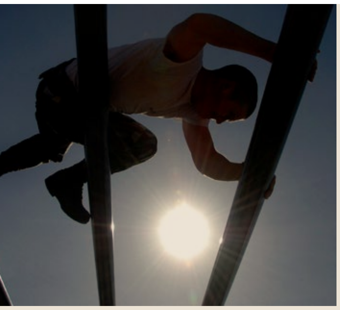
APRIL 2020

Volume 27
Number 04

MSMR

MEDICAL SURVEILLANCE MONTHLY REPORT



A publication of the Armed Forces Health Surveillance Branch

Commentary: The Warrior Heat- and Exertion-Related Event Collaborative and the Fort Benning Heat Center

David W. DeGroot, PhD (MAJ, MS, USA); Francis G. O'Connor, MD, MPH (COL(ret), MC, USA)

The effects of extreme environmental heat on the health and performance of the warfighter have been documented for centuries.[1,2] The U.S. military has conducted and supported research aimed at reducing the impact of heat stress since World War II, greatly advancing our understanding of the physiology of heat stress, the pathophysiology of exertional heat illness (EHI), and the associated epidemiology and risk factors.[3–5] However, weather is an established mission variable and the warfighter needs to be prepared to conduct operations and training in adverse environmental conditions.[6] The combination of environmental heat and/or high metabolic heat production coupled with clothing and equipment factors practically guarantees that EHI casualties will occur. As detailed in this issue of the *MSMR*, EHI, hyponatremia, and rhabdomyolysis continue to affect individual warfighters and pose a significant burden on the military medical system.

In June 2016, a soldier died of hyponatremia during Ranger School training.[7] This was the eighth death due to hyponatremia or exertional heat stroke at Fort Benning since 1998 and illustrates what has been termed the "tragedy loop."[8] In other words, when such a death occurs, there is renewed interest in prevention through education and training as well as in the medical management of EHI casualties. That response is usually effective, but, with the passage of time, there is a loss of institutional memory as experienced leaders and trainers are reassigned and replaced by less experienced personnel. This loss may culminate in another death, and the cycle would begin anew. With 1 exception, all of the heat illness–related deaths at Fort Benning in the past 22 years have illustrated that the tragedy loop follows a 2- to 3-year time course.[8]

In the wake of the most recent death, clinicians at Martin Army Community Hospital (MACH) recognized that a more sustainable approach was necessary to break the tragedy loop and to prevent future deaths due to heat illness. In 2017, Fort Benning hosted the first "Heat Forum," which brought together clinicians, researchers, and leaders from across the Army. At the same time, an ad hoc "Heat Center" was created, consisting of a group of dedicated clinicians and other healthcare professionals who focused their efforts on improving prevention efforts, standardizing medical management, and facilitating research. Ultimately, the participants realized that this ad hoc approach was not sustainable, as it depended on busy clinicians being able to devote time outside their clinical responsibilities. In 2019, with the support of leaders at the Army Office of the Surgeon General, Regional Health Command-Atlantic, and the Consortium for Health and Military Performance (CHAMP) at the Uniformed Services University of the Health Sciences (USUHS), the Warrior Heat- and Exertion-Related Event Collaborative (WHEC) and the Fort Benning Heat Center were created. The fourth annual Heat Forum took place that same year, and the meeting has expanded to include attendees and participants from across the Department of Defense (DoD).

The WHEC is a joint service, multidisciplinary executive advisory board composed of representatives from CHAMP, the U.S. Army Research Institute of Environmental Medicine (USARIEM), the Army Public Health Center (APHC), the Army Training and Doctrine Command, the Departments of the Navy and the Air Force, and selected civilian institutions. A key issue is the lack of coordination and synchronization of policies and procedures not only between the services, but also between installations within a given service. An objective of the WHEC will be to develop clinical practice guidelines that reflect the best evidence for preventing, mitigating, risk stratifying, and improving the management of EHI and related illnesses in warfighters. Importantly, the WHEC will maintain a web-based repository of clinical practice guidelines, information papers, and an "ask the expert" function to assist in providing up-to-date information to address prevention, mitigation, and return-to-duty concerns. The WHEC website can be accessed at https://www.hprc-online.org/resources-partners/whec.

The WHEC will also provide guidance and leadership, assist in coordinating and facilitating research, and collaborate with service-specific research centers, including the Heat Center at Fort Benning. The Army Surgeon General's Office tasking was simply to do all possible to decrease the morbidity and mortality of EHI and related conditions and end the aforementioned tragedy loop.

For each of the last 4 years, owing in part to the total number of trainees, the environmental conditions, and the physical demands of training, Fort Benning has experienced the highest numbers of EHIs of any installation in the DoD, so positioning the first field operating agency Heat Center at Fort Benning was a logical decision.[9] Three areas of focus of the Heat Center have been identified—prevention, medical management, and research.

Prevention is the foundation of the Center's efforts. Through the annual Heat Forum, senior leader engagements, and the training of leaders and cadre down to the level of sergeants and staff sergeants, Heat Center staff provide education and training to support prevention efforts. A current initiative of the Heat Center is the creation and inclusion of EHI prevention training for all cadre and drill sergeants during their in-processing and instructor orientation at Fort Benning. As heat illness treatment is often not covered in medical curricula, education of new MACH staff supports the medical management line of effort.

Over the years, MACH staff have refined treatment protocols for the medical management of EHI casualties. The other services, in particular the Navy in support of Marine Corps training, have also developed unique and successful strategies for the management of EHI and related conditions. The WHEC aims to share these protocols, from point of injury through return to duty, with all installations and services. The goal is to coordinate best practices across the DoD to mitigate EHI and related conditions across the DoD. The WHEC, leveraging clinical consultation in the National Capital Region and across the U.S., will activate and commission a clinical consultation hotline to assist with challenging EHI case decisions.

Lastly, while USARIEM, USUHS, and the APHC have a long history of exceptional laboratory-based and epidemiological research on the effects of heat stress on the warfighter, because of a lack of access to heat casualty patients, they have been limited in their ability to conduct clinically meaningful research on this population. Given the sheer volume of EHI casualties at Fort Benning, active research collaborations between the Heat Center, USUHS, USARIEM, and the U.S. Army Medical Material Development Agency have been established.

Given the demands of military training, it is an unrealistic goal to prevent all EHI in the military. To be prepared to fight anywhere, the warfighter must be trained in a range of conditions, including hot environments. The WHEC and the Heat Center are ideally positioned to support efforts to reduce the severity of EHI as much as possible and to eliminate all heat-related deaths in the military and end the tragedy loop.

Author affiliations: Martin Army Community Hospital, Fort Benning, GA (MAJ DeGroot); the Uniformed Services University of the Health Sciences, Bethesda, MD (Dr. O'Connor).

REFERENCES

1. Goldman RF. Introduction to heat-related problems in military operations. In: Pandolf KB, Burr RE, eds. *Medical Aspects of Harsh Environments, Volume 1*. Falls Church, VA: Office of the Surgeon General; 2001:3–49.
2. Sanders E. Heat of battle takes toll on U.S. Forces. *Los Angeles Times*. 11 August 2004. https://www.latimes.com/archives/la-xpm-2004-aug-11-fg-summer11-story.html. Accessed 19 February 2020.
3. Adolph EF. *Physiology of Man in the Desert*. New York, NY: Interscience Publishers; 1947.
4. Yaglou CP, Minard D. Control of heat casualties at military training centers. *AMA Arch Ind Health*. 1957;16(4):302–316.
5. Pandolf KB, Francesconi R, Sawka MN, et al. United States Army Research Institute of Environmental Medicine: Warfighter research focusing on the past 25 years. *Adv Physiol Educ*. 2011;35(4):353–360.
6. Headquarters, Department of the Army. Army Doctrine Publication 3-0. Unified Land Operations. 6 October 2017.
7. Lilley K. West Point grad dies after hospitalization during Ranger School. *Army Times*. 28 July 2016. https://www.armytimes.com/news/your-army/2016/07/28/west-point-grad-dies-after-hospitalization-during-ranger-school/. Accessed 19 February 2020.
8. Galer M. The Heat Center Initiative. *U.S. Army, Risk Management Quarterly*. 2019;Spring:6–8.
9. Armed Forces Health Surveillance Branch. Update: Heat illness, active component, U.S. Armed Forces, 2018. *MSMR*. 2019;26(4):15–20.

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.

Update: Heat Illness, Active Component, U.S. Armed Forces, 2019

In 2019, there were 507 incident cases of heat stroke and 2,174 incident cases of heat exhaustion among active component service members. The overall crude incidence rates of heat stroke and heat exhaustion were 0.39 cases and 1.65 cases per 1,000 person-years, respectively. In 2019, subgroup-specific rates of incident heat stroke were highest among males, those less than 20 years old, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations. Subgroup-specific incidence rates of heat exhaustion in 2019 were notably higher among service members less than 20 years old, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations. During 2015–2019, a total of 348 heat illnesses were documented among service members in Iraq and Afghanistan; 7.5% (n=26) were diagnosed as heat stroke. Commanders, small unit leaders, training cadre, and supporting medical personnel must ensure that the military members whom they supervise and support are informed about the risks, preventive countermeasures, early signs and symptoms, and first-responder actions related to heat illnesses.

WHAT ARE THE NEW FINDINGS?

