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The Military Relevance of Heat illnesses and Their Sequelae

This issue of the *MSMR* provides an annual update on adverse health consequences most often associated with training or operations in environments with high heat and frequent high humidity. Military training and operational environments create a constellation of circumstances that make service members highly susceptible to heat illnesses and the associated morbidities of exertional hyponatremia and exertional rhabdomyolysis.

The mantra "train as you fight" requires that service members be frequently exposed to harsh environmental conditions. During initial recruit training, large amounts of time are spent outdoors, often in high heat—many military training installations are in the Southern U.S., for perennial use. The environmental stresses of heat and humidity introduced at these installations among individuals, encumbered with heavy gear, who may be unconditioned for the duration and intensity of the physical activity required during training, cohere to create the perfect conditions for heat illness.

The first topic of this issue, heat illnesses, focuses on heat exhaustion and heat stroke. These conditions represent 2 different occasions when the body can no longer rid itself of excessive heat generated either from activity or absorbed through the environment. Internal body temperature begins to rise during heat exhaustion, the earlier stage, when affected individuals are generally still aware of their surroundings and can assist in their own care. Heat stroke represents a much more dangerous condition, in which the major organ system begin to fail from heat overload. Heat stroke is clinically characterized by an alteration of consciousness, typically stupor, delirium, lethargy, or unconsciousness. Mortality is a serious risk with heat stroke, and immediate action to cool the body is urgently required.

The topic of this issue's second and third articles, exertional rhabdomyolysis and exertional hyponatremia, are both commonly associated with heat illness, but represent organ damage (rhabdomyolysis) or unintended side effects from overaggressive rehydration (hyponatremia). Both conditions can result in rapid physical and mental deterioration. Death may result if symptoms are not promptly recognized and treated. While both rhabdomyolysis and hyponatremia have many non-heat-related causes, this issue deals exclusively with cases associated with high levels of exertion.

These consequences can generally be mitigated, if not fully prevented, by careful environmental risk assessment, implementation of appropriate heat countermeasures, and decisive medical support. Increased awareness by leaders and medical staff of the importance of being alert to the health risks inherent to operations in a high heat environment, especially for service members who are deconditioned or compelled to the limits of their physical endurance, is a critical part of effective prevention approaches. Leaders, as part of their risk assessments, must balance mitigation efforts against the requirements of their operations or training activities.

The most effective countermeasures against heat illness include restricting activity to early morning or evening hours when environmental heat is lower; adherence to work and rest cycles based upon current heat conditions; removal or modification of gear to facilitate heat loss; maintenance of proper hydration levels; maximized physical fitness; and gradual acclimatization to the local heat environment.

Update

Heat Exhaustion and Heat Stroke Among Active Component Members of the U.S. Armed Forces, 2019-2023

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The most serious types of heat illnesses, heat exhaustion and heat stroke, are occupational hazards associated with many of the military's training and operational environments. These illnesses can typically be prevented by appropriate situational awareness, risk management strategies, along with effective countermeasures. In 2023, the crude incidence of heat stroke and heat exhaustion were 31.7 and 172.7 cases per 100,000 person-years, respectively. The rates of incident heat stroke declined during the 2019 to 2023 surveillance period, but rates of incident heat exhaustion increased over the same period. In 2023, higher rates of heat stroke were observed among male service members compared to their female counterparts, and female service members experienced higher rates of heat exhaustion compared to male personnel. Heat illness rates were also higher among those younger than age 20, Marine Corps and Army service members, non-Hispanic Black service members, and recruits. Leaders, training cadres, and supporting medical and safety personnel must inform their subordinate and supported service members of heat illness risks, preventive measures, early signs and symptoms of illness, and appropriate interventions.

What are the new findings?

From 2019 to 2023, the crude annual incidence rate of heat stroke decreased 15.6%, while the crude annual incidence rate of heat exhaustion increased by 4.6% during the same period. The observed decrease in heat stroke coincident with observed increase in heat exhaustion may demonstrate evidence of successful awareness and prevention efforts emphasizing recognition of the early signs and symptoms of less severe heat illness, which resulted in avoidance of more severe illness such as heat stroke. This is the first heat illness surveillance report that includes U.S. Coast Guard and Space Force data. Consequently, a comparison of the crude annual rates for 2019-2023 in this report are not directly comparable to those published in previous reports.

What is the impact on readiness and force health protection?

Many factors inherent to military training and operational environments can increase risk of heat illness: environmental factors (e.g., heat and humidity), occupational factors (e.g., strenuous activity and intense training), and personal factors (e.g., highly motivated individuals and populations). Despite these risks, heat illness incidence and severity can be reduced by implementing and enforcing appropriate countermeasures. Units that fail to implement heat illness mitigation measures risk impeding or interrupting training programs, resulting in otherwise preventable reductions in operational tempo or critical mission failure due to lost personnel and resources.

