: recommendations and treatment algorithms from a multidisciplinary working group. *Mil Med*. 2016;181(4):311–318.
19. Lee JK, Kenefick RW, Cheuvront SN. Novel cooling strategies for military training and operations. *J Strength Cond Res*. 2015;29 Suppl 11:S77–S81.
20. Armed Forces Health Surveillance Branch. Update: Heat injuries, active component, U.S. Armed Forces, 2016. *MSMR*. 2017;24(3):9–13.
21. Armed Forces Health Surveillance Branch. Surveillance Case Definition. Heat Illness. March 2018. https://www.health.mil/Reference-Center/Publications/2017/03/01/Heat-Injuries.

Work/Rest Times and Fluid Replacement Guide

Heat Category	WBGT Index (°F)	Easy Work Walking on hard surface, 2.5 mph, <30 lb. load; weapon maintenance, marksmanship training.		Moderate Work Patrolling, walking in sand, 2.5 mph, no load; calisthenics.		Hard Work Walking in sand, 2.5 mph, with load; field assaults.	
		Work/Rest *(minutes)*	***Fluid Intake*** *(quarts/hour)*	***Work/Rest*** *(minutes)*	***Fluid Intake*** *(quarts/hour)*	***Work/Rest*** *(minutes)*	***Fluid Intake*** *(quarts/hour)*
1	78° - 81.9°	NL	½	NL	¾	40/20 (70)*	¾ (1)*
2 (GREEN)	82° - 84.9°	NL	½	50/10 (150)*	¾ (1)*	30/30 (65)*	1 (1¼)*
3 (YELLOW)	85° - 87.9°	NL	¾	40/20 (100)*	¾ (1)*	30/30 (55)*	1 (1¼)*
4 (RED)	88° - 89.9°	NL	¾	30/30 (80)*	¾ (1¼)*	20/40 (50)*	1 (1¼)*
5 (BLACK)	> 90°	50/10 (180)*	1	20/40 (70)*	1 (1¼)*	10/50 (45)*	1 (1½)*

NL = No limit to work time per hour.

*Use the amounts in parentheses for continuous work when rest breaks are not possible. Leaders should ensure several hours of rest and rehydration time after continuous work.

This guidance will sustain performance and hydration for at least 4 hours of work in the specified heat category. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or full shade (± ¼ qt/hr).

Rest means minimal physical activity (sitting or standing) in the shade if possible.

Body Armor - Add 5°F to WBGT index in humid climates.

NBC (MOPP 4) - Add 10°F (Easy Work) or 20°F (Moderate or Hard Work) to WBGT Index.

CAUTION: Hourly fluid intake should not exceed 1½ qts. Daily fluid intake should not exceed 12 qts.

USAPHC

Approved for public release, distribution unlimited.

CP-O33-0615

Update: Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2013–2017

Among active component service members in 2017, there were 492 incident diagnoses of rhabdomyolysis likely due to exertional rhabdomyolysis, for an unadjusted incidence rate of 40.2 cases per 100,000 person-years. Subgroup-specific rates in 2017 were highest among males, those aged 19 years or younger, non-Hispanic black service members, Marine Corps or Army members, recruit trainees, and those in "other" or combat-specific occupations. During 2013–2017, crude rates of exertional rhabdomyolysis increased steadily from 2013 through 2016, after which rates declined slightly in 2017. Compared to service members in other race/ethnicity groups, the overall rate of exertional rhabdomyolysis was highest among non-Hispanic blacks. Overall and annual rates were highest among Marine Corps members, intermediate among those in the Army, and lowest among those in the Air Force and Navy. Most cases of exertional rhabdomyolysis were diagnosed at installations that support basic combat/recruit training or major ground combat units of the Army or the Marine Corps. Medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members (particularly recruits) present with muscular pain or swelling, limited range of motion, or the excretion of dark urine (possibly due to myoglobinuria) after strenuous physical activity, particularly in hot, humid weather.

Rhabdomyolysis is a condition characterized by the rapid breakdown of skeletal muscle cells and subsequent release of intracellular muscle contents into the circulation. This process is most often recognized by markedly elevated creatinine kinase levels and the appearance of red to brown urine (due to myoglobinuria).[1,2] In exertional rhabdomyolysis, damage to skeletal muscle is generally caused by high-intensity, protracted, or repetitive physical activity, usually after engaging in unaccustomed strenuous exercise (especially with eccentric and/or muscle-lengthening contractions).[3] Illness severity ranges from elevated serum muscle enzyme levels without clinical symptoms to life-threatening disease associated with extreme enzyme elevations, electrolyte imbalances, and kidney failure.[1-4]

Risk factors for exertional rhabdomyolysis include younger age, male sex, lower level of physical fitness, a prior heat illness, lower level of education, and exertion during the warmer months of the year.[1,3,5-8] Acute kidney injury is the most dangerous potential complication of exertional rhabdomyolysis and is thought to be due to an excessive concentration of free myoglobin in the urine accompanied by volume depletion, resulting in renal tubular obstruction, direct tubular cell injury, and vasoconstriction.[4,9]

In U.S. military members, rhabdomyolysis is a significant threat during physical exertion, particularly under heat stress.[5,7,10,11] Each year, the *MSMR* summarizes numbers, rates, trends, risk factors, and locations of occurrences of exertional heat injuries, including exertional rhabdomyolysis. This report includes the data for 2013–2017. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of the *MSMR*.[10–11]

METHODS

The surveillance period was 1 January 2013 through 31 December 2017. 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 the surveillance period. All data used to determine incident exertional rhabdomyolysis diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System) treatment facilities worldwide. In-theater diagnoses of exertional rhabdomyolysis were identified from medical records of service members deployed to Southwest Asia/Middle East and whose healthcare encounters were documented in the Theater Medical Data Store (TMDS).

For this analysis, a case of exertional rhabdomyolysis was defined as an individual with 1) a hospitalization or outpatient medical encounter with a diagnosis in any position of either "rhabdomyolysis" (ICD-9: 728.88; ICD-10: M62.82) or "myoglobinuria" (ICD-9: 791.3; ICD-10: R82.1) plus a diagnosis in any position of one of the following: "volume depletion (dehydration)" (ICD-9: 276.5*; ICD-10: E86.0, E86.1, E86.9), "effects of heat" (ICD-9: 992.0–992.9; ICD-10: T67.0–T67.9), "effects of thirst (deprivation of water)" (ICD-9: 994.3; ICD-10: T73.1), "exhaustion due to exposure" (ICD-9: 994.4; ICD-10: T73.2), or "exhaustion due to excessive exertion (overexertion)" (ICD-9: 994.5; ICD-10: T73.3).[12] Each individual could be considered an incident case of exertional rhabdomyolysis only once per calendar year.