Annual rates of incident heat stroke and heat exhaustion cases among active component U.S. military members rose from 2015 through 2018 but then dropped in 2019. Although sizable proportions of heat stroke and heat exhaustion cases were not identified by way of mandatory reports through the Disease Reporting System internet (DRSi), the proportions of heat stroke cases identified via reportable medical events increased steadily between 2015 and 2019.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Heat stroke and heat exhaustion can reduce operational readiness by causing considerable morbidity, particularly during training of recruits and of Marine Corps and Army members in combat arms specialties. Complete and timely submission of mandatory reports of heat illness events ensures that local public health and command leaders have ready access to real-time surveillance data to identify trends and to guide preventive measures.

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 because of strenuous physical exertion and environmental heat stress.[1,2] Acute dehydration often accompanies heat exhaustion but is not required for the diagnosis.[3] The clinical criteria for heat exhaustion include a 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 or 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 (i.e., a core body temperature of 104°F/40°C or greater), profound central nervous system dysfunction (e.g., delirium, seizures, or 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] Multiorgan system failure is the ultimate cause of mortality due to heat stroke.[5]

Timely medical intervention can prevent milder cases of heat illness (e.g., 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 because of high environmental heat and/or a high rate of metabolic heat production.[11,12] In some military settings, wearing needed protective clothing or equipment may make it biophysically difficult to dissipate body heat.[13,14] The resulting body heat burden and associated cardiovascular strain reduce exercise performance and increase the risk of heat-related illness.[11,15]

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.[16–22] 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.[11,23] Moreover, with the projected rise in the intensity and frequency of extreme heat conditions associated with global climate change, heat-related illnesses will likely represent an increasing challenge to the military.[24–26]

In the U.S. Military Health System (MHS), the most serious types of heat-related illness 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 reportable medical events of heat illness as well as heat illness-related hospitalizations and ambulatory visits among active component service members during 2019 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 2015 through 31 December 2019. 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 service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the MHS) treatment facilities worldwide. In-theater diagnoses of heat illness were identified from medical records of service members deployed to Southwest Asia or the Middle East and whose healthcare encounters were documented in the Theater Medical Data Store. 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 any 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 (International Classification of Diseases, 9th Revision [ICD-9]: 992.0; International Classification of Diseases, 10th Revision [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.[27] Because of an update to the Disease Reporting System internet (DRSi) medical event reporting system in July 2017, the type of reportable medical events for heat illness (i.e., heat stroke or heat exhaustion) could not be distinguished using reportable medical event records in DMSS data. Instead, information on the type of reportable medical event for heat illness during the entire 2015–2019 surveillance period was extracted from the DRSi. It is important to note that *MSMR* analyses carried out before 2018 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 and the April 2018 and April 2019 *MSMR* analyses. If an individual had a diagnosis for both heat stroke and heat exhaustion during a given year, only 1 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 with hospitalizations prioritized over reportable events, which were prioritized over ambulatory visits.

For surveillance purposes, a "recruit trainee" was defined as an active component service member (grades E1–E4) who was assigned to 1 of the services' 8 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 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) (e.g., Iraq or 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 1 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 MHS, MHS GENESIS, was implemented at 4 military treatment facilities in the state of Washington in 2017 (Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center). Implementation of the second wave of MHS GENESIS sites began in 2019 and included 3 facilities in California (Travis Air Force Base [AFB], the Presidio of Monterey, and Naval Air Station Lemoore) and 1 in Idaho (Mountain Home AFB). Medical data from facilities using MHS GENESIS are not available in the DMSS. Therefore, medical encounter data for individuals seeking care at any of these facilities after their conversion to MHS GENESIS during 2017–2019 were not included in the current analysis.

RESULTS

In 2019, there were 507 incident cases of heat stroke and 2,174 incident cases of heat exhaustion among active component service members **(Table 1)**. The crude overall incidence rates of heat stroke and heat exhaustion were 0.39 and 1.65 per 1,000 person-years (p-yrs), respectively. In 2019, subgroup-specific incidence rates of heat stroke were highest among males, those less than 20 years old, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations **(Table 1)**. The rates of incident heat stroke among Marine Corps and Army members were more than 10 times the rates among Air Force and Navy members. The incidence rate of heat stroke among service women was 44.8% lower than the rate among service men. There were only 51 cases of heat stroke reported among recruit trainees, but their incidence rate was more than 4 times that of other enlisted members and officers.

The crude overall incidence rates of heat exhaustion among males and females were close in value (1.66 per 1,000 p-yrs and 1.62 per 1,000 p-yrs, respectively) **(Table 1)**. In 2019, compared to their respective counterparts, service members less than 20 years old, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations had notably higher rates of incident heat exhaustion.

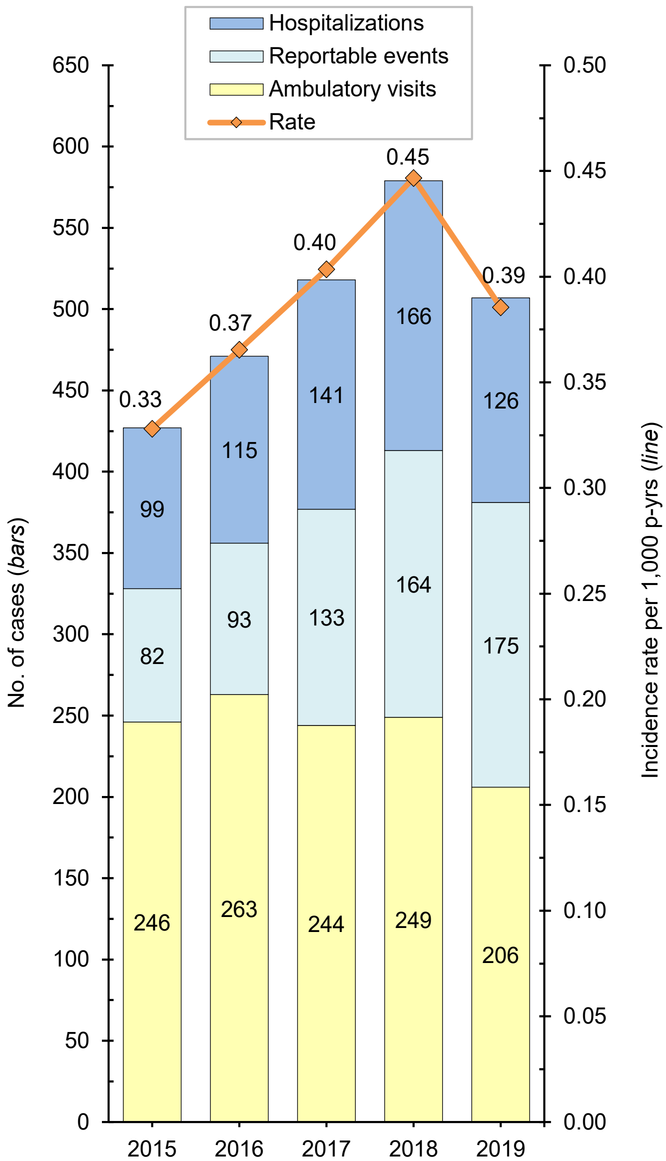
Crude (unadjusted) annual incidence rates of heat stroke increased steadily from 0.33 per 1,000 p-yrs in 2015 to 0.45 cases per 1,000 p-yrs in 2018 and then dropped to 0.39 cases per 1,000 p-yrs in 2019 **(Figure 1)**. In the last year of the surveillance period, there were fewer heat stroke-related hospitalizations and ambulatory visits than in 2018 but more reportable medical events. The proportions of total heat stroke cases from hospitalizations remained relatively stable during 2015–2019 (range: 23.2%–28.7%). The proportions of total heat stroke cases from reportable medical events increased steadily over the course of the period (from 19.2% in 2015 to 34.5% in 2019), while the proportions of total cases from ambulatory visits decreased (from 57.6% in 2015 to 49.6% in 2019).

TABLE 1. Incident cases[a] and incidence rates[b] of heat illness, by demographic and military characteristics, active component, U.S. Armed Forces, 2019

	Heat stroke		Heat exhaustion		Total heat illness cases	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	507	0.39	2,174	1.65	2,681	2.04
Sex						
Male	456	0.42	1,815	1.66	2,271	2.08
Female	51	0.23	359	1.62	410	1.85
Age group (years)						
<20	113	1.09	591	5.68	704	6.77
20–24	203	0.48	972	2.30	1,175	2.77
25–29	114	0.38	355	1.17	469	1.54
30–34	48	0.23	150	0.73	198	0.96
35–39	19	0.12	67	0.44	86	0.56
40+	10	0.08	39	0.31	49	0.39
Race/ethnicity group						
Non-Hispanic white	304	0.41	1,215	1.66	1,519	2.07
Non-Hispanic black	77	0.36	397	1.87	474	2.24
Hispanic	74	0.34	353	1.62	427	1.96
Asian/Pacific Islander	33	0.58	135	2.39	168	2.97
Other/unknown	19	0.20	74	0.78	93	0.98
Service						
Army	330	0.70	1,238	2.62	1,568	3.32
Navy	23	0.07	137	0.41	160	0.48
Air Force	21	0.06	190	0.58	211	0.65
Marine Corps	133	0.71	609	3.27	742	3.99
Military status						
Recruit	51	1.76	402	13.86	453	15.62
Enlisted	361	0.34	1,630	1.55	1,991	1.89
Officer	95	0.41	142	0.61	237	1.02
Military occupation						
Combat-specific[c]	214	1.20	710	3.97	924	5.17
Motor transport	8	0.20	65	1.65	73	1.86
Pilot/air crew	5	0.11	12	0.26	17	0.37
Repair/engineering	46	0.12	298	0.77	344	0.88
Communications/intelligence	77	0.27	322	1.14	399	1.41
Healthcare	30	0.26	141	1.23	171	1.49
Other/unknown	127	0.48	626	2.36	753	2.84
Home of record[d]						
Midwest	93	0.40	419	1.82	512	2.22
Northeast	64	0.39	240	1.45	304	1.83
South	225	0.40	991	1.75	1,216	2.15
West	121	0.39	493	1.58	614	1.97
Other/unknown	4	0.10	31	0.75	35	0.85