Heat illnesses, which can drastically affect both individual and unit readiness, continue to contribute significantly to annual morbidity within the active component of the U.S. Armed Forces. Heat illness refers to a group of disorders that result from a disruption of thermoregulation due to heat stress caused by environmental heat exposure, high energy expenditure (i.e., metabolic heat production), or a combination of both factors.[1-4] Metabolic heat production increases during prolonged engagement in strenuous physical activity, and additional exposure to environmental heat stress elevates core and skin temperatures.[2,3] Documented measures to reduce the risk of heat illnesses include, but are not limited to, electrolyte intake, adherence to fluid replacement and work-rest guidelines, and body cooling methods (e.g., arm immersion cooling systems).[3,5] Identifying high-risk service members, such as those who are unacclimatized, taking certain medications (e.g., antihistamines, tricyclic antidepressants, ADHD medication, beta-blocker antihypertensives), have low physical fitness, or were previously diagnosed with heat illness, is also critical in reducing morbidity due to heat illnesses.[3]

Heat illness occurs within a continuum of severity, from less severe (e.g., heat cramps, rash, edema, and syncope), then to heat exhaustion, followed by potentially life-threatening (e.g., heat stroke). Heat exhaustion and heat stroke are reportable medical events (RMEs) in the U.S. Military Health System (MHS). All occurrences that require medical intervention or result in change of duty status must be reported.[6]

Specific signs and symptoms that characterize heat illnesses allow initial recognition of their occurrence in the field and subsequent identification of a heat illness that should be reported. A confirmed case of heat exhaustion must fulfill 3 conditions, during or immediately following exertion or heat exposure: 1) evidence of elevated core body temperature (not greater than 104°F/40°C), 2) short-term physical collapse or debilitation, with 3) no significant central nervous system dysfunction.[7]

Acute dehydration often accompanies heat exhaustion but is not required for diagnosis.[8] If any central nervous system dysfunction develops (e.g., dizziness or headache), it should be mild and rapidly resolve with rest and cooling measures, otherwise the patient may be experiencing a heat stroke.[7,8]

Heat stroke is a debilitating and potentially life-threatening condition characterized by severe hyperthermia. During a period of heat exposure or exertion, a probable case of heat stroke requires 1) evidence of elevated core body temperature and 2) central nervous system dysfunction (e.g., change in mental status, delirium, stupor, loss of consciousness, or coma). A confirmed case of heat stroke requires verification and documentation of a core body temperature of 104°F/40°C or greater with central nervous system dysfunction.[8,9] The onset of heat stroke should prompt aggressive intervention featuring rapid cooling (e.g., iced sheets) and supportive therapy such as fluid replacement only when previous fluid intake can be confirmed, to avoid water intoxication (i.e., hyponatremia).[8-10] Multiple organ failure is the ultimate cause of mortality from heat stroke.[9]

Ongoing surveillance of heat illnesses is necessary to determine if prevention guidelines and countermeasures are working, in addition to identifying high-risk groups and activities that may lead to heat illness. Since 2001 the *MSMR* has published regular updates on the incidence of heat illness among U.S. active component service members (ACSMs). This update presents summaries of heat stroke and heat exhaustion case counts, incidence rates, and locations between 2019 and 2023.

Methods

The surveillance population for this analysis includes all individuals who served in the active component of the Army, Navy, Marine Corps, Air Force, Space Force, or Coast Guard at any time during the surveillance period of January 1, 2019 through December 31, 2023. Space Force data are only complete for 2023.

All data used to determine incident heat illness diagnoses were derived from 4 sources: MHS Management, Analysis and Reporting Tool (M2), Defense Medical Surveillance System (DMSS), Disease Reporting System internet (DRSi), and Theater Medical Data Store (TMDS). Heat illness cases were identified using specific diagnostic codes from the ambulatory care encounters and hospitalizations of ACSMs in fixed military and civilian (if reimbursed through the MHS) hospitals and clinics worldwide. In addition to medical encounter data, heat illness medical event reports were identified in DRSi, including information on hospitalization status (yes/no). If a heat illness was reported in DRSi, but not found in the medical record, the case was still counted. For example, an individual could be treated in the field by a medic for mild or non-life-threatening heat illness without a recorded medical encounter, but the case is deemed a reportable heat exhaustion because of symptoms observed in the field.

In this update, a case of heat illness was defined as an individual with 1) a hospitalization or outpatient medical encounter record with a primary (first-listed) or secondary (second-listed) diagnosis of heat stroke (International Classification of Diseases, 9th Revision [ICD-9]: 992.0; ICD, 10th Revision: T67.0*) or heat exhaustion (ICD-9: 992.3–992.5; ICD-10: T67.3*–T67.5*) or 2) a RME record of heat exhaustion or heat stroke.[11] The asterisk denotes that all subsequent digits or characters noted in the diagnostic code were included in the identification of ICD-10 codes (e.g., T67.3XXA).

An individual was considered a case of heat illness only once per calendar year. If a service member had diagnoses for both heat stroke and heat exhaustion during a given year, the more severe diagnosis (heat stroke) was selected. If a service member had inpatient and outpatient encounters for heat stroke or heat exhaustion, the inpatient encounter was prioritized over the outpatient visit, when identifying hospitalized cases. Within a calendar year, if an individual had a diagnostic code that denoted a subsequent encounter (i.e., ICD-10 7th digit equal to "D") or an encounter for sequelae (i.e., ICD-10 7th digit equal to "S"), but had no diagnostic codes indicating an initial visit (i.e., ICD-10 7th digit equal to "A"), the case was removed to avoid over-estimating heat illness cases by including those receiving follow-up care.

For health surveillance purposes, recruits were identified as ACSMs assigned to service-specific training locations and basic training periods using an algorithm based on age, rank, and time in service. Recruits were considered a separate category of enlisted service members in summaries of heat illnesses by military grade. In summaries of heat illness by location, the Defense Medical Information System Identifier (DMIS ID) was utilized to determine the installation or geographic location of diagnosis and medical treatment. Heat illness cases from the U.S. Central Command (CENTCOM) area of responsibility (AOR) were reported separately and identified with specific combatant command or country codes.

In-theater diagnoses of heat illness were identified from medical records of deployed service members whose health care encounters were documented in TMDS, and the same case-defining criteria and incidence rules described previously were applied to those encounters. Evacuations were identified if the service member had a follow-up inpatient encounter in a permanent military hospital or clinic in the U.S. or Europe, from 5 days preceding until 10 days following their heat illness event.