To exclude cases of rhabdomyolysis that were secondary to traumatic injuries, intoxications, or adverse drug reactions, medical encounters with diagnoses in any position of "injury, poisoning, toxic effects" (ICD-9: 800–999; ICD-10: S00–T88)—except the codes specific for "sprains and strains of joints and adjacent muscles," and "effects of heat, thirst, and exhaustion"—were not considered indicative of exertional rhabdomyolysis.[12]

For surveillance purposes, a "recruit trainee" was defined as an active component member in an enlisted grade (E1–E4) who was assigned to one of the Services' recruit training locations (per the individual's initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his or her service. Recruit trainees were considered a separate category of enlisted service members in summaries of rhabdomyolysis cases by military grade overall.

In-theater diagnoses of exertional rhabdomyolysis were analyzed separately; however, the same case-defining criteria and incidence rules were applied to identify incident cases. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR also were analyzed separately. Evacuations were considered case-defining if affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

The new electronic health record for the Military Health System, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter and person-time data for individuals seeking care at one of these facilities during 2017 were not included in this analysis.

RESULTS

In 2017, there were 492 incident diagnoses of rhabdomyolysis likely associated with physical exertion and/or heat stress (exertional rhabdomyolysis) **(Table 1)**. The crude (unadjusted) incidence rate was 40.2 cases per 100,000 person-years (p-yrs). Subgroup-specific incidence rates of exertional rhabdomyolysis were highest among males (43.5 cases per 100,000 p-yrs), those aged 19 years or younger (82.6 cases per 100,000 p-yrs), non-Hispanic black service members (69.0 cases per 100,000 p-yrs), Marine Corps or Army members (87.4 cases per 100,000 p-yrs and 53.8 cases per 100,000 p-yrs, respectively), recruit trainees, and those in "other/unknown" or combat-specific occupations (67.1 cases per 100,000 p-yrs and 62.5 cases per 100,000 p-yrs, respectively) **(Table 1)**. Of note, incidence rates among recruit trainees were seven times those among other enlisted members and officers, even though cases among this group accounted for only 15.4% of all cases in 2017.

During 2013–2017, crude annual incidence rates of incident diagnoses of exertional rhabdomyolysis increased steadily from 27.9 cases per 100,000 p-yrs in 2013 to 41.4 cases per 100,000 p-yrs in 2016, after which rates declined slightly to 40.2 cases per 100,000 p-yrs in 2017 **(Figure 1)**. During the surveillance period, the overall incidence rate of exertional rhabdomyolysis was highest among non-Hispanic blacks in every year except 2013, when the highest rate occurred among Asian/Pacific Islanders **(Table 1, data not shown)**. Overall and annual incidence rates of exertional rhabdomyolysis were highest among service members in the Marine Corps, intermediate among those in the Army, and lowest among those in the Air Force and Navy **(Table 1, Figure 2)**. The most pronounced increases in annual incidence rates were observed among Marine Corps members and Army members during 2013–2016 (51.1% and 52.6%, respectively); however, rates among service members in the Air Force and Navy remained relatively stable **(Figure 2)**. During the surveillance period, most cases (69.1%) occurred during May–September **(Figure 3)**.

Rhabdomyolysis by location

During the 5-year surveillance period, the medical treatment facilities at 10 installations diagnosed at least 50 cases each and, together, more than half (51.1%) of all diagnosed cases **(Table 2)**. Of these 10 installations, four provide support to recruit/basic combat training centers (Marine Corps Recruit Depot Parris Island/Beaufort, SC; Fort Benning, GA; Joint Base San Antonio–Lackland, TX; and Fort Leonard Wood, MO). In addition, six installations support large combat troop populations (Fort Bragg, NC; Marine Corps Base [MCB] Camp Pendleton, CA; MCB Camp Lejeune/Cherry Point, NC; Fort Shafter, HI; Fort Hood, TX; and Fort Campbell, KY). The most cases overall, together accounting for more than one-fifth (22.2%) of all cases, were diagnosed at Fort Bragg, NC (n=265) and MCRD Parris Island/Beaufort, SC (n=238) **(Table 2)**.

Rhabdomyolysis in Iraq and Afghanistan

There were five incident cases of exertional rhabdomyolysis diagnosed and treated in Iraq/Afghanistan **(data not shown)** during the 5-year surveillance period. Deployed service members who were affected by exertional rhabdomyolysis were non-Hispanic white or non-Hispanic black (n=3; 60.0% and n=2; 40.0%, respectively); male (n=5); aged 20–24 years (n=2; 40.0%) or 30–34 years (n=2; 40.0%); in the Army (n=5); enlisted (n=5); and in combat-specific occupations (n=3; 60.0%). One active component service member was medically evacuated from Iraq/Afghanistan for exertional rhabdomyolysis; this medical evacuation occurred in September 2015 **(data not shown)**.

EDITORIAL COMMENT

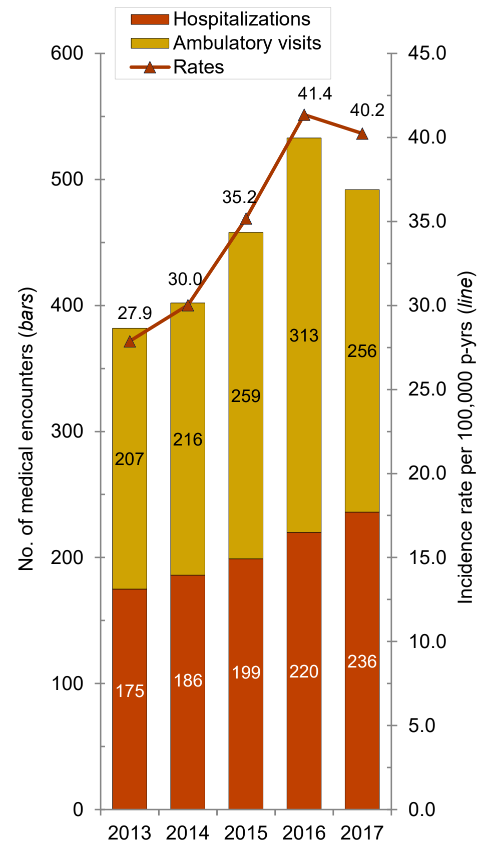
This report documents an increase in the crude annual incidence rates of diagnoses of exertional rhabdomyolysis among active component U.S. military members during 2013–2016 after which rates declined slightly in 2017. Exertional rhabdomyolysis continued to occur most frequently from late spring through early fall

TABLE 1. Incident cases[a] and incidence rates[b] of exertional rhabdomyolysis, active component, U.S. Armed Forces, 2017