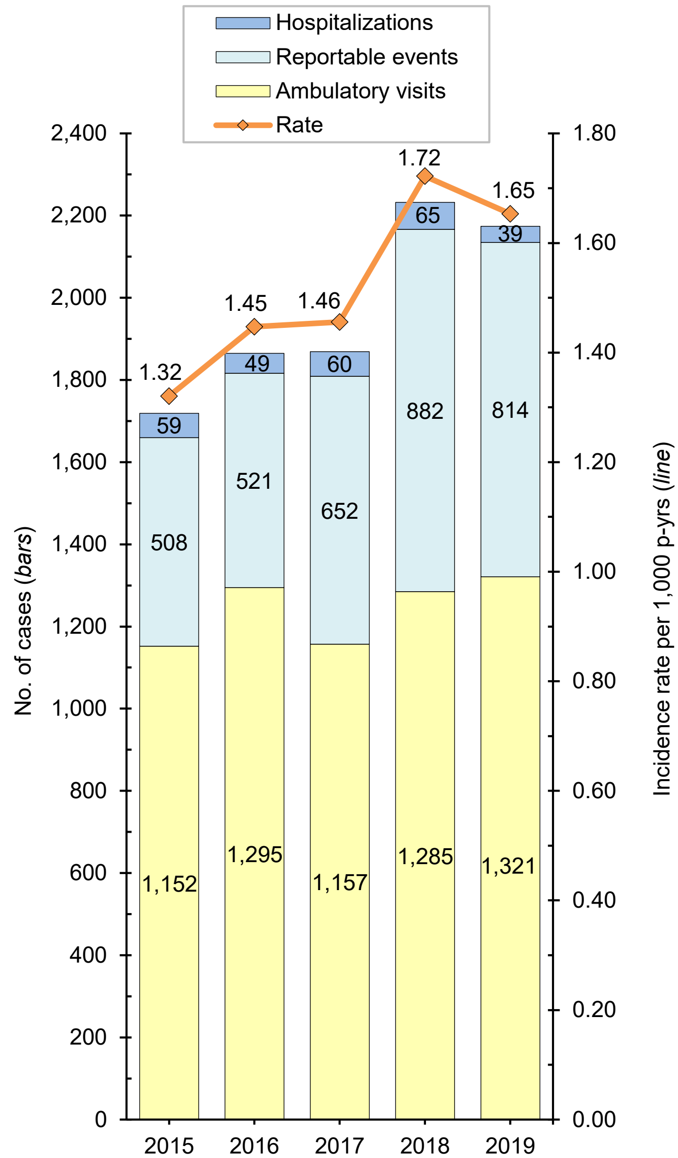
[a]One case per person per year.
[b]Number of cases per 1,000 person-years.
[c]Infantry/artillery/combat engineering/armor.
[d]As self-reported at time of entry into service.
No., number.

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, 2015–2019



[a]Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits).
No., number; p-yrs, person-years.

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, 2015–2019



[a]Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits).
No., number; p-yrs, person-years.

Crude annual rates of incident heat exhaustion increased between 2015 and 2016, were stable during 2016–2017, increased to a peak of 1.72 per 1,000 p-yrs in 2018, and then dropped to 1.65 per 1,000 p-yrs in 2019 **(Figure 2)**. During the 5-year surveillance period, the proportions of total heat exhaustion cases from reportable medical events fluctuated between 27.9% and 39.5% and the proportions of cases from ambulatory visits varied between 57.6% and 69.4%. However, the proportions of heat exhaustion cases from hospitalizations remained relatively stable (range: 1.8%–3.4%).

Heat illnesses by location

During the 5-year surveillance period, a total of 12,361 heat-related illnesses were diagnosed at more than 250 military installations and geographic locations worldwide **(Table 2)**. Less than 5% of the total heat illness cases occurred outside of the U.S. (n=537). Four Army installations accounted for slightly more than one-third (34.4%) of all heat illnesses during the period (Fort Benning, GA [n=1,757]; Fort Bragg, NC [n=1,087]; Fort Campbell, KY [n=752]; and Fort Polk, LA [n=652]). Six other locations accounted for an additional one-quarter (25.4%) of heat illness events (Marine Corps Base [MCB] Camp Lejeune/Cherry Point, NC [n=865];

TABLE 2. Heat illness events,[a] by location of diagnosis/report (with at least 100 cases during the period), active component, U.S. Armed Forces, 2015–2019

Location of diagnosis	No.	% total
Fort Benning, GA	1,757	14.2
Fort Bragg, NC	1,087	8.8
MCB Camp Lejeune/ Cherry Point, NC	865	7.0
Fort Campbell, KY	752	6.1
Fort Polk, LA	652	5.3
MCRD Parris Island/ Beaufort, SC	637	5.2
MCB Camp Pendleton, CA	531	4.3
NMC San Diego, CA	498	4.0
Fort Hood, TX	341	2.8
MCB Quantico, VA	273	2.2
JBSA-Lackland AFB, TX	272	2.2
Fort Stewart, GA	262	2.1
Okinawa, Japan	259	2.1
Fort Jackson, SC	254	2.1
NH Twentynine Palms, CA	197	1.6
Fort Shafter, HI	177	1.4
Fort Leonard Wood, MO	171	1.4
Fort Sill, OK	123	1.0
Fort Irwin, CA	104	0.8
Fort Riley, KS	102	0.8
NMC Portsmouth, VA	101	0.8
Outside of the U.S.	537	4.3
All other locations	2,409	19.5
Total	12,361	100.0

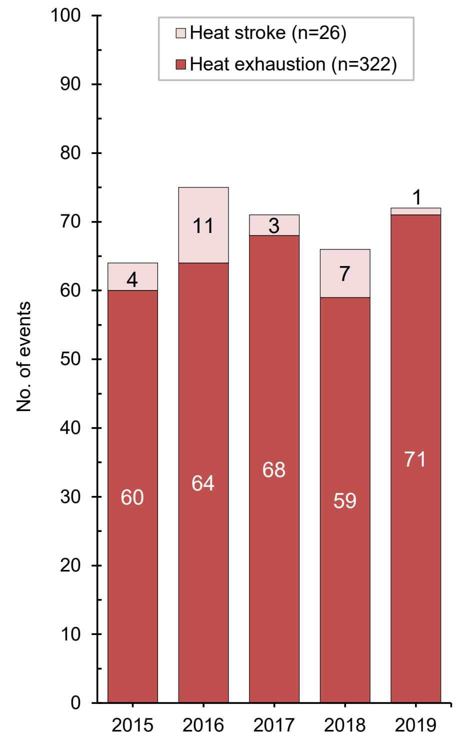
[a]One heat illness per person per year.
No., number; MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NMC, Naval Medical Center; JBSA, Joint Base San Antonio; AFB, Air Force Base; NH, Naval Hospital.

Marine Corps Recruit Depot Parris Island/ Beaufort, SC [n=637]; MCB Camp Pendleton, CA [n=531]; Naval Medical Center San Diego, CA [n=498]; Fort Hood, TX [n=341]; and MCB Quantico, VA [n=273]). Of these 10 locations with the most heat illness events, 7 are located in the southeastern U.S. The 21 locations with more than 100 cases of heat illness accounted for over three-quarters (76.2%) of all active component cases during 2015–2019.

Heat illnesses in Iraq and Afghanistan

During the 5-year surveillance period, a total of 348 heat illnesses were diagnosed and treated in Iraq and Afghanistan **(Figure 3)**. Of the total cases of heat illness, 7.5% (n=26) were diagnosed as heat stroke. Deployed service members who were affected by heat illnesses were most frequently male (n=291; 83.6%), non-Hispanic white (n=207; 59.5%), 20–24 years old (n=186; 53.4%), in the Army (n=180; 51.7%), enlisted (n=339; 97.4%), and in repair/engineering (n=110; 31.6%) or combat-specific (n=104; 29.9%) occupations **(data not shown)**. During the surveillance period, 3 service members were medically evacuated for heat illnesses from Iraq or Afghanistan; all of the evacuations took place in the summer months (May–September).

FIGURE 3. Numbers of heat illnesses diagnosed in Iraq/Afghanistan, active component, U.S. Armed Forces, 2015–2019



No., number.

EDITORIAL COMMENT

This annual update of heat illnesses among service members in the active component documented that the unadjusted annual rates of incident heat stroke increased steadily between 2015 and 2018 and then dropped in 2019. The crude annual incidence rate of heat exhaustion in 2019 represents a 13.7% decrease from the peak rate in 2018.