Incidence rates were calculated as incident cases of heat illness per 100,000 ACSM person-years (p-years). Percent change in incidence was calculated using unrounded rates. Because reporting heat exhaustion and heat stroke cases is required, the proportion of outpatient and inpatient cases that also had a report in DRSi was calculated.[4]

Results

In 2023, the MHS reported 415 cases of heat stroke, resulting in a crude incidence rate of 31.7 cases per 100,000 p-yrs **(Table 1)**. Subgroup-specific incidence rates of heat stroke were highest among men, those younger than age 20, non-Hispanic Black service members, Marine Corps and Army personnel, recruits, and those in combat-specific occupations.

TABLE 1. Incident Cases[a] and Incidence Rates[b] of Heat Illness, Active Component, U.S. Armed Forces, 2023

	Heat Stroke		Heat Exhaustion		Total Heat Illness Diagnoses	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	415	31.7	2,263	172.7	2,678	204.4
Sex						
Male	361	33.4	1,790	165.8	2,151	199.2
Female	54	23.4	473	205.2	527	228.7
Age group, y						
<20	59	72.2	623	762.7	682	834.9
20–24	191	47.7	936	233.7	1,127	281.4
25–29	101	32.9	399	130.0	500	162.9
30–34	40	18.4	179	82.3	219	100.6
35–39	19	11.3	83	49.4	102	60.8
40+	5	3.7	43	31.8	48	35.5
Race and ethnicity						
White, non-Hispanic	224	32.4	1,143	165.3	1,367	197.7
Black, non-Hispanic or African American	74	35.6	394	189.4	468	224.9
Hispanic or Latino	63	25.2	459	183.3	522	208.4
Other/unknown[c]	54	33.7	267	166.7	321	200.4
Service						
Army	243	54.2	1,232	274.6	1,475	328.8
Navy	34	10.3	173	52.7	207	63.0
Air Force	22	7.0	363	115.0	385	121.9
Marine Corps	113	66.5	481	283.2	594	349.7
Space Force	0	-	8	93.6	8	93.6
Coast Guard	3	7.7	6	15.5	9	23.2
Military status						
Recruit trainees	33	391.3	625	7,411.9	658	7,803.2
Enlisted	306	28.9	1,429	135.1	1,735	164.0
Officer	76	31.2	209	85.7	285	116.9
Military occupation						
Combat-specific[d]	152	91.1	476	285.3	628	376.4
Motor transport	12	27.5	41	93.9	53	121.4
Pilot/air crew	4	8.8	9	19.7	13	28.4
Repair/engineering	21	5.7	124	33.4	145	39.1
Communications/intelligence	10	3.6	23	8.2	33	11.8
Health care	20	18.9	75	71.0	95	89.9
Other/unknown	196	65.7	1,515	507.6	1,711	573.3

Abbreviations: No., number; y, years.
[a] One case per person per calendar year.
[b] Rate per 100,000 person-years.
[c] Includes those of American Indian/Alaskan Native, Asian, Native Hawaiian/Pacific Islander, and unknown race and ethnicity.
[d] Infantry/artillery/combat engineering/armor.

The crude annual incidence rate of heat stroke decreased 15.6% **(Figure 1)** from 2019 through 2023, with a 5.9% decline from 2022 to 2023. Meanwhile, the proportion of heat stroke cases that were hospitalized increased from 36.9% in 2022 to 40.2% in 2023. Of all inpatient heat stroke cases, 71.3% were reported to DRSi, while just over half (54.8%) of outpatient heat stroke cases had a medical event report in DRSi.

The 2,263 cases of heat exhaustion in 2023 correspond to a crude incidence rate of 172.7 cases per 100,000 p-yrs **(Table 1)**. Unlike heat stroke, where higher rates were observed among male service members, the rate of heat exhaustion was 24% higher among female service members. Similar to heat stroke, with the exception of the difference in rates by sex, higher rates of heat exhaustion were noted for personnel younger than age 20, non-Hispanic Black service members, Marine Corps and Army personnel, and recruits. The incidence rate of heat exhaustion among recruits was 12.5 and 13.5 times higher than other enlisted service members and officers, respectively.

Between 2019 and 2023, the crude annual incidence rate of heat exhaustion increased 4.6%, including an 8.0% increase from 2022 to 2023 **(Figure 2)**. The proportion of heat exhaustion cases that were hospitalized also increased from 2022 (2.8%) to 2023 (6.0%). Over three-quarters of the inpatient heat exhaustion cases (77.3%) were reported in DRSi, while only 38.0% of outpatient heat exhaustion cases had a medical event report in DRSi.

Heat illnesses by location

During the 5-year surveillance period, 12,488 heat illnesses were diagnosed at more than 250 military installations and geographic locations worldwide **(Table 2)**. Of these heat illness cases, 5.8% occurred outside the U.S., including 282 in Okinawa, Japan. Between 2019 and 2023, 21 locations reported at least 100 cases of heat illness, and those locations accounted for over three-quarters (77.5%) of all active component cases. Three Army installations: Fort Moore, GA; Fort Liberty, NC; Ft Campbell, KY, and 2 Marine Corps bases, MCB Camp Lejeune/Cherry Point, NC, and MCRD Parris Island/Beaufort, SC, accounted for 40.4% of the total heat illnesses during the surveillance period. Of the 21 locations with at least 100 cases of heat illness, 13 are in the southern U.S.