	Hospitalized		Ambulatory		Total	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	236	19.3	256	20.9	492	40.2
Sex						
Male	221	21.6	225	22.0	446	43.5
Female	15	7.6	31	15.7	46	23.2
Age group						
<20	53	31.0	88	51.5	141	82.6
20–24	63	20.2	70	22.4	133	42.6
25–29	55	19.7	52	18.6	107	38.3
30–34	32	16.3	24	12.2	56	28.5
35–39	22	15.6	15	10.7	37	26.3
40+	11	9.0	7	5.7	18	14.7
Race/ethnicity						
Non-Hispanic white	118	16.9	134	19.2	252	36.2
Non-Hispanic black	64	31.8	75	37.2	139	69.0
Hispanic	31	16.4	28	14.8	59	31.3
Asian/Pacific Islander	8	16.4	12	24.6	20	41.0
Other/unknown	15	17.2	7	8.0	22	25.2
Service						
Army	116	26.5	120	27.4	236	53.8
Navy	17	5.8	15	5.2	32	11.0
Air Force	28	9.0	36	11.6	64	20.6
Marine Corps	75	41.0	85	46.4	160	87.4
Military status						
Enlisted	158	16.2	179	18.4	337	34.6
Officer	47	21.5	32	14.7	79	36.2
Recruit	31	103.9	45	150.9	76	254.8
Military occupation						
Combat-specific[c]	42	26.3	58	36.3	100	62.5
Armor/motor transport	8	18.9	7	16.5	15	35.4
Pilot/air crew	6	13.4	4	8.9	10	22.4
Repair/engineering	34	9.7	37	10.5	71	20.2
Communications/intelligence	43	16.7	38	14.7	81	31.4
Health care	23	21.3	19	17.6	42	38.8
Other/unknown	80	31.0	93	36.1	173	67.1
Home of record[d]						
Midwest	38	17.2	48	21.7	86	38.9
Northeast	31	19.7	29	18.5	60	38.2
South	116	22.2	131	25.1	247	47.2
West	48	17.0	46	16.3	94	33.4
Other/unknown	3	7.5	2	5.0	5	12.5

[a]One case per person per year
[b]Number of cases per 100,000 person-years
[d]Infantry/artillery/combat engineering
[d]As self-reported at time of entry into service

FIGURE 1. Annual incident cases and incidence rates of exertional rhabdomyolysis, by clinical setting, active component, U.S. Armed Forces, 2013–2017



at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

The risks of heat injuries, including exertional rhabdomyolysis, are increased among individuals who suddenly increase overall levels of physical activity, recruits who are not physically fit when they begin training, and recruits from relatively cool and dry climates who may not be acclimated to the high heat and humidity at training camps in the summer.[1,2,7] Soldiers and Marines in combat units often conduct rigorous unit physical training, personal fitness training, and field training exercises regardless of weather conditions. Thus, it is not surprising that recruit camps and installations with large ground combat units account for most of the cases of exertional rhabdomyolysis.

The annual incidence rates among non-Hispanic black service members were

FIGURE 2. Annual incidence rates of exertional rhabdomyolysis, by service, active component, U.S. Armed Forces, 2013–2017

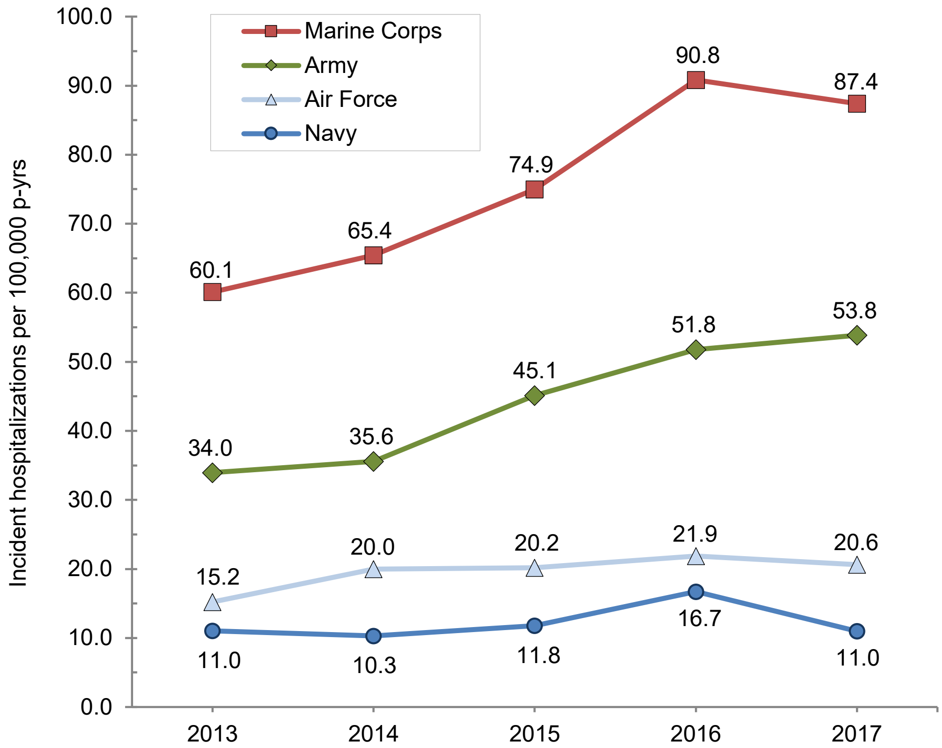


FIGURE 3. Cumulative numbers of incident cases of exertional rhabdomyolysis, by month, active component, U.S. Armed Forces, 2013–2017

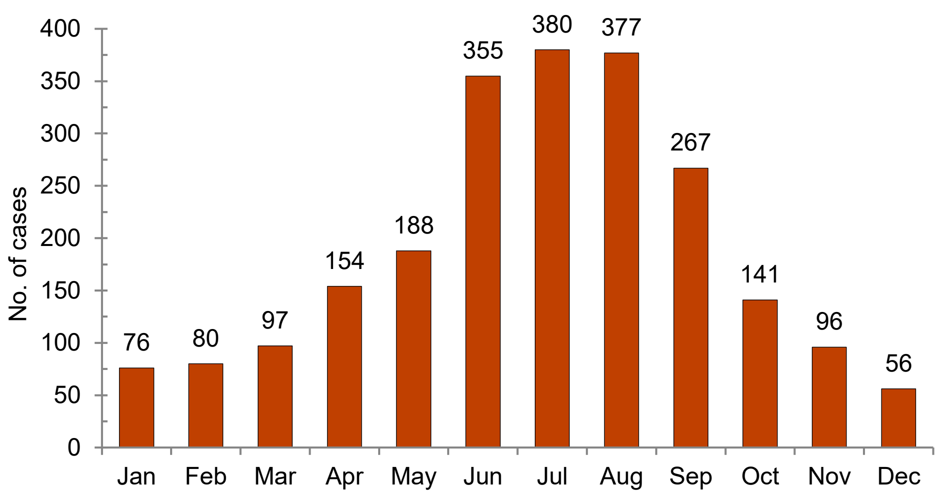


TABLE 2. Incident cases of exertional rhabdomyolysis, by installation (with at least 30 cases during the surveillance period), active component, U.S. Armed Forces, 2013–2017