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 and carried into the 2020 revision.[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 *MSMR* updates before 2018.

As has been noted in previous *MSMR* heat illness updates, results indicate that a sizable proportion of cases identified through DMSS records of ambulatory visits did not prompt mandatory reports through the reporting system.[23] However, this study did not directly 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 documented as reportable medical events because treatment providers were not attentive to the criteria for reporting or because of ambiguity in interpreting the criteria (e.g., the heat illness did not result in a change in duty status, or the 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 demonstrates 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 Marine Corps and Army members (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 the military members whom they supervise and support are informed regarding the risks, preventive countermeasures (e.g., water consumption), early signs and symptoms, and first-responder actions related to heat illnesses.[16–22,28–30] 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 through the Army Public Health Center website at https://phc.amedd.army.mil/topics/discond/.

REFERENCES

1. Atha WF. Heat-related illness. *Emerg Med Clin North Am*. 2013;31(4):1097–1108.
2. Simon HB. Hyperthermia. *N Engl J Med*. 1993;329(7):483–487.
3. O'Connor FG, Sawka MN, Deuster P. Disorders due to heat and cold. In: Goldman L, Schafer AI, eds. *Goldman-Cecil Medicine.* 25th ed. Philadelphia, PA: Elsevier Saunders; 2016:692–693.
4. Armed Forces Health Surveillance Branch, Defense Health Agency. 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, January 2020. https://health.mil/Reference-Center/Publications/2020/01/01/Armed-Forces-Reportable-Medical-Events-Guidelines. Accessed 1 April 2020.
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(3):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(2):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. Hancock PA, Ross JM, Szalma JL. A meta-analysis of performance response under thermal stressors. *Hum Factors*. 2007;49(5):851–877.
13. Caldwell JN, Engelen L, van der Henst C, Patterson MJ, Taylor NA. The interaction of body armor, low-intensity exercise, and hot-humid conditions on physiological strain and cognitive function. *Mil Med*. 2011;176(5):488–493.
14. Maynard SL, Kao R, Craig DG. Impact of personal protective equipment on clinical output and perceived exertion. *J R Army Med Corps.* 2016;162(3):180–183.
15. Sawka MN, Cheuvront SN, Kenefick RW. High skin temperature and hypohydration impair aerobic performance. *Exp Physiol*. 2012;97(3):327–332.
16. Goldman RF. Introduction to heat-related problems in military operations. In: Lounsbury DE, Bellamy RF, Zajtchuk R, eds. *Textbook of Military Medicine: Medical Aspects of Harsh Environments, Volume 1*. Falls Church, VA: Office of the Surgeon General; 2001:3–49.
17. Sonna LA. Practical medical aspects of military operations in the heat. In: Lounsbury DE, Bellamy RF, Zajtchuk R, eds. *Textbook of Military Medicine: Medical Aspects of Harsh Environments, Volume 1*. Falls Church, VA: Office of the Surgeon General; 2001:293–309.
18. Headquarters, Department of the Army and Air Force. Technical Bulletin, Medical 507, Air Force Pamphlet 48-152. Heat Stress Control and Heat Casualty Management. 7 March 2003.
19. Headquarters, United States Marine Corps, Department of the Navy. Marine Corps Order 6200.1E. Marine Corps Heat Injury Prevention Program. Washington DC: Department of the Navy; 6 June 2002.
20. Navy Environmental Health Center. Technical Manual NEHC-TM-OEM 6260.6A. Prevention and Treatment of Heat and Cold Stress Injuries. Published June 2007.
21. 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.
22. Lee JK, Kenefick RW, Cheuvront SN. Novel cooling strategies for military training and operations. *J Strength Cond Res*. 2015;29(suppl 11):S77–S81.
23. Armed Forces Health Surveillance Branch. Update: Heat illness, active component, U.S. Armed Forces, 2018. *MSMR*. 2019;26(4):15–20.
24. Dahl K, Licker R, Abatzoglou JT, Declet-Barreto J. Increased frequency of and population exposure to extreme heat index days in the United States during the 21st century. *Environ Res Commun*. 2019;1:075002.
25. Parsons IT, Stacey MJ, Woods DR. Heat adaptation in military personnel: mitigating risk, maximizing performance. *Front Physiol.* 2019;10:1485.
26. Kenny GP, Notley SR, Flouris AD, Grundstein A. Climate change and heat exposure: impact on health in occupational and general populations. In: Adams W, Jardine J, eds. *Exertional Heat Illness: A Clinical and Evidence-Based Guide*. Cham, Switzerland: Springer Nature; 2020:225–261.
27. Armed Forces Health Surveillance Branch. Surveillance case definition: Heat illness. https://health.mil/Reference-Center/Publications/2019/10/01/Heat-Injuries. Accessed on 1 April 2020.
28. Headquarters, Department of the Army Training and Doctrine Command. Memorandum. TRADOC Heat Illness Prevention Program 2018. 8 January 2018.
29. Kazman JB, O'Connor FG, Nelson DA, Deuster PA. Exertional heat illness in the military: risk mitigation. In: Hosokawa Y, ed. *Human Health and Physical Activity During Heat Exposure*. Cham, Switzerland: SpringerBriefs in Medical Earth Sciences; 2018:59–71.
30. Nye NS, O'Connor FG. Exertional heat illness considerations in the military. In: Adams W, Jardine J, eds. *Exertional Heat Illness: A Clinical and Evidence-Based Guide*. Cham, Switzerland: Springer Nature; 2020:181–210.

Update: Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2015–2019

Among active component service members in 2019, there were 512 incident cases of exertional rhabdomyolysis, for an unadjusted incidence rate of 38.9 cases per 100,000 person-years (p-yrs). Subgroup-specific rates in 2019 were highest among males, those less than 20 years old, non-Hispanic black service members, Army or Marine Corps members, and those in "other/unknown" or combat-specific occupations. During 2015–2019, crude rates of exertional rhabdomyolysis fluctuated between a low of 35.2 per 100,000 p-yrs in 2015 and a high of 42.4 per 100,000 p-yrs in 2018, after which the rate decreased to 38.9 per 100,000 p-yrs in 2019. Compared to service members in other race/ethnicity groups, non-Hispanic blacks had the highest overall rate of exertional rhabdomyolysis in every year except 2018. 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 darkened urine after strenuous physical activity, especially in hot, humid weather.

WHAT ARE THE NEW FINDINGS?

During the 5-year period, the annual numbers and rates of incident exertional rhabdomyolysis cases peaked in 2018 and then dropped in 2019. Exertional rhabdomyolysis continued to occur most frequently from late spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Prompt recognition and treatment of exertional rhabdomyolysis usually prevent severe complications. However, some service members who experience exertional rhabdomyolysis may be at risk for recurrences, which may limit their military effectiveness and potentially predispose them to serious injury. Moreover, untimely recurrences may compromise a unit's mission. Commanders and supervisors should be vigilant for early signs of exertional heat injuries and, when such signs are detected, should intervene aggressively.

Rhabdomyolysis is characterized by the breakdown of skeletal muscle cells and the subsequent release of intracellular muscle contents into the circulation. The characteristic triad of rhabdomyolysis includes weakness, myalgias, and red to brown urine (due to myoglobinuria) accompanied by an elevated serum concentration of creatine kinase.[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] Even athletes who are used to intense training and who are being carefully monitored are at risk of this condition,[4] especially if new overexertion-inducing exercises are being introduced.[5] Illness severity ranges from elevated serum muscle enzyme levels without clinical symptoms to life-threatening disease associated with extreme enzyme elevations, electrolyte imbalances, and acute kidney failure.[1–3,6]

Risk factors for exertional rhabdomyolysis include exertion in hot and humid conditions, younger age, male sex, a lower level of physical fitness, a prior heat illness, impaired sweating, and a lower level of education.[1,3,7–10] Acute kidney injury, due to an excessive concentration of free myoglobin in the urine accompanied by volume depletion, renal tubular obstruction, and renal ischemia, represents a serious complication of rhabdomyolysis.[6,11] Severely affected patients can also develop compartment syndrome, fever, dysrhythmias, metabolic acidosis, and altered mental status.[10]

In U.S. military members, rhabdomyolysis is a significant threat during physical exertion, particularly under heat stress.[7,9,12] Moreover, although rhabdomyolysis can affect any service member, new recruits, who are not yet accustomed to the physical exertion required of basic training, may be at particular risk.[9] Each year, the *MSMR* summarizes the numbers, rates, trends, risk factors, and locations of occurrences of exertional heat injuries, including exertional rhabdomyolysis. This report includes the data for 2015–2019. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of the *MSMR*.[12]

METHODS

The surveillance period was 1 January 2015 through 31 December 2019. 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 [MHS]) 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.