Heat illnesses in CENTCOM AOR

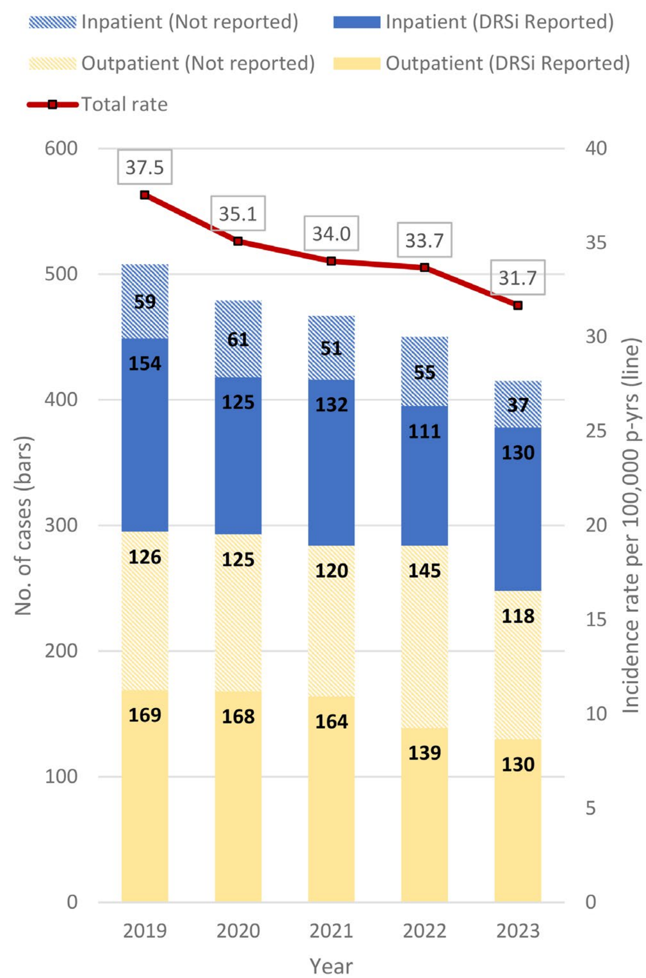
During the 5-year surveillance period, there were 258 cases of heat illness in the CENTCOM AOR **(Figure 3)**. Of the cases of heat illness, 7.0% (n=18) were heat stroke. Cases of heat illness occurred most frequently among deployed service members who were male (n=194, 75.2%), 20-24 years old (n=125, 48.4%) and in the Army (n=86, 33.3%) or Navy (n=85, 32.9%) (data not shown). During the surveillance period, 3 service members were medically evacuated for heat illnesses from the CENTCOM AOR: 1 evacuation occurred in November 2020, 1 in August 2022, and 1 in July 2023 (data not shown).

Discussion

Over the 5-year surveillance period, the rate of heat stroke decreased annually from 2019 to 2023, while the rate of heat exhaustion dropped in 2020 compared to 2019 and then increased annually from 2021 to 2023. Between 2022 and 2023, the increase in the heat exhaustion rate (8.0% rate increase) was greater than the decrease in the heat stroke rate (5.9% rate decrease). While the reason for the observed decrease in heat stroke and observed increase in heat exhaustion is unknown, current heat illness prevention guidelines emphasize education about the signs, symptoms, and management of heat casualties, with the goal of preventing more severe heat illness (i.e., heat stroke).[3,5,12] Earlier recognition of what constitutes a heat illness may increase the likelihood of identifying a case of heat exhaustion.[13]

While the required reporting of inpatient cases for both heat stroke and heat exhaustion is more complete than outpatient case reporting, which is also required, the proportion of all cases reported to DRSi remained about 40%, on average, throughout the 5-year reporting period. It is possible

FIGURE 1. Incident Cases[a] and Incidence Rates of Heat Stroke, by Encounter Type and Year of Diagnosis, Active Component, U.S. Armed Forces, 2019–2023



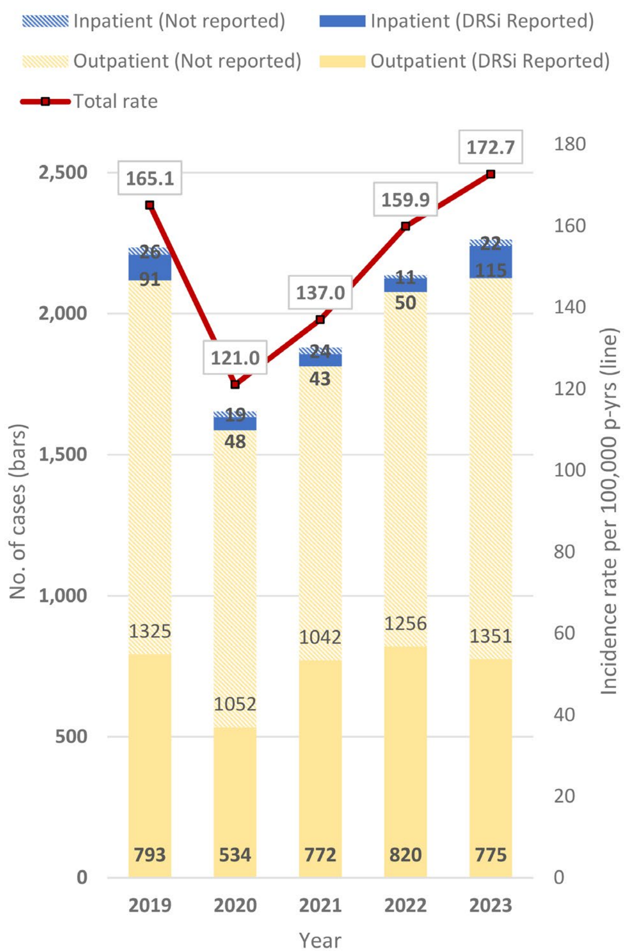
Abbreviations: No., number; p-yrs, person-years; DRSi, Disease Reporting System internet.
[a] Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; inpatient visit > outpatient visit). Reported denotes case was reported to DRSi. Not reported denotes case was not reported to DRSi.