Location of diagnosis	No.	% total
Fort Bragg, NC	265	11.7
MCRD Parris Island/ Beaufort, SC	238	10.5
MCB Camp Pendleton, CA	112	4.9
Fort Benning, GA	109	4.8
MCB Camp Lejeune/Cherry Point, NC	106	4.7
Fort Shafter, HI	86	3.8
Fort Hood, TX	70	3.1
JBSA-Lackland AFB, TX	65	2.9
Fort Campbell, KY	57	2.5
Fort Leonard Wood, MO	50	2.2
Fort Carson, CO	44	1.9
Fort Bliss, TX	37	1.6
Fort Gordon, GA	36	1.6
Fort Jackson, SC	35	1.5
NMC San Diego, CA	34	1.5
Fort Stewart, GA	34	1.5
Okinawa, Japan	34	1.5
Fort Belvoir, VA	33	1.5
Other locations	822	36.3
Total	2,267	100.0

MCRD, Marine Corps Recruit Depot; JBSA, Joint Base San Antonio; MCB, Marine Corps Base; NMC, Naval Medical Center

higher than the rates among members of other race/ethnicity groups in 2017 and in 3 of the 4 previous years. This observation has been attributed, at least in part, to an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait.[13–16] However, in 2013, the rate among Asian/Pacific Islanders was the highest of all race/ethnicity groups. Although the annual incidence rates of exertional rhabdomyolysis for service members in this group have been increasing since 2009, the reasons for such a trend are unknown. Supervisors at all levels should ensure that guidelines to prevent heat injuries are consistently implemented and should be vigilant for early signs of exertional heat injuries, including rhabdomyolysis, among all service members.

The findings of this report should be interpreted with consideration of its limitations. A diagnosis of "rhabdomyolysis" alone does not indicate the cause. Ascertainment of the probable causes of cases of exertional rhabdomyolysis was attempted by using a combination of ICD-9/ICD-10 diagnostic codes related to rhabdomyolysis with additional codes indicative of the effects of exertion, heat, or dehydration. Furthermore, other ICD-9/ICD-10 codes were used to exclude cases of rhabdomyolysis that may have been secondary to trauma, intoxication, or adverse drug reactions.

The measures that are effective at preventing exertional heat injuries in general apply to the prevention of exertional rhabdomyolysis. In the military training setting, risk of exertional rhabdomyolysis can be reduced by emphasizing graded, individual preconditioning before starting a more strenuous exercise program and adhering to recommended work/rest and hydration schedules, especially in hot weather. The physical activities of overweight and/or previously sedentary new recruits should be closely monitored. Strenuous activities during relatively cool mornings following days of high heat stress should be particularly closely monitored; in the past, such situations have been associated with increased risk of exertional heat injuries (including rhabdomyolysis).[6]

Management after treatment for exertional rhabdomyolysis, including the decision to return to physical activity and duty, is a persistent challenge among athletes and military members.[7,8,17] It is recommended that those who have had a clinically confirmed exertional rhabdomyolysis event be further evaluated and risk-stratified for recurrence before return to activity/duty.[8,17,18] Low-risk patients may gradually return to normal activity levels, while those deemed high risk for recurrence will require further evaluative testing (e.g., genetic testing for myopathic disorders).[17,18]

Commanders and supervisors at all levels should watch for early signs of exertional heat injuries and should intervene aggressively when dangerous conditions, activities, or suspicious illnesses are detected. Finally, medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members (particularly recruits) present with muscular pain or swelling, limited range of motion, or the excretion of dark urine (possibly due to myoglobinuria) after strenuous physical activity, particularly in hot, humid weather.

REFERENCES

1. Zutt R, van der Kooi AJ, Linthorst GE, Wanders RJ, de Visser M. Rhabdomyolysis: review of the literature. *Neuromuscul Disord*. 2014;24(8):651–659.
2. Giannoglou GD, Chatzizisis YS, Misirli G. The syndrome of rhabdomyolysis: pathophysiology and diagnosis. *Eur J Intern Med.* 2007;18(2):90–100.
3. Rawson ES, Clarkson PM, Tarnopolsky MA. Perspectives on exertional rhabdomyolysis. *Sports Med*. 2017;47(Suppl 1):33–49.
4. Bosch X, Poch E, Grau JM. Rhabdomyolysis and acute kidney injury. *N Engl J Med*. 2009;361(1):62–72.
5. Hill OT, Wahi MM, Carter R, Kay AB, McKinnon CJ, Wallace RE. Rhabdomyolysis in the U.S. active duty Army, 2004–2006. *Med Sci Sports Exerc*. 2012;44(3):442–449.
6. Lee G. Exercise-induced rhabdomyolysis. *RI Med J (2013)*. 2014;97(11):22–24.
7. Hill OT, Scofield DE, Usedom J, et al. Risk factors for rhabdomyolysis in the U.S. Army. *Mil Med*. 2017;182(7):e1836–e1841.
8. Knapik JJ, O'Connor FG: Exertional rhabdomyolysis: epidemiology, diagnosis, treatment, and prevention. *J Spec Oper Med*. 2016;15(3): 65–71.
9. Holt S, Moore K. Pathogenesis of renal failure in rhabdomyolysis: the role of myoglobin. *Exp Nephrol*. 2000;8(2):72–76.
10. Armed Forces Health Surveillance Branch. Update: Exertional rhabdomyolysis, active component, U.S. Army, Navy, Air Force, and Marine Corps, 2015. *MSMR*. 2016;23(3):21–24.
11. Armed Forces Health Surveillance Branch. Update: Exertional rhabdomyolysis among active component members, U.S. Armed Forces, 2012–2016. *MSMR*. 2017;24(3):14–18.
12. Armed Forces Health Surveillance Branch. Surveillance Case Definition. Exertional Rhabdomyolysis. April 2017. https://www.health.mil/Reference-Center/Publications/2017/03/01/Rhabdomyolysis-Exertional.
13. Gardner JW, Kark JA. Fatal rhabdomyolysis presenting as mild heat illness in military training. *Mil Med*. 1994;159(2):160–163.
14. Makaryus JN, Catanzaro JN, Katona KC. Exertional rhabdomyolysis and renal failure in patients with sickle cell trait: is it time to change our approach? *Hematology*. 2007;12(4):349–352.
15. Ferster K, Eichner ER. Exertional sickling deaths in Army recruits with sickle cell trait. *Mil Med*. 2012;177(1):56–59.
16. Nelson DA, Deuster PA, Kurina LM. Sickle cell trait and rhabdomyolysis among U.S. Army soldiers. *N Engl J Med.* 2016;375(17):1696.
17. O'Connor FG, Brennan FH Jr, Campbell W, Heled Y, Deuster P. Return to physical activity after exertional rhabdomyolysis. *Curr Sports Med Rep*. 2008;7(6):328–331.
18. Atias D, Druyan A, Heled Y. Recurrent exertional rhabdomyolysis: coincidence, syndrome, or acquired myopathy? *Curr Sports Med Rep*. 2013;12(6):365–369.