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" (International Classification of Diseases, 9th Revision [ICD-9]: 728.88; International Classification of Diseases, 10th Revision [ICD-10]: M62.82) or "myoglobinuria" (ICD-9: 791.3; ICD-10: R82.1) plus a diagnosis in any position of 1 of the following: "volume depletion (dehydration)" (ICD-9: 276.5*; ICD-10: E86.0, E86.1, E86.9), "effects of heat and light" (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*).[13] 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.[13]

For surveillance purposes, a "recruit trainee" was defined as an active component member in an enlisted grade (E1–E4) who was assigned to 1 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 and 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 MHS, MHS GENESIS, was implemented at 4 military treatment facilities in the state of Washington in 2017 (Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center). Implementation of the second wave of MHS GENESIS sites began in 2019 and included 3 facilities in California (Travis Air Force Base [AFB], the Presidio of Monterey, and Naval Air Station Lemoore) and 1 in Idaho (Mountain Home AFB). Medical data from facilities using MHS GENESIS are not available in the DMSS. Therefore, medical encounter data for individuals seeking care at any of these facilities after their conversion to MHS GENESIS during 2017–2019 were not included in the current analysis.

RESULTS

In 2019, there were 512 incident cases of rhabdomyolysis likely associated with physical exertion and/or heat stress (exertional rhabdomyolysis) **(Table 1)**. The crude (unadjusted) incidence rate was 38.9 cases per 100,000 person-years (p-yrs). Subgroup-specific incidence rates of exertional rhabdomyolysis were highest among males (43.3 per 100,000 p-yrs), those less than 20 years old (88.0 per 100,000 p-yrs), non-Hispanic black service members (66.1 per 100,000 p-yrs), Marine Corps or Army members (91.9 per 100,000 p-yrs and 47.3 per 100,000 p-yrs, respectively), and those in "other/unknown" or combat-specific occupations (72.1 per 100,000 p-yrs and 66.0 per 100,000 p-yrs, respectively) **(Table 1)**. Of note, the incidence rate among recruit trainees was more than 6 times that among other enlisted members and officers, even though cases among this group accounted for only 13.3% of all cases in 2019.

During the surveillance period, crude rates of exertional rhabdomyolysis fluctuated between a low of 35.2 per 100,000 p-yrs in 2015 and a high of 42.4 per 100,000 p-yrs in 2018, after which the rate decreased to 38.9 per 100,000 p-yrs in 2019 **(Figure 1)**. The annual incidence rates of exertional rhabdomyolysis were highest among non-Hispanic blacks in every year except 2018, when the highest rate occurred among Asian/Pacific Islanders **(data not shown)**. Overall and annual rates of incident 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)**. Among Marine Corps and Army members, annual rates increased between 2015 and 2018 (35.7% and 21.0% increases, respectively) and then dropped in 2019 **(Figure 2)**. Annual rates among Navy members increased 41.1% over the course of the 5-year surveillance period, while rates among service members in the Air Force remained relatively stable. During 2015–2019, approximately three-quarters (75.3%) of the cases occurred between May and October **(Figure 3)**.

Rhabdomyolysis by location

During the 5-year surveillance period, the medical treatment facilities at 13 installations diagnosed at least 50 cases each; when combined, these installations diagnosed more than half (57.3%) of all cases **(Table 2)**. Of these 13 installations, 4 provide support to recruit/basic combat training

TABLE 1. Incident cases[a] and incidence rates[b] of exertional rhabdomyolysis, by demographic and military characteristics, active component, U.S. Armed Forces, 2019

	Hospitalizations		Ambulatory visits		Total	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	211	16.0	301	22.9	512	38.9
Sex						
Male	201	18.4	273	25.0	474	43.3
Female	10	4.5	28	12.6	38	17.2
Age group (years)						
<20	56	29.7	110	58.3	166	88.0
20–24	62	18.3	77	22.7	139	41.0
25–29	53	17.4	62	20.4	115	37.8
30–34	20	9.7	31	15.0	51	24.7
35–39	16	10.4	13	8.5	29	18.9
40+	4	3.2	8	6.4	12	9.7
Race/ethnicity group						
Non-Hispanic white	100	13.6	153	20.9	253	34.5
Non-Hispanic black	61	28.8	79	37.3	140	66.1
Hispanic	27	12.4	42	19.3	69	31.7
Asian/Pacific Islander	13	23.0	10	17.7	23	40.7
Other/unknown	10	10.5	17	17.9	27	28.4
Service						
Army	83	17.6	140	29.7	223	47.3
Navy	29	8.8	26	7.9	55	16.6
Air Force	33	10.1	30	9.2	63	19.3
Marine Corps	66	35.5	105	56.4	171	91.9
Military status						
Recruit	22	74.9	46	156.7	68	231.6
Enlisted	161	15.3	222	21.1	383	36.4
Officer	28	12.1	33	14.2	61	26.3
Military occupation						
Combat-specific[c]	39	21.8	79	44.2	118	66.0
Motor transport	5	12.7	8	20.3	13	33.0
Pilot/air crew	2	4.3	1	2.2	3	6.5
Repair/engineering	36	9.2	41	10.5	77	19.8
Communications/intelligence	36	12.8	49	17.4	85	30.1
Healthcare	11	9.6	14	12.2	25	21.8
Other/unknown	82	31.0	109	41.2	191	72.1
Home of record[d]						
Midwest	34	14.8	48	20.8	82	35.6
Northeast	22	13.3	54	32.6	76	45.8
South	100	17.7	139	24.6	239	42.3
West	54	17.3	57	18.3	111	35.6
Other/unknown	1	2.4	3	7.2	4	9.7

[a]One case per person per year.
[b]Rate per 100,000 person-years.
[c]Infantry/artillery/combat engineering/armor.
[d]As self-reported at time of entry into service.
No., number.

centers (Marine Corps Recruit Depot [MCRD] Parris Island/Beaufort, SC; Fort Benning, GA; Joint Base San Antonio–Lackland, TX; and Fort Leonard Wood, MO). In addition, 6 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). During 2015–2019, the most cases overall were diagnosed at MCRD Parris Island/Beaufort, SC (n=282), and Fort Bragg, NC (n=274), which together accounted for more than one-fifth (21.8%) of all cases **(Table 2)**.

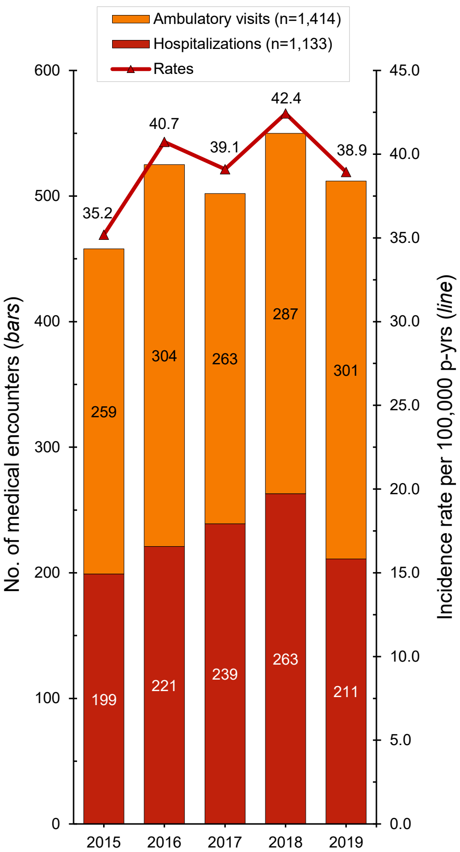
Rhabdomyolysis in Iraq and Afghanistan

There were 7 incident cases of exertional rhabdomyolysis diagnosed and treated in Iraq/Afghanistan during the 5-year surveillance period **(data not shown)**. Deployed service members who were affected by exertional rhabdomyolysis were most frequently non-Hispanic black or non-Hispanic white (n=5; 71.4% and n=2; 28.6%, respectively), male (n=7), aged 20–29 years (n=4; 57.1%), in the Army (n=7), enlisted (n=7), and in communication/intelligence (n=2; 28.6%) or repair/engineering occupations (n=2; 28.6%). One active component service member was medically evacuated from Iraq/Afghanistan for exertional rhabdomyolysis during the surveillance period; this medical evacuation occurred in September 2015 **(data not shown)**.

EDITORIAL COMMENT

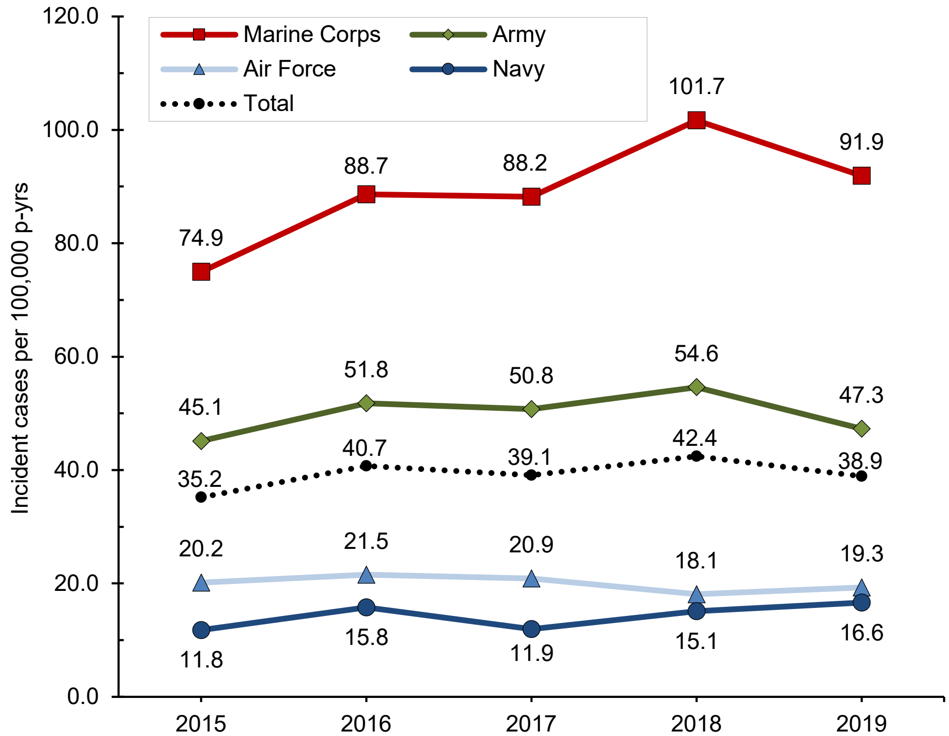
This report documents that the crude annual incidence rates of exertional rhabdomyolysis among active component U.S. military members fluctuated between a low of 35.2 per 100,000 p-yrs in 2015 and a high of 42.4 per 100,000 p-yrs in 2018, after which rates decreased to 38.9 per 100,000 p-yrs (8.2% decrease) in 2019. Exertional rhabdomyolysis continued to occur most frequently from late spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