that treatment providers are unaware of the reporting criteria, which provides opportunities to improve providers' awareness of DRSi as the system of record for DOD RMEs and the specific requirements for reporting heat illnesses. Additionally, the diagnosis and diagnostic coding of similar heat-related clinical illnesses can be subjective and subject to errors, and clinical definitions for heat stroke and heat illness differ somewhat from surveillance definitions.[14]

This report includes data from the Coast Guard and Space Force active components for the first time. While the personnel in these services represent a combined average of about 3-4% of the ACSM population in the U.S. Armed Forces, they account for less than 1% of heat illness cases. The inclusion of Coast Guard and Space Force personnel may have a slight dampening effect on heat illness rates when reviewing U.S. Armed Forces rates in prior *MSMR* reports; comparing heat illness rates presented in this report to those in previous *MSMR* reports is not advised.

There are limitations to this update that should be considered when interpreting its findings. Although heat illnesses were summarized by the location of diagnosis or report, medical care may not occur at the same location (i.e., installation) as the heat illness event, particularly if the case required a level of care not available locally. To account for locations with significant

FIGURE 2. Incident Cases[a] and Incidence Rates of Heat Exhaustion, by Encounter Type and Year of Diagnosis, Active Component, U.S. Armed Forces, 2019–2023



Abbreviations: No., number; p-yrs, person-years; DRSi, Disease Reporting System internet.
[a] Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; inpatient > outpatient visits). Reported denotes case was reported to DRSi. Not reported denotes case was not reported to DRSi.

TABLE 2. Heat Illness Events[a] by Location of Diagnosis or Report (with minimum 100 cases during the period), Active Component, U.S. Armed Forces, 2019–2023

Location of Diagnosis	No.	% Total
Fort Moore, GA	2,072	16.6
MCB Camp Lejeune/ Cherry Point, NC	941	7.5
Fort Liberty, NC	817	6.5
Fort Campbell, KY	630	5.0
MCRD Parris Island,SC	589	4.7
JB San Antonio, TX	580	4.6
Fort Johnson, LA	500	4.0
MCRD San Diego/ NB San Diego, CA	491	3.9
Fort Cavazos, TX	456	3.7
MCB Camp Pendleton, CA	391	3.1
MCB Quantico, VA	322	2.6
Fort Jackson, SC	314	2.5
Fort Sill, OK	282	2.3
Okinawa, Japan	282	2.3
Twentynine Palms, CA	186	1.5
Fort Stewart, GA	163	1.3
Fort Irwin, CA	159	1.3
Fort Shafter, HI	157	1.3
Fort Leonard Wood, MO	145	1.2
Fort Riley, KS	104	0.8
Fort Bliss, TX	101	0.8
Outside U.S.[b]	446	3.6
All other locations	2,359	18.9
Total	12,488	100.0

Abbreviations: No., number; MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NB, Naval Base; NH, Naval Hospital; JB, Joint Base.
[a] One heat illness per person per year.
[b] Excluding Okinawa, Japan.

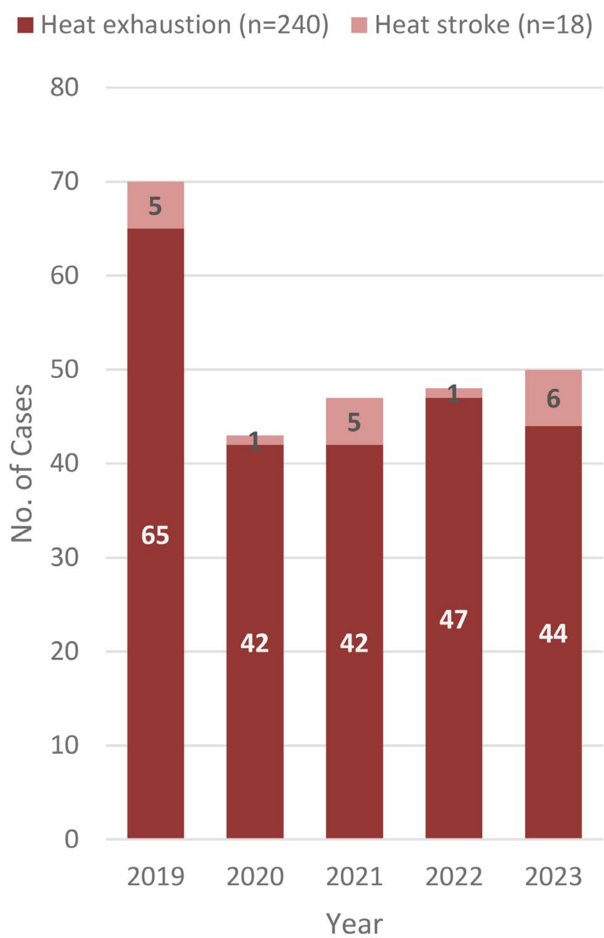
Note: Initial entry recruit training locations include Fort Jackson, Fort Leonard Wood, Fort Moore, Fort Sill, MCRD Parris Island, MCRD San Diego/ NB San Diego, and JB San Antonio. Fort Johnson is the Joint Readiness Training Center (JRTC) and Fort Irwin is the National Training Center (NTC).

medical care redundancy, some installations were combined (e.g., MCB Camp Lejeune/Cherry Point, NC, in **Table 2**); this merging of locations was most prevalent with Marine Corps and Navy locations.