Update: Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2002–2017

From 2002 through 2017, there were 1,552 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.1 cases per 100,000 person-years (p-yrs). Compared to their respective counterparts, overall incidence rates of exertional hyponatremia were higher among females, those aged 19 years or younger, and recruit trainees. The overall incidence rate during the 16-year period was highest in the Marine Corps, intermediate in the Army and Air Force, and lowest in the Navy. Overall rates during the surveillance period were highest among non-Hispanic white and Asian/Pacific Islander service members and lowest among non-Hispanic black service members. Between 2002 and 2017, crude annual incidence rates of exertional hyponatremia peaked in 2010 (12.7 per 100,000 p-yrs) and then decreased to 5.3 cases per 100,000 p-yrs in 2013 before increasing in 2014 and 2015. The crude annual rate in 2017 (6.2 per 100,000 p-yrs) represented a decrease of 27.6% from 2015. Service members and their supervisors must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, recreational activities) in hot, humid weather.

Exertional, or exercise-associated, hyponatremia refers to a low serum, plasma or blood sodium concentration (below 135 milliequivalents/liter) that develops during or up to 24 hours following prolonged physical activity.[1] Acute hyponatremia creates an osmotic imbalance between fluids outside and inside of cells. This osmotic gradient causes water to flow from outside to inside the cells of various organs, including the lungs (pulmonary edema) and brain (cerebral edema), producing serious and sometimes fatal clinical effects.[1,2] Swelling of the brain increases intracranial pressure, which can decrease cerebral blood flow and disrupt brain function (e.g., hypotonic encephalopathy, seizures, coma). Without rapid and definitive treatment to relieve increasing intracranial pressure, brain stem herniation can compromise the life-sustaining functions that are controlled by the cardiorespiratory centers of this portion of the brain.[2-4]

Serum sodium concentration is determined mainly by the total content of exchangeable body sodium and potassium relative to total body water. Thus, exertional hyponatremia can result from loss of sodium and/or potassium, a relative excess of body water, or a combination of both.[5,6] However, overconsumption of fluids and the resultant excess of total body water are the primary driving factors in the development of exertional hyponatremia.[1,7,8] Other important factors include the persistent secretion of antidiuretic hormone (arginine vasopressin), excessive sodium losses in sweat, and inadequate sodium intake during prolonged physical exertion, particularly during heat stress.[2-4,9] The importance of sodium losses through sweat in the development of exertional hyponatremia is influenced by the fitness level of the individual. Less fit individuals generally have a higher sweat sodium concentration, a higher rate of sweat production, and an earlier onset of sweating during exercise.[10-12]

This report uses a surveillance case definition for exertional hyponatremia to estimate the frequencies, rates, trends, geographic locations, and demographic and military characteristics of exertional hyponatremia cases among U.S. military members from 2002 through 2017.[13]

METHODS

The surveillance period was 1 January 2002 through 31 December 2017. The surveillance population included all individuals who served in an active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. All data used to determine incident exertional hyponatremia diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System) treatment facilities worldwide. In-theater diagnoses of hyponatremia were identified from medical records of service members deployed to Southwest Asia/Middle East and whose healthcare encounters were documented in the Theater Medical Data Store (TMDS). TMDS records are available only for the years 2008–2017.

For this analysis, a case of exertional hyponatremia was defined as a hospitalization or ambulatory visit with a primary (first-listed) diagnosis of "hypo-osmolality and/or hyponatremia" (ICD-9: 276.1; ICD-10: E87.1) and no other illness or injury-specific diagnoses (ICD-9: 001–999) in any diagnostic position; or both a diagnosis of "hypo-osmolality and/or hyponatremia" (ICD-9: 276.1; ICD-10: E87.1) and at least one of the following within the first three diagnostic positions (dx1–dx3): "fluid overload" (ICD-9: 276.9; ICD-10: E87.70, E87.79), "alteration of consciousness" (ICD-9: 780.0*; ICD-10: R40.*), "convulsions" (ICD-9: 780.39; ICD-10: R56.9), "altered mental status" (ICD-9: 780.97; ICD-10: R41.82), "effects of heat/light" (ICD-9: 992.0–992.9; ICD-10: T67.0*–T67.9*), or "rhabdomyolysis" (ICD-9: 728.88; ICD-10: M62.82).[13]

Medical encounters were not considered case-defining events if the associated records included the following diagnoses in any diagnostic position: alcohol/illicit drug abuse; psychosis, depression, or other major mental disorders; endocrine (e.g., pituitary, adrenal) disorders; kidney diseases; intestinal infectious diseases; cancers; major traumatic injuries; or complications of medical care. Each individual could be considered an incident case of exertional hyponatremia only once per calendar year.

For surveillance purposes, a "recruit trainee" was defined as an active component member in an enlisted grade (E1–E4) who was assigned to one of the Services' recruit training locations (per the individual's initial military personnel record). For this report, each service member was considered a recruit trainee for the period of time corresponding to the usual length of recruit training in his/her service. Recruit trainees were considered a separate category of enlisted service members in summaries of exertional hyponatremia by military grade overall.

In-theater diagnoses of exertional rhabdomyolysis were analyzed separately using the same case-defining criteria and incidence rules were applied to identify incident cases. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if the affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

The new electronic health record for the Military Health System, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter and person-time data for individuals seeking care at one of these facilities during 2017 were not included in this analysis.

RESULTS

During 2002–2017, permanent medical facilities recorded 1,552 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.1 cases per 100,000 person-years (p-yrs) **(Table 1)**. In 2017, there were 75 incident diagnoses of exertional hyponatremia (incidence rate: 6.2 per 100,000 p-yrs) among active component members. During this year, males represented 85.3% of exertional hyponatremia cases (n=64); the annual incidence rate was slightly higher among males (6.3 per 100,000 p-yrs) than females (5.7 per 100,000 p-yrs) **(Table 1)**. The highest age group–specific annual incidence rates were among the youngest (19 years or younger) and the oldest (40 years or older) service members. Although the Army had the most cases during 2017 (n=29), the highest incidence rate was among members of the Marine Corps (13.7 per 100,000 p-yrs). In 2017, there were only seven cases of exertional hyponatremia among recruit trainees, but their incidence rate was more than twice that of officers and five times that of other enlisted members **(Table 1)**.

During the 16-year surveillance period, females had a higher overall incidence rate of exertional hyponatremia than males **(Table 1)**. The overall incidence rate was highest in the Marine Corps (14.9 per 100,000 p-yrs), intermediate in the Army and Air Force (6.7 and 6.0 per 100,000 p-yrs, respectively), and lowest in the Navy (4.5 per 100,000 p-yrs). Overall rates during the surveillance period were highest among non-Hispanic white and Asian/Pacific Islander service members and lowest among non-Hispanic black service members. Although recruit trainees accounted for less than one-tenth (8.9%) of all exertional hyponatremia cases, their overall crude incidence rate was five and three and one-half times the rates among other enlisted members and officers, respectively **(Table 1)**. During the 16-year period, 86.3% (n=1,339) of all cases were diagnosed and treated without having to be hospitalized **(data not shown)**.