FIGURE 1. Incident cases and incidence rates of extertional rhabdomyolysis, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2015–2019



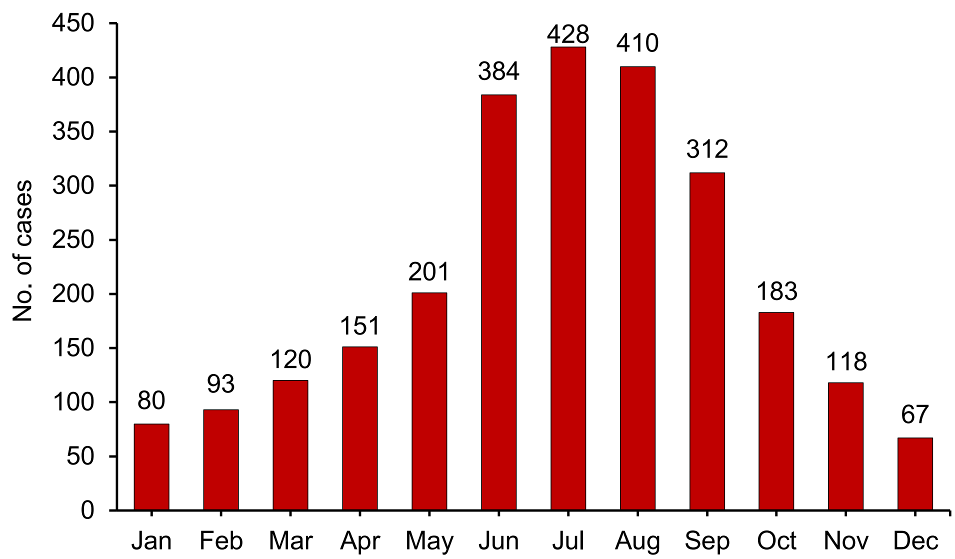
No., number; p-yrs, person-years.

FIGURE 2. Annual incidence rates of exertional rhabdomyolysis, by service, active component, U.S. Armed Forces, 2015–2019



P-yrs, person-years.

FIGURE 3. Cumulative numbers of exertional rhabdomyolysis cases, by month of diagnosis, active component, U.S. Armed Forces, 2015–2019



No., number.

The risks of heat injuries, including exertional rhabdomyolysis, are elevated 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.[1,2,9] 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 higher than the rates among members of other race/ethnicity groups in 4 of the 5 previous years, with the exception of 2018. This observation has been attributed, at least in part, to an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait[14–17] and is supported by at least 1 other study among U.S. service members.[9] 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

TABLE 2. Incident cases of exertional rhabdomyolysis, by installation (with at least 30 cases during the period), active component, U.S. Armed Forces, 2015–2019

Location of diagnosis	No.	% total
MCRD Parris Island/ Beaufort, SC	282	11.1
Fort Bragg, NC	274	10.8
Fort Benning, GA	141	5.5
MCB Camp Pendleton, CA	137	5.4
MCB Camp Lejeune/ Cherry Point, NC	114	4.5
Fort Shafter, HI	76	3.0
Fort Hood, TX	73	2.9
JBSA-Lackland AFB, TX	70	2.7
Fort Leonard Wood, MO	66	2.6
Fort Carson, CO	62	2.4
NMC San Diego, CA	57	2.2
Fort Campbell, KY	57	2.2
Fort Gordon, GA	50	2.0
Fort Belvoir, VA	44	1.7
Fort Bliss, TX	38	1.5
Okinawa, Japan	39	1.5
NH Twentynine Palms, CA	36	1.4
Fort Stewart, GA	34	1.3
NMC Portsmouth, VA	34	1.3
Fort Jackson, SC	33	1.3
Fort Polk, LA	32	1.3
Eglin AFB, FL	30	1.2
Other/unknown locations	768	30.2
Total	2,547	100.0

No., number; MCRD, Marine Corps Recruit Depot; MCB, Marine Corps Base; JBSA, Joint Base San Antonio; AFB, Air Force Base; NMC Naval Medical Center; NH, Naval Hospital.

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, the risk of exertional rhabdomyolysis can be reduced by emphasizing graded, individual preconditioning before starting a more strenuous exercise program and by 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).[8]

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.[9,10,18] 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.[10,18–20] 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).[18,19]

Commanders and supervisors at all levels should be vigilant 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 darkened urine (possibly due to myoglobinuria) after strenuous physical activity, especially 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. McKewon S. Two Nebraska football players hospitalized, treated after offseason workout. *Omaha World-Herald*. 20 January 2019. https://www.omaha.com/huskers/football/two-nebraska-football-players-hospitalized-treated-after-offseason-workout/article_d5929674-53a7-5d90-803e-6b4e9205ee60.html. Accessed 10 March 2020.
5. Raleigh MF, Barrett JP, Jones BD, Beutler AI, Deuster PA, O'Connor FG. A cluster of exertional rhabdomyolysis cases in a ROTC program engaged in an extreme exercise program. *Mil Med*. 2018;183(suppl 1):516–521.
6. Bosch X, Poch E, Grau JM. Rhabdomyolysis and acute kidney injury. *N Engl J Med.* 2009;361(1):62–72.
7. Hill OT, Wahi MM, Carter R, Kay AB, McKinnon CJ, Wallace RF. Rhabdomyolysis in the U.S. active duty Army, 2004–2006. *Med Sci Sports Exerc*. 2012;44(3):442–449.
8. Lee G. Exercise-induced rhabdomyolysis. *R I Med J (2013)*. 2014;97(11):22–24.
9. Hill OT, Scofield DE, Usedom J, et al. Risk factors for rhabdomyolysis in the U.S. Army. *Mil Med*. 2017;182(7):e1836–e1841.
10. Knapik JJ, O'Connor FG. Exertional rhabdomyolysis: epidemiology, diagnosis, treatment, and prevention. *J Spec Oper Med*. 2016;15(3):65–71.
11. Holt S, Moore K. Pathogenesis of renal failure in rhabdomyolysis: the role of myoglobin. *Exp Nephrol*. 2000;8(2):72–76.
12. Armed Forces Health Surveillance Branch. Update: Exertional rhabdomyolysis among active component members, U.S. Armed Forces, 2014–2018. *MSMR*. 2019;26(4):21–26.
13. Armed Forces Health Surveillance Branch. Surveillance case definition. Exertional rhabdomyolysis. https://www.health.mil/Reference-Center/Publications/2017/03/01/Rhabdomyolysis-Exertional. Accessed 10 March 2020.
14. Gardner JW, Kark JA. Fatal rhabdomyolysis presenting as mild heat illness in military training. *Mil Med*. 1994;159(2):160–163.
15. 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.
16. Ferster K, Eichner ER. Exertional sickling deaths in Army recruits with sickle cell trait. *Mil Med*. 2012;177(1):56–59.
17. Nelson DA, Deuster PA, Carter R, Hill OT, Wolcott VL, Kurina LM. Sickle cell trait, rhabdomyolysis, and mortality among U.S. Army soldiers. *N Engl J Med.* 2016;375(5):435–442.
18. 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.
19. Atias D, Druyan A, Heled Y. Recurrent exertional rhabdomyolysis: coincidence, syndrome, or acquired myopathy? *Curr Sports Med Rep*. 2013;12(6):365–369.
20. O'Connor FG, Deuster P, Leggit J, et al. Clinical Practice Guideline for the Management of Exertional Rhabdomyolysis in Warfighters. Bethesda, Maryland: Uniformed Services University. 2017.

Update: Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2004–2019

From 2004 through 2019, there were 1,612 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.4 cases per 100,000 person-years (p-yrs). Compared to their respective counterparts, females, those less than 20 years old, and recruit trainees had higher overall incidence rates of exertional hyponatremia diagnoses. 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 Asian/Pacific Islander and non-Hispanic white service members and lowest among non-Hispanic black service members. Between 2004 and 2019, crude annual incidence rates of exertional hyponatremia peaked in 2010 at 12.7 per 100,000 p-yrs and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. The crude annual rates fluctuated between 2014 and 2019, reaching the 2 highest rates in 2015 (8.6 per 100,000 p-yrs) and in 2019 (7.1 per 100,000 p-yrs). 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, and recreational activities) in hot, humid weather.