The method used to identify recruits likely resulted in some misclassification of recruit training status. The algorithm did not account for the additional training time in the Army's One Station Unit Training beyond the traditional basic combat training period. In addition, there was likely incomplete capture of heat illnesses treated in the field during training and deployments, rather than at a fixed military hospital or clinic; this may be particularly true for heat exhaustion cases when symptoms rapidly resolve after a period of rest. Finally, military hospitals and clinics transitioned to MHS GENESIS in waves from February 2017 to March 2024, and the reliability and completeness of MHS GENESIS data are still being evaluated. Gaps in diagnosis codes have been identified, which may result in clinical event under-reporting through medical encounter data.

Maintaining regular heat illness surveillance helps identify the magnitude of the impact these conditions have on service member health, training, and force readiness. At the command and unit level, emphasis on evidence-based prevention, mitigation and risk management, with continued education on the signs, symptoms, and early field interventions for heat illness, are crucial steps in reducing the impact of heat illness morbidity on the force. To ensure protection throughout the force, DOD standards, policies, or procedures should determine the prevention, mitigation, and management of heat illnesses.

FIGURE 3. Incident Cases of Heat Illnesses in the CENTCOM AOR, Active Component, U.S. Armed Forces, 2019–2023



Abbreviations: CENTCOM AOR, U.S. Central Command area of responsibility; No., number.

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Disclaimer

The views expressed in this presentation are those of the authors and do not necessarily reflect the official policy of the Department of Defense, Defense Health Agency, nor the U.S. Government.

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Update

Exertional Rhabdomyolysis Among Active Component Members of the U.S. Armed Forces, 2019–2023

A largely preventable condition, exertional rhabdomyolysis persists as an occupational hazard of military training and operations, especially in high heat environments among individuals exerting themselves to their physical endurance limits. During the 5-year surveillance period of this study, unadjusted incidence rates of exertional rhabdomyolysis per 100,000 person-years among U.S. active component service members fluctuated, reaching a low of 38.0 cases in 2020 and peaking at 40.5 cases in 2023. The rate in 2020 constituted a decline of 3.8% from the rate in 2019 (39.5 cases). Beginning in 2020, incidence rates per 100,000 person-years gradually increased, by 1.8% in 2021 (38.7 cases), 5.3% in 2022 (40.0 cases), and 6.6% in 2023 (40.5 cases). Consistent with prior reports, subgroup-specific crude rates in 2023 were highest among men, those less than 20 years old, non-Hispanic Black service members, Marine Corps or Army members, and those in combat-specific and 'other' occupations. Recruits experienced the highest rates of exertional rhabdomyolysis during each year, with incidence rates 6 to 10 times greater than all other service members.

What are the new findings?

The 529 reported incident cases of exertional rhabdomyolysis among active component U.S. service members in 2023 represent an unadjusted annual incidence rate of 40.5 cases per 100,000 person-years, the highest rate observed during this study's 2019–2023 surveillance period. This increase in crude incidence rates was most noticeable in the Marine Corps, which reported a 10.5% rise in 2023, from the previous year. The rates in the Army remained steady for the last 2 years of the surveillance period, but have increased by 26.9% from 2019. This year's report includes exertional rhabdomyolysis rates for the Coast Guard.

What is the impact on readiness and force health protection?

Service members who experience exertional rhabdomyolysis may be at risk for recurrence, which could limit their military effectiveness and potentially predispose them to serious injury. The risk of exertional rhabdomyolysis can be reduced through prompt recognition of its symptoms by commanders, informed by awareness of environmental conditions, cognizance of troop fitness levels, emphasis on graded, individual preconditioning prior to more strenuous training, and adherence to recommended work and rest ratios featuring appropriate hydration schedules, especially in hot, humid weather.

Initiation of high-intensity physical activity at unaccustomed intensity or duration, particularly under heat stress, increases the risk of exertional rhabdomyolysis.[1] A potentially serious condition, exertional rhabdomyolysis requires vigilance for early diagnosis and aggressive treatment to prevent severe consequences.

Rhabdomyolysis is characterized by the breakdown of skeletal muscle cells and leakage of intracellular contents (myoglobin, sarcoplasmic proteins, and electrolytes) into the extracellular fluid and the circulatory system. Myoglobin is toxic to the tubular cells of the kidney and can lead to renal failure. Rhabdomyolysis severity ranges from asymptomatic or mild elevation of serum muscle enzyme levels to life-threatening conditions due to electrolyte imbalances, acute kidney failure, disseminated intravascular coagulation, compartment syndrome, cardiac arrhythmia, and liver dysfunction.[1-4]

The characteristic triad of rhabdomyolysis symptoms are muscle pain, weakness and red to brown colored urine due to high levels of myoglobin, although over half of patients do not have all of these specific symptoms.[5] The standard diagnostic criteria for exertional rhabdomyolysis are elevated serum creatine phosphokinase (CPK) levels indicating myonecrosis (usually defined as CPK level of at least 5 times the upper limit of normal) following recent exercise.[2,3,6]

Exertional rhabdomyolysis is most commonly identified among new recruits at recruit training and combat installations during the first 90 days of basic training,[7,8] but can also be observed in athletes accustomed to intense training,[9] particularly when they extend themselves to endurance limits.[10] A history of heat illness and prior heat stroke have also been described as significant risk factors for recruits who sustained rhabdomyolysis,[8,11] revealing the potential for comorbid conditions.

MSMR annually summarizes the numbers, rates, trends, risk factors, and locations of exertional heat injury occurrences including exertional rhabdomyolysis. This report assesses Military Heath System (MHS) data from 2019 through 2023. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of *MSMR*.[7]

Methods

The surveillance period ranged from January 2019 through December 2023 and included all individuals who served in the active components of the Army, Navy, Air Force, Marine Corps, Coast Guard, and Space Force (which was assigned to the Air Force for analysis purposes). 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 MHS) hospitals and clinics worldwide. In-theater diagnoses of exertional rhabdomyolysis were identified from medical records of service members deployed to Southwest Asia and the Middle East whose health care encounters were documented in the Theater Medical Data Store.