Between 2002 and 2017, crude annual incidence rates of exertional hyponatremia peaked in 2010 (12.7 per 100,000 p-yrs) and then decreased to 5.3 cases per 100,000 p-yrs in 2013 before increasing in 2014 and 2015. The crude annual incidence rate in 2017 (6.2 per 100,000 p-yrs) represented a decrease of 27.6% from 2015 **(Figure 1)**. During 2002–2017, annual incidence rates of exertional hyponatremia were consistently higher among Marine Corps members, compared to those in the other Services **(Figure 2)**. Between 2016 and 2017, annual incidence rates increased among Marine Corps members, decreased among members of the Air Force and Navy and remained stable among members of the Army **(Figure 2)**.

Exertional hyponatremia by location

During the 16-year surveillance period, exertional hyponatremia cases were diagnosed at the medical treatment facilities at more than 200 U.S. military installations and geographic locations worldwide; however, 14 installations contributed 20 or more cases each and accounted for 47.0% of the total cases **(Table 2)**. The installation with the most cases overall was the Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC (n=199).

Exertional hyponatremia in Iraq and Afghanistan

From 2008 through 2017, a total of 13 cases of exertional hyponatremia were diagnosed and treated in Iraq and Afghanistan. Deployed service members who were affected by exertional hyponatremia were most frequently male (n=11; 84.6%), non-Hispanic white (n=10; 76.9%), aged 20–24 years (n=5; 38.5%), in the Army (n=8; 61.5%), enlisted (n=11; 84.6%), and in combat-specific (n=6; 46.2%) and communications/intelligence (n=3; 23.1%) occupations **(data not shown)**. During the entire surveillance period, nine service members were medically evacuated from Iraq or Afghanistan for exertional hyponatremia **(data not shown)**.

TABLE 1. Incident cases[a] and incidence rates[b] of exertional hyponatremia, active component, U.S. Armed Forces, 2002–2017

	2017		Total 2002–2017	
	No.	Rate[b]	No.	Rate[b]
Total	75	6.2	1,552	7.1
Sex				
Male	64	6.3	1,288	6.9
Female	11	5.7	264	8.2
Age group				
<20	11	11.7	199	13.1
20–24	25	6.6	492	6.9
25–29	11	4.0	278	5.6
30–34	7	3.6	165	5.0
35–39	8	5.7	183	7.0
40+	13	10.7	235	10.2
Race/ethnicity				
Non-Hispanic white	56	8.1	1,063	8.0
Non-Hispanic black	4	2.0	188	5.1
Hispanic	7	3.8	149	5.7
Asian/Pacific Islander	3	6.3	65	8.0
Other/unknown	5	5.9	87	6.1
Service				
Army	29	6.6	544	6.7
Navy	10	3.7	241	4.5
Air Force	11	3.5	319	6.0
Marine Corps	25	13.7	448	14.9
Military status				
Enlisted	44	4.6	1,089	6.1
Officer	24	11.1	325	8.9
Recruit	7	23.9	138	30.9
Military occupation				
Combat-specific[c]	15	9.4	241	8.3
Armor/motor transport	2	4.8	45	5.4
Pilot/air crew	2	4.5	46	5.5
Repair/engineering	14	4.1	277	4.3
Communications/intelligence	10	3.9	270	5.5
Health care	6	5.6	126	6.7
Other/unknown	26	10.2	547	13.3
Home of record[d]				
Midwest	12	5.5	299	7.4
Northeast	19	12.3	231	8.1
South	28	5.4	647	7.2
West	13	4.7	291	6.1
Other/unknown	3	7.6	84	7.6

[a]One case per person per year
[b]Number of cases per 100,000 person-years
[c]Infantry/artillery/combat engineering
[d]As self-reported at time of entry into service

EDITORIAL COMMENT

This report documents that, after a 2-year period (2014–2015) of increasing numbers and rates of exertional hyponatremia among active component U.S. military members, numbers and rates of diagnoses decreased slightly in 2016 and 2017. Patterns of overall incidence rates of exertional hyponatremia in specific subgroups (e.g., sex, age, race/ethnicity, service, and military status) were generally similar to those noted in previous *MSMR* updates. However, it is important to note that in previous *MSMR* analyses, in-theater cases were included if there was a diagnosis of hypoosmolality and/or hyponatremia in any diagnostic position. In the current report, the same case-defining criteria that were applied to inpatient and outpatient encounters were applied to the in-theater encounters. Therefore, the results of the in-theater analysis are not comparable to those presented in previous *MSMR* updates.

Several important limitations should be considered when interpreting the results of this analysis. For example, there is no diagnostic code specific for exertional hyponatremia. Thus, for surveillance purposes, cases of presumed exertional hyponatremia were ascertained from records of medical encounters that included diagnoses of hypo-osmolality and/or hyponatremia, but not of other conditions (e.g., metabolic, renal, psychiatric, or iatrogenic disorders) that increase the risk of hyponatremia in the absence of physical exertion or heat stress. As such, exertional hyponatremia cases here likely include hyponatremia from both exercise and non-exercise-related conditions. Consequently, the results of this analysis should be considered estimates of the actual incidence of symptomatic exertional hyponatremia from excessive water consumption among U.S. military members. The accuracy of estimated numbers, rates, trends, and correlates of risk depends on the completeness and accuracy of diagnoses that are documented in standardized records of relevant medical encounters. As a result, an increase in recorded diagnoses indicative of exertional hyponatremia may reflect, at least in part, increasing awareness of, concern

FIGURE 1. Annual incident cases and incidence rates of exertional hyponatremia, active component, U.S. Armed Forces, 2002–2017