WHAT ARE THE NEW FINDINGS?

Annual incidence rates of exertional hyponatremia in service members have risen slightly during the past 2 years but remained well below the peak rates of 2009–2011. As in previous years, rates of exertional hyponatremia were highest among service members under 20 years of age, recruit trainees, Marines, and those in combat-specific occupations.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Exertional hyponatremia can not only reduce operational readiness by causing considerable morbidity, particularly among recruit trainees and Marine Corps and Army members in combat arms specialties, but it occasionally causes death. Service members, leaders, and trainers must observe the published guidelines that pertain to proper hydration during physical exertion, especially during warm weather.

Exertional (or exercise-associated) hyponatremia refers to a low serum, plasma, or blood sodium concentration (below 135 mEq/L) 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 (which can cause pulmonary edema) and brain (which can cause 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, potentially causing hypotonic encephalopathy, seizures, or coma. Rapid and definitive treatment is needed to relieve increasing intracranial pressure and prevent brain stem herniation, which can result in respiratory arrest.[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 2004 through 2019.[13]

METHODS

The surveillance period was 1 January 2004 through 31 December 2019. The surveillance population included all individuals who served in an active component of the U.S. 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 service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System [MHS]) 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 became available in the DMSS beginning in 2008.

For this analysis, a case of exertional hyponatremia was defined as 1) a hospitalization or ambulatory visit with a primary (first-listed) diagnosis of "hypo-osmolality and/or hyponatremia" (International Classification of Diseases, 9th Revision [ICD-9]: 276.1; International Classification of Diseases, 10th Revision [ICD-10]: E87.1) and no other illness or injury-specific diagnoses (ICD-9: 001–999) in any diagnostic position or 2) both a diagnosis of "hypo-osmolality and/or hyponatremia" (ICD-9: 276.1; ICD-10: E87.1) and at least 1 of the following within the first 3 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 or 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 1 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 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 hyponatremia were analyzed separately using the same case-defining criteria and incidence rules that were applied to identify incident cases at fixed treatment facilities. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq and 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 MHS, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in the DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Implementation of the second wave of MHS GENESIS sites began in 2019 and included 3 facilities in California (Travis Air Force Base [AFB], the Presidio of Monterey, and Naval Air Station Lemoore) and 1 in Idaho (Mountain Home AFB). Therefore, medical encounter data for individuals seeking care at any of these facilities during 2017–2019 were not included in this analysis.

RESULTS

During 2004–2019, permanent medical facilities recorded 1,612 incident diagnoses of exertional hyponatremia among active component service members, for a crude overall incidence rate of 7.4 cases per 100,000 person-years (p-yrs) **(Table 1)**. In 2019, there were 94 incident diagnoses of exertional hyponatremia (incidence rate: 7.1 per 100,000 p-yrs) among active component service members. During this year, males represented 85.1% of exertional hyponatremia cases (n=80); the annual incidence rate was slightly higher among males (7.3 per 100,000 p-yrs) than females (6.3 per 100,000 p-yrs) **(Table 1)**. The highest age group-specific incidence rates in 2019 were among the youngest (less than 20 years old) service members. Although the Army had the most cases during 2019 (n=40), the highest incidence rate was among members of the Marine Corps (15.0 per 100,000 p-yrs). In 2019, there were only 18 cases of exertional hyponatremia among recruit trainees, but their incidence rate was 7 times that of officers and more than 11 times that of other enlisted members **(Table 1)**.

During the 16-year surveillance period, females had a slightly higher overall incidence rate of exertional hyponatremia diagnoses than males **(Table 1)**. The overall incidence rate was highest in the Marine Corps (15.7 per 100,000 p-yrs) and lowest in the Navy (4.7 per 100,000 p-yrs). Overall rates during the surveillance period were highest among Asian/Pacific Islander (8.7 per 100,000 p-yrs) and non-Hispanic white service members (8.2 per 100,000 p-yrs) and lowest among non-Hispanic black service members (5.5 per 100,000 p-yrs). Although recruit trainees accounted for slightly less than one-tenth (9.9%) of all exertional hyponatremia cases, their overall crude incidence rate was 5.7 and 3.9 times the rates among other enlisted members and officers, respectively **(Table 1)**. During the 16-year period, 86.2% (n=1,389) of all cases were diagnosed and treated without having to be hospitalized **(Figure 1)**.

Between 2004 and 2019, crude annual rates of incident exertional hyponatremia diagnoses peaked in 2010 at 12.7 per 100,000 p-yrs and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. The crude annual rates fluctuated between 2014 and 2019, reaching a high in 2015 (8.6 per 100,000 p-yrs) before decreasing through 2017. Crude annual rates rose again in 2018 and 2019, reaching 7.1 per 100,000 p-yrs in 2019 **(Figure 1)**. During 2004–2019, annual incidence rates of exertional hyponatremia diagnoses were consistently higher in the Marine Corps compared to those in the other services, with the overall trend in rates primarily influenced by the trend among Marine Corps members **(Figure 2)**. Between 2018 and 2019, annual incidence rates increased among Marine Corps, Army, and Air Force members and decreased among members of the Navy **(Figure 2)**.

Exertional hyponatremia by location

During the 16-year surveillance period, exertional hyponatremia cases were diagnosed at the medical treatment facilities of more than 150 U.S. military installations and geographic locations worldwide; however, 15 U.S. installations contributed 20 or more cases each and accounted for 50.3% of the total cases **(Table 2)**. The installation with the most exertional hyponatremia cases overall was the Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC (n=217).

Exertional hyponatremia in Iraq and Afghanistan

From 2008 through 2019, a total of 18 cases of exertional hyponatremia were diagnosed and treated in Iraq and Afghanistan. No new cases were diagnosed in 2019. Deployed service members who were affected by exertional hyponatremia were most frequently male (n=16; 88.9%), non-Hispanic white (n=14; 77.8%), aged 20–24 years (n=8; 44.4%), in the Army (n=13; 72.2%), enlisted (n=15; 83.3%), and in

TABLE 1. Incident cases[a] and incidence rates[b] of exertional hyponatremia, active component, U.S. Armed Forces, 2004–2019

	2019		Total 2004–2019	
	No.	Rate[b]	No.	Rate[b]
Total	94	7.1	1,612	7.4
Sex				
Male	80	7.3	1,350	7.3
Female	14	6.3	262	8.0
Age group (years)				
<20	25	24.0	215	14.5
20–24	15	3.5	498	7.0
25–29	19	6.3	296	5.9
30–34	15	7.3	184	5.6
35–39	7	4.6	183	7.2
40+	13	10.5	236	10.4
Race/ethnicity group				
Non-Hispanic white	53	7.2	1,080	8.2
Non-Hispanic black	15	7.1	197	5.5
Hispanic	14	6.4	169	6.1
Asian/Pacific Islander	7	12.4	72	8.7
Other/unknown	5	5.3	94	6.4
Service				
Army	40	8.5	572	7.0
Navy	7	2.1	248	4.7
Air Force	19	5.8	319	6.0
Marine Corps	28	15.0	473	15.7
Military status				
Recruit	18	62.1	159	35.7
Enlisted	56	5.3	1,116	6.3
Officer	20	8.6	337	9.1
Military occupation				
Combat-specific[c]	13	7.3	270	8.7
Motor transport	1	2.5	33	5.1
Pilot/air crew	3	6.5	51	6.2
Repair/engineering	16	4.1	287	4.5
Communications/intelligence	15	5.3	279	5.8
Healthcare	8	7.0	118	6.3
Other/unknown	38	14.4	574	13.9
Home of record[d]				
Midwest	13	5.6	300	7.4
Northeast	14	8.4	236	8.4
South	42	7.4	690	7.6
West	23	7.4	311	6.4
Other/unknown	2	4.8	75	8.3

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

combat-specific (n=7; 38.9%) or communications/intelligence (n=4; 22.2%) occupations **(data not shown)**. During the entire surveillance period, 7 service members were medically evacuated from Iraq or Afghanistan for exertional hyponatremia **(data not shown)**.

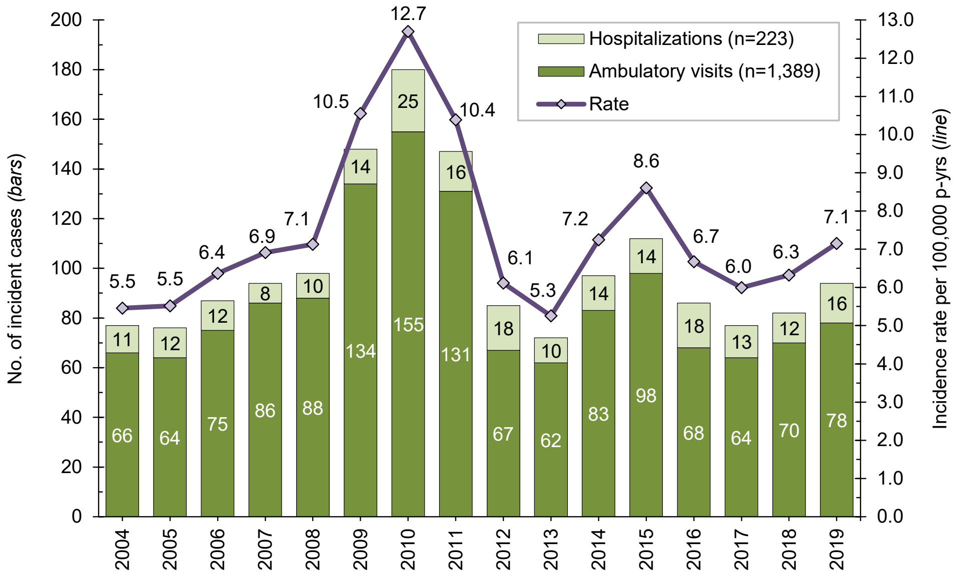
EDITORIAL COMMENT

This report documents that after a period (2015–2017) of decreasing numbers and rates of exertional hyponatremia among active component U.S. military members, numbers and rates of diagnoses increased slightly in 2018 and 2019. Subgroup-specific patterns of overall incidence rates of exertional hyponatremia (e.g., sex, age, race/ethnicity, service, and military status) were generally similar to those reported in previous *MSMR* updates.[14] It is important to note that in *MSMR* analyses before April 2018, in-theater cases were included if there was a diagnosis of hypo-osmolality and/or hyponatremia in any diagnostic position. Beginning in 2018, 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 earlier *MSMR* updates.