A case of exertional rhabdomyolysis was defined as an individual with International Classification of Diseases, 9th and 10 revisions (ICD-9/ICD-10) diagnostic codes in any position indicating a hospitalization or outpatient medical encounter with either "rhabdomyolysis" or "myoglobinuria," with a diagnosis in any position of 1 of the following: "volume depletion (dehydration)," "effects of heat and light," "effects of thirst (deprivation of water)," "exhaustion due to exposure," or "exhaustion due to excessive exertion (overexertion)"[12] **(Table 1)**. Each individual could be considered an incident case of exertional rhabdomyolysis only once per calendar year.

Cases of rhabdomyolysis associated with trauma, intoxication, and adverse drug reactions were excluded.[6] For health surveillance purposes, recruits were identified as active component members assigned to service-specific training locations during coincident service-specific basic training periods. Recruits were considered a separate category of enlisted service members in summaries of exertional rhabdomyolysis by military grade overall.

In-theater diagnoses of exertional rhabdomyolysis were analyzed separately using the same case-defining criteria and incidence rules that identified incident cases at fixed treatment facilities. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Southwest Asia, Middle East) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if affected service members met the aforementioned criteria in a permanent military medical facility in the U.S. or Europe from 5 days preceding until 10 days following their evacuation dates.

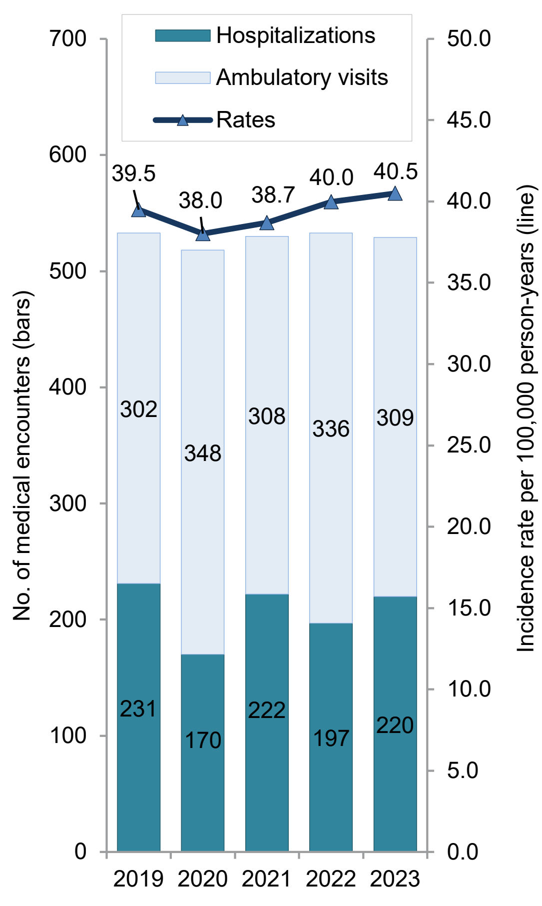
TABLE 1. ICD-9 and ICD-10 Diagnostic Codes Utilized to Define Cases of Exertional Rhabdomyolysis

Primary condition	ICD-9[a]	ICD-10[a]
Rhabdomyolysis	728.88	M62.82
Myoglobinuria	791.3	R82.1
Associated conditions	ICD-9[a]	ICD-10[a]
Volume depletion (dehydration)	276.5*	E86.0, E86.1, E86.9
Effects of heat and light	992.0-992.9	T67.0*-T67.9*
Effects of thirst (deprivation of water)	994.3	T73.1*
Exhaustion due to exposure	994.4	T73.2*
Exhaustion due to excessive exertion (overexertion)	994.5	T73.3*

Abbreviation: ICD, International Classification of Diseases, 9th and 10th revisions.

[a]An asterisk (*) indicates that any subsequent digit or character is included.

FIGURE 1. Incident Cases and Incidence Rates of Extertional Rhabdomyolysis, by Source of Report and Year of Diagnosis, Active Component, U.S. Armed Forces, 2019–2023



Results

In 2023, there were 529 cases of rhabdomyolysis likely associated with physical exertion or heat stress (i.e., exertional rhabdomyolysis), with 41.6% (n=220) resulting in hospitalization **(Table 2)**. Consistent with prior annual reports, crude incidence rates remained highest among men, those younger than 20 years old, non-Hispanic Black service members, Marine Corps or Army members, and those in 'other' and combat-specific occupations. Recruits continued to present the highest rates of exertional rhabdomyolysis in 2023, at a rate of over 12 times greater than officers and other enlisted service members.

During the 5-year surveillance period, total crude incidence rates of exertional rhabdomyolysis per 100,000 person-years (p-yrs) among U.S. active component service members (ACSMs) fluctuated from a low of 38.0 cases in 2020 and high of 40.5 cases in 2023. The rate in 2020 constituted a decline of 3.8% from the 2019 rate (39.5 cases). Beginning in 2020, however, the total crude incidence rates per 100,000 p-yrs began gradually increasing: 1.8% in 2021 (38.7 cases), 5.3% in 2022 (40.0 cases), and 6.6% in 2023 (40.5 cases) **(Figure 1)**.