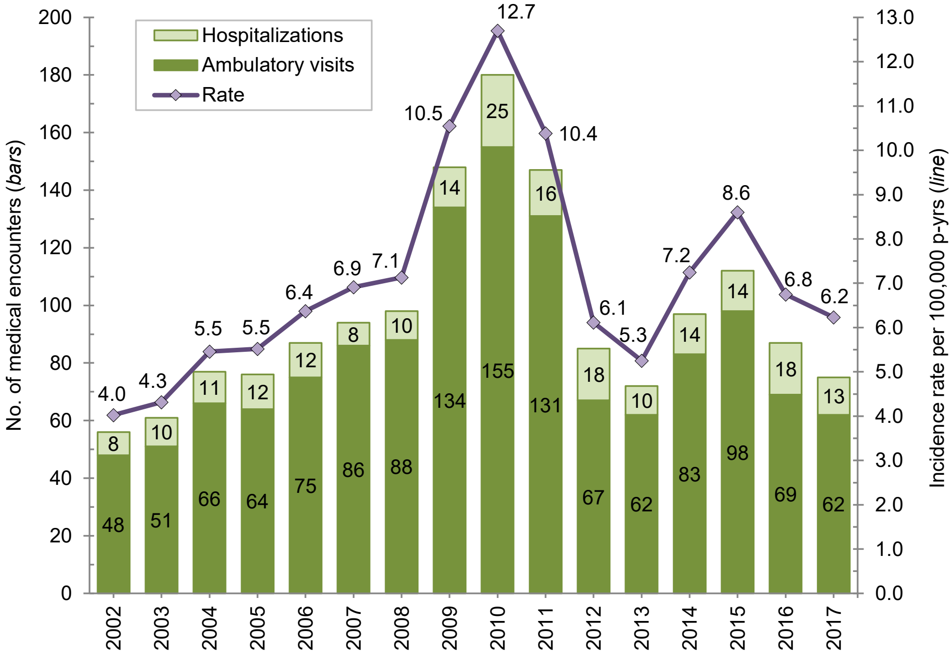
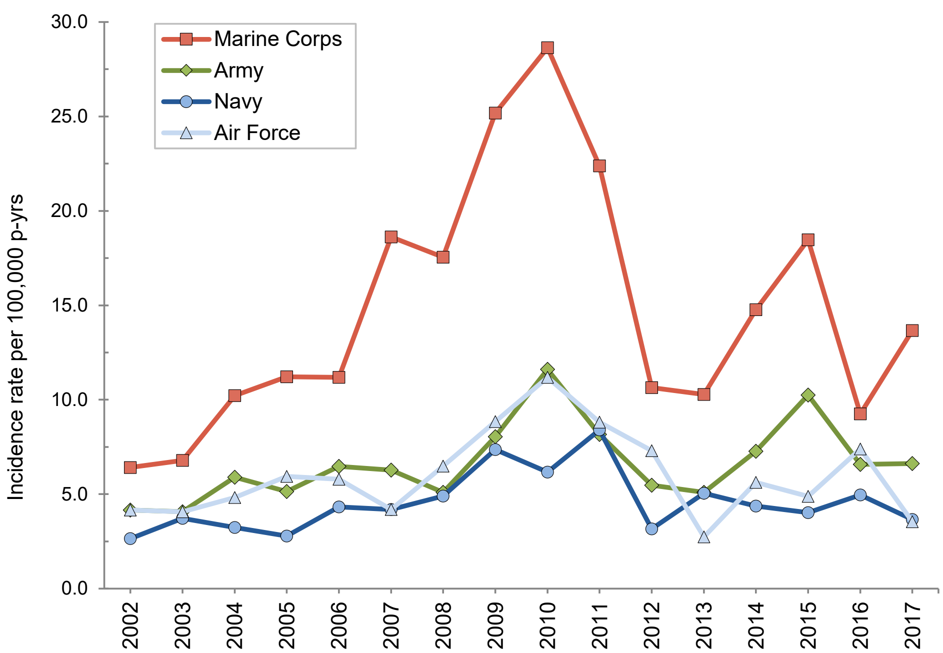


FIGURE 2. Annual incidence rates of exertional hyponatremia, by service, active component, U.S. Armed Forces, 2002–2017



regarding, and aggressive management of, incipient cases by military supervisors and primary healthcare providers.

In the past, concerns about hyponatremia resulting from excessive water consumption were focused at training—particularly recruit training—installations. In this analysis, rates were relatively high among the youngest—hence, the most junior—service members, and the highest numbers of cases tended to be diagnosed at medical facilities that support large recruit training centers (e.g., MCRD Parris Island/Beaufort, SC; Fort Benning, GA; and Joint Base San Antonio–Lackland Air Force Base, TX) and large Army and Marine Corps combat units (e.g., Fort Bragg, NC, and Marine Corps Base Camp Lejeune/Cherry Point, NC).

In response to previous cases of exertional hyponatremia in the U.S. military, the guidelines for fluid replacement during military training in hot weather were revised and implemented.[14-16] The revised guidelines were designed to protect service members from not only heat injury, but also hyponatremia due to excessive water consumption. The guidelines limited fluid intake regardless of heat category or work level to no more than 1.5 quarts hourly and 12 quarts daily.[16] There were fewer hospitalizations of soldiers for hyponatremia due to excessive water consumption during the year after (vs. the year before) implementation of the new guidelines.[17]

During endurance events, a "drink-to-thirst" or a programmed fluid intake plan of 400–800 mL per estimated hour of activity has been suggested to limit the risk of exertional hyponatremia, although this rate should be customized to the individual's tolerance and experience.[4,8,18,19] In addition to these guidelines, reducing the availability of fluids may help prevent exertional hyponatremia during endurance events.[18,19] Carrying a maximum fluid load of 1 quart of fluid per estimated hour of activity and encouraging a "drink-to-thirst" approach to hydration may help prevent both severe exertional hyponatremia and dehydration during military training exercises and recreational hikes that exceed 2–3 hours.[4,8,18,19]

Women had relatively high rates of hyponatremia during the entire surveillance period; women may be at greater risk because of lower fluid requirements and longer periods of exposure to risk during some training exercises (e.g., land navigation courses, load-bearing marches).[9] Although the incidence of women experiencing exertional hyponatremia was greater than that of men in this analysis and among samples of marathon runners in the general population, a large study of marathon runners suggested that the apparent sex difference did not remain after adjustment for body mass index and racing times.[20-22]

TABLE 2. Incident cases of exertional hyponatremia, by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 2002–2017

Location of diagnosis	No.	%
MCRD Parris Island/ Beaufort, SC	199	12.8
Fort Benning, GA	96	6.2
JBSA-Lackland AFB, TX	63	4.1
Fort Bragg, NC	50	3.2
MCB Camp Lejeune/ Cherry Point, NC	49	3.2
Walter Reed NMMC, MD[a]	49	3.2
MCB Camp Pendleton, CA	35	2.3
MCB Quantico, VA	35	2.3
NMC Portsmouth, VA	32	2.1
NMC San Diego, CA	29	1.9
Fort Jackson, SC	25	1.6
Fort Shafter, HI	24	1.5
Fort Campbell, KY	22	1.4
Fort Leonard Wood, MO	21	1.4
Other locations	823	53.0
Total	1,552	100.0

[a]Walter Reed National Military Medical Center (NMMC) is a consolidation of National Naval Medical Center (Bethesda, MD) and Walter Reed Army Medical Center (Washington, DC). This number represents the sum of the two sites prior to the consolidation (November 2011) and the number reported at the consolidated location.

MCRD, Marine Corps Recruit Depot; JBSA, Joint Base San Antonio; MCB, Marine Corps Base; NMC, Naval Medical Center

In many circumstances (e.g., recruit training, Ranger School), military trainees rigorously adhere to standardized training schedules—regardless of weather conditions. In hot and humid weather, commanders, supervisors, instructors, and medical support staff must be aware of and enforce guidelines for work–rest cycles and water consumption. The finding in this report that most cases of hyponatremia were treated in outpatient settings suggests that monitoring by supervisors and medical staff identified most cases during the early and less severe manifestations of hyponatremia.

In general, service members and their supervisors must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, recreational activities) in hot, humid weather. Military members (particularly recruit trainees and women) and their supervisors must be vigilant for early signs of heat-related illnesses and intervene immediately and appropriately (but not excessively) in such cases.