Several important limitations should be considered when interpreting the results of this analysis. First, 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. In addition, 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 regarding, and aggressive management of incipient cases by military supervisors and primary healthcare providers.

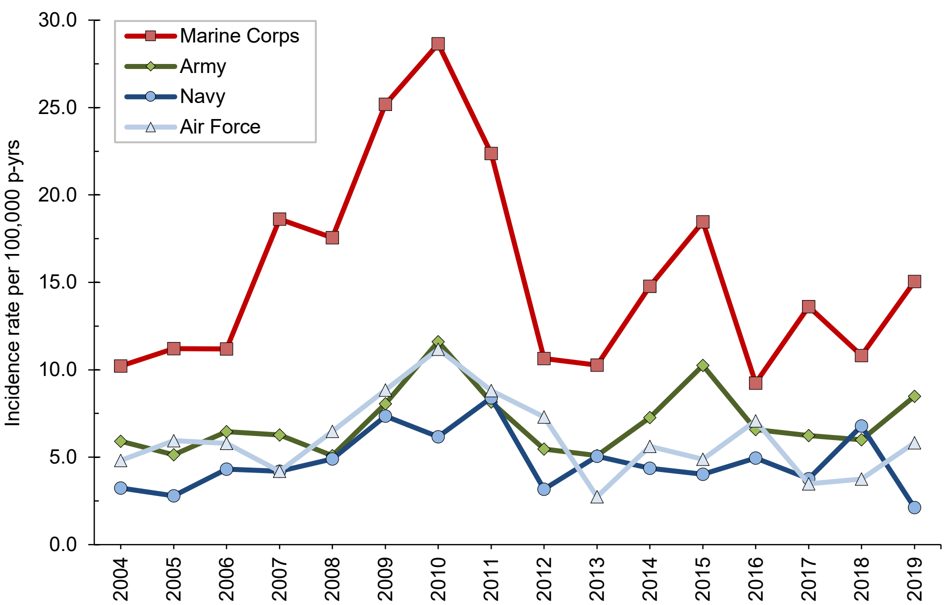
In the past, concerns about hyponatremia resulting from excessive water consumption were focused at training—particularly recruit training—installations. In this analysis, rates were relatively high among the youngest, and hence the most junior service members, and the highest numbers of cases tended to be diagnosed at medical facilities that support

FIGURE 1. Annual incident cases and rates of exertional hyponatremia, active component, U.S. Armed Forces, 2004–2019



No, number; p-yrs, person-years.

FIGURE 2. Annual incidence rates of exertional hyponatremia, by service, active component, U.S. Armed Forces, 2004–2019



P-yrs, person-years.

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 recent prior cases of exertional hyponatremia in the U.S. military, the guidelines for fluid replacement during military training in hot weather were revised and promulgated in 1998.[15–18] The revised guidelines were designed to protect service members from not only heat injury, but also hyponatremia due to excessive water consumption by limiting fluid intake regardless of heat category or work level to no more than 1.5 quarts hourly and 12 quarts daily.[16,17] 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.[19] In 2003, the revised guidelines were included in the multiservice Technical Medical Bulletin 507, Heat Stress Control and Heat Casualty Management that provides guidance to military and civilian healthcare providers, allied medical personnel, and military leadership.[20] A recent study found that this military fluid intake guidance remains valid for preventing excessive dehydration as well as overhydration and can be used by military health professionals and leadership to adequately maintain a normal level of hydration in service members working in the 5 designated flag conditions (levels of heat/humidity stress) while wearing contemporary uniform configurations (including protective gear/equipment) across a range of metabolic rates.[21]

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.[4,8,17,19] In addition to these guidelines, reducing the availability of fluids may help prevent exertional hyponatremia during endurance events.[22,23] 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.[4,8,22–24] Although rare, exercise-related hyponatremia and exertional heat stroke can present simultaneously with symptoms that may be hard to differentiate.[25] Encouraging a “drink-to-thirst” approach while incorporating prevention strategies for heat stroke may help mitigate such rare cases.

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 or load-bearing marches).[9] The finding that the overall incidence of women experiencing exertional hyponatremia was greater than that of men in this analysis is similar to results found among samples of marathon runners in the general population. However, a large study of marathon runners suggested that the apparent sex difference did not remain after

TABLE 2. Incident cases of exertional hyponatremia, by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 2004–2019

Location of diagnosis	No.	% total
MCRD Parris Island/ Beaufort, SC	217	13.5
Fort Benning, GA	114	7.1
JBSA-Lackland AFB, TX	73	4.5
Fort Bragg, NC	53	3.3
Walter Reed NMMC, MD[a]	48	3.0
MCB Camp Lejeune/Cherry Point, NC	46	2.9
MCB Camp Pendleton, CA	38	2.4
MCB Quantico, VA	37	2.3
NMC San Diego, CA	34	2.1
NMC Portsmouth, VA	32	2.0
Fort Campbell, KY	27	1.7
Fort Shafter, HI	26	1.6
Fort Jackson, SC	24	1.5
Fort Hood, TX	21	1.3
Fort Leonard Wood, MO	21	1.3
Other/unknown locations	801	49.7
Total	1,612	100.0

[a]Walter Reed 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 2 sites before the consolidation (Nov 2011) and the number reported at the consolidated location.
No., number; MCRD, Marine Corps Recruit Depot; JBSA, Joint Base San Antonio; AFB, Air Force Base; NMMC; National Military Medical Center; MCB, Marine Corps Base; NMC, Naval Medical Center.

adjustment for body mass index and racing times.[26–28]

In many circumstances (e.g., recruit training and 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 personnel 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 as well as the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, and 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. Finally, the recent validation of the current fluid intake guidance highlights its importance as a resource to leadership in sustaining military readiness.

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 U S A*. 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. March 2017. https://health.mil/Military-Health-Topics/Combat-Support/Armed-Forces-Health-Surveillance-Branch/Epidemiology-and-Analysis/Surveillance-Case-Definitions. Accessed 23 March 2020.
14. Armed Forces Health Surveillance Branch. Update: Exertional hyponatremia, active component, U.S. Armed Forces, 2003–2018. *MSMR*. 2019;26(3):27–31.
15. 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.
16. Department of the Army, Office of the Surgeon General. Memorandum. Policy guidance for fluid replacement during training, dated 29 April 1998.
17. Montain S., Latzka WA, Sawka MN. Fluid replacement recommendations for training in hot weather. *Mil Med*. 1999;164(7):502–508.
18. 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.
19. 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;5(2):2–3,8–9.
20. Headquarters, Department of the Army and Air Force. Technical Bulletin, Medical 507, Air Force Pamphlet, 48–152. Heat Stress Control and Heat Casualty Management. 7 March 2003.
21. Luippold AJ, Charkoudian N, Kenefick RW, et al. Update: Efficacy of military fluid intake guidelines. *Mil Med*. 2018;183(9/10):e338–e342.
22. 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.
23. Thomas DT, Erdman KA, Burke LM. American College of Sports Medicine Joint Position Statement. Nutrition and athletic performance. *Med Sci Sport Exerc*. 2016;48(3):543–568.
24. Nolte HW, Nolte K, Hew-Butler T. Ad libitum water consumption prevents exercise-associated hyponatremia and protects against dehydrations in soldiers performing a 40-km route-march. *Mil Med Res*. 2019;6(1):1.
25. Oh RC, Galer M, Bursey MM. Found in the field—a soldier with heat stroke, exercise-associated hyponatremia, and kidney injury. *Curr Sports Med Rep*. 2018;17(4):123–125.
26. Almond CS, Shin AY, Fortescue EB, et al. Hyponatremia among runners in the Boston Marathon. *N Engl J Med*. 2005;352(15):1550–1556.
27. Ayus JC, Varon J, Arieff AI. Hyponatremia, cerebral edema, and noncardiogenic pulmonary edema in marathon runners. *Ann Intern Med*. 2000;132(9):711–714.
28. Hew TD, Chorley JN, Cianca JC, Divine JG. The incidence, risk factors, and clinical manifestations of hyponatremia in marathon runners. *Clin J Sport Med*. 2003;13(1):41–47.

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). AFHSB is a designated public health authority within the Defense Health Agency. 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 email 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)