REFERENCES

1. Hew-Butler T, Rosner MH, Fowkes-Godek S, et al. Statement of the Third International Exercise-Associated Hyponatremia Consensus Development Conference, Carlsbad, California, 2015. *Clin J Sport Med*. 2015;25(4):303–320.
2. Montain SJ. Strategies to prevent hyponatremia during prolonged exercise. *Curr Sports Med. Rep*. 2008;7(4):S28–S35.
3. Chorley J, Cianca J, Divine J. Risk factors for exercise-associated hyponatremia in non-elite marathon runners. *Clin J Sport Med*. 2007;17(6):471–477.
4. Hew-Butler T, Loi V, Pani A, Rosner MH. Exercise-associated hyponatremia: 2017 update. *Front Med (Lausanne)*. 2017;4:21.
5. Edelman IS, Leibman J, O'Meara MP, Birkenfeld LW. Interrelations between serum sodium concentration, serum osmolarity and total exchangeable sodium, total exchangeable potassium and total body water. *J Clin Invest*. 1958;37(9):1236–1256.
6. Nguyen MK, Kurtz I. Determinants of plasma water sodium concentration as reflected in the Edelman equation: role of osmotic and Gibbs-Donnan equilibrium. *Am J Physiol Renal Physiol*. 2004;286(5):F828–F837.
7. Noakes TD, Sharwood K, Speedy D, et al. Three independent biological mechanisms cause exercise-associated hyponatremia: evidence from 2,135 weighed competitive athletic performances. *Proc Natl Acad Sci USA*. 2005;102(51):18550–18555.
8. Oh RC, Malave B, Chaltry JD. Collapse in the heat—from overhydration to the emergency room—three cases of exercise-associated hyponatremia associated with exertional heat illness. *Mil Med*. 2018;183(3-4):e225–e228.
9. Carter R III. Exertional heat illness and hyponatremia: an epidemiological prospective. *Curr Sports Med Rep*. 2008;7(4):S20–S27.
10. Buono MJ, Ball KD, Kolkhorst FW. Sodium ion concentration vs. sweat rate relationship in humans. *J Appl Physiol (1985)*. 2007;103(3):990–994.
11. Buono MJ, Sjoholm NT. Effect of physical training on peripheral sweat production. *J Appl Physiol (1985)*. 1988;65(2):811–814.
12. Nadel ER, Pandolf KB, Roberts MF, Stolwijk JA. Mechanisms of thermal acclimation to exercise and heat. *J Appl Physiol*. 1974;37(4):515–520.
13. Armed Forces Health Surveillance Branch. Surveillance Case Definition. Hyponatremia. July 2015. https://www.health.mil/Reference-Center/Publications/2017/03/01/Hyponatremia-Exertional.
14. Army Medical Surveillance Activity. Case reports: hyponatremia associated with heat stress and excessive water consumption: Fort Benning, GA; Fort Leonard Wood, MO; Fort Jackson, SC, June–August 1997. *MSMR*. 1997;3(6):2–3,8.
15. O'Brien KK, Montain SJ, Corr WP, Sawka MN, Knapik JJ, Craig SC. Hyponatremia associated with overhydration in U.S. Army trainees. *Mil Med*. 2001;166(5):405–410.
16. Montain SJ, Latzka WA, Sawka MN. Fluid replacement recommendations for training in hot weather. *Mil Med*. 1999;164(7):502–508.
17. Army Medical Surveillance Activity. Surveillance trends: hyponatremia associated with heat stress and excessive water consumption: the impact of education and a new Army fluid replacement policy. *MSMR*. 1999;3(6):2–3,8–9.
18. Hew-Butler T, Verbalis JG, Noakes TD. Updated fluid recommendation: position statement from the International Marathon Medical Directors Association (IMMDA). *Clin J Sport Med*. 2006;16(4):283–292.
19. Thomas DT, Erdman KA, Burke LM. American College of Sports Medicine Joint Position Statement. Nutrition and Athletic Performance. *Med Sci Sports Exerc*. 2016;48(3):543–568.
20. Almond CS, Shin AY, Fortescue EB, et al. Hyponatremia among runners in the Boston Marathon. *N Engl J Med* (2005). 352(15):1550–1556.
21. Ayus JC, Varon J, Arieff AI. Hyponatremia, cerebral edema, and noncardiogenic pulmonary edema in marathon runners. *Ann Intern Med*. 2000;132(9):711–714.
22. Hew TD, Chorley JN, Cianca JC, et al. The incidence, risk factors, and clinical manifestations of hyponatremia in marathon runners. *Clin J Sport Med*. 2003;13(1):41–47.

MSMR's Invitation to Readers

Medical Surveillance Monthly Report (MSMR) invites readers to submit topics for consideration as the basis for future *MSMR* reports. The *MSMR* editorial staff will review suggested topics for feasibility and compatibility with the journal's health surveillance goals. As is the case with most of the analyses and reports produced by Armed Forces Health Surveillance Branch staff, studies that would take advantage of the healthcare and personnel data contained in the Defense Medical Surveillance System (DMSS) would be the most plausible types. For each promising topic, Armed Forces Health Surveillance Branch staff members will design and carry out the data analysis, interpret the results, and write a manuscript to report on the study. This invitation represents a willingness to consider good ideas from anyone who shares the *MSMR*'s objective to publish evidence-based reports on subjects relevant to the health, safety, and well-being of military service members and other beneficiaries of the Military Health System (MHS).

In addition, the *MSMR* encourages the submission for publication of reports on evidence-based estimates of the incidence, distribution, impact, or trends of illness and injuries among members of the U.S. Armed Forces and other beneficiaries of the MHS. Information about manuscript submissions is available at www.health.mil/MSMRInstructions.

Please email your article ideas and suggestions to the *MSMR* Editor at dha.ncr.health-surv.mbx.msmr@mail.mil.

Medical Surveillance Monthly Report (MSMR)
Armed Forces Health Surveillance Branch
11800 Tech Road, Suite 220
Silver Spring, MD 20904

MEDICAL SURVEILLANCE MONTHLY REPORT (MSMR), in continuous publication since 1995, is produced by the Armed Forces Health Surveillance Branch (AFHSB). The *MSMR* provides evidence-based estimates of the incidence, distribution, impact, and trends of illness and injuries among U.S. military members and associated populations. Most reports in the *MSMR* are based on summaries of medical administrative data that are routinely provided to the AFHSB and integrated into the Defense Medical Surveillance System for health surveillance purposes.

Archive: Past issues of the *MSMR* are available as downloadable PDF files at www.health.mil/MSMRArchives.

Online Subscriptions: Submit subscription requests at www.health.mil/MSMRSubscribe.

Editorial Inquiries: Call (301) 319-3240 or send email to: dha.ncr.health-surv.mbx.msmr@mail.mil.

Instructions for Authors: Information about article submissions is provided at www.health.mil/MSMRInstructions.

Follow us:
www.facebook.com/AFHSBPAGE
http://twitter.com/AFHSBPAGE

ISSN 2158-0111 (print)
ISSN 2152-8217 (online)