The military service branch with the highest rate was the Marine Corps, at 94.7 cases per 100,000 p-yrs, followed by the Army, at 61.4; Air Force, at 16.7; Coast Guard, at 12.9; with the lowest rate observed in the Navy, at 10.7 cases per 100,000 p-yrs **(Figure 2)**. Significant variability was observed within services. The Marine Corps displayed wide fluctuations, with a notable increase of 10.5% in 2023 compared to 2022. Trends in the Army showed more consistency, steadily increasing from 48.4 cases in 2019 to 61.4 cases per 100,000 p-yrs in both 2022 and 2023, representing a 26.9% increase over the 5-year period. Rates in the Air Force, Navy, and Coast Guard generally remained all below 20 cases per 100,000 p-yrs, albeit with occasional greater annual fluctuations in range.

Hospitalization rates were lowest in 2020, at 32.8%, with an average of 39.4% over the 5-year period **(Figure 1)**. From 2019 to 2023, approximately three-quarters (74.8%) of cases occurred during the warmer months (i.e., April through September) **(Figure 3)**.

TABLE 2. Incident Cases[a] and Incidence Rates[b] of Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2023

	Hospitalizations		Ambulatory visits		Total	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	220	16.8	309	23.7	529	40.5
Gender						
Male	209	19.4	286	26.6	495	46.0
Female	11	4.8	23	10.0	34	14.8
Age group, y						
<20	34	22.8	87	58.3	121	81.1
20–24	77	23.3	92	27.9	169	51.2
25–29	60	19.6	78	25.4	138	45.0
30–34	33	15.2	37	17.0	70	32.2
35–39	7	4.2	10	6.0	17	10.1
40+	9	6.7	5	3.7	14	10.4
Race and ethnicity						
White, non-Hispanic	105	15.2	149	21.6	254	36.8
Black, non-Hispanic	55	26.5	66	31.8	121	58.4
Hispanic	34	13.6	67	26.8	101	40.4
Other/unknown	26	16.3	27	16.9	53	33.2
Service						
Army	129	28.8	146	32.6	275	61.4
Navy	16	4.9	19	5.8	35	10.7
Air Force	28	8.7	26	8.0	54	16.7
Marine Corps	45	26.6	115	68.1	160	94.7
Coast Guard	2	5.2	3	7.7	5	12.9
Military status						
Enlisted	167	16.1	191	18.4	358	34.4
Officer	24	9.8	49	20.1	73	29.9
Recruit	29	124.6	69	296.4	98	421.0
Military occupation						
Combat-specific[c]	70	42.0	85	51.0	155	92.9
Motor transport	8	18.4	5	11.5	13	29.9
Pilot/air crew	2	4.4	0	0.0	2	4.4
Repair/engineering	22	5.9	32	8.6	54	14.6
Communications/intelligence	36	12.9	42	15.1	78	28.0
Health care	19	18.0	9	8.5	28	26.5
Other	63	21.3	136	46.0	199	67.4
Home of record						
Midwest	26	12.7	49	24.0	75	36.8
Northeast	26	16.5	43	27.4	69	43.9
South	111	19.7	147	26.1	258	45.8
West	48	15.9	58	19.2	106	35.1
Other/unknown	9	11.3	12	15.1	21	26.4

Abbreviation: No., number; y, years.

[a] One case per person per year.

[b] Rate per 100,000 person-years.

[c] Infantry/artillary/combat engineering/armor.

Rhabdomyolysis by location

During the 5-year surveillance period, 12 installations reported at least 50 cases each; when combined, these installations diagnosed more than half (56.3%) of all cases **(Table 3)**. Four of those 12 installations support recruit or basic combat training centers: Marine Corps Recruit Depot (MCRD) Parris Island, SC; Fort Moore, GA; Joint Base San Antonio-Lackland, TX; and Fort Leonard Wood, MO; while 6 of those installations support large combat troop populations: Fort Liberty, NC;

TABLE 3. Incident Cases of Exertional Rhabdomyolysis by Installation (with at least 20 cases during the period), Active Component, U.S. Armed Forces, 2019–2023

Location of Diagnosis	No.	% total
Fort Liberty, NC	288	10.9
MCRD Parris Island, SC	248	9.4
Fort Moore, GA	199	7.5
Camp Lejeune/Cherry Point, NC	134	5.1
Camp Pendleton, CA	99	3.7
Fort Campbell, KY	92	3.5
Fort Cavazos, TX	84	3.2
JBSA-Lackland AFB, TX	78	3.0
NMC San Diego, CA	77	2.9
Fort Shafter, HI	75	2.8
Fort Leonard Wood, MO	64	2.4
MCB Quantico, VA	50	1.9
Fort Johnson, LA	48	1.8
Fort Carson, CO	48	1.8
Fort Bliss, TX	44	1.7
NH Okinawa, Japan	38	1.4
NH Twentynine Palms, CA	33	1.2
Fort Belvoir, VA	31	1.2
NMC Portsmouth, VA	26	1.0
Fort Eisenhower, GA	22	0.8
Fort Riley, KS	21	0.8
Other/Unknown locations	844	31.9
Total	2,643	100.0

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

MCB Camp Lejeune/Cherry Point, NC; Marine Corps Base (MCB) Camp Pendleton, CA; Fort Cavazos, TX; Fort Shafter, HI; and Fort Campbell, KY. From 2019 to 2023, MCRD Parris Island and Fort Liberty together accounted for about one-fifth (20.3%) of all cases **(Table 3)**.

Rhabdomyolysis in Iraq and Afghanistan

Eight cases of exertional rhabdomyolysis were diagnosed and treated in Iraq and Afghanistan during the surveillance period; 2 were diagnosed in 2019, and 1 case annually from 2020 to 2022, and 3 cases in 2023 (data not shown). The majority of those deployed service members affected by exertional rhabdomyolysis were male (n=5), non-Hispanic White (n=4) or non-Hispanic White (n=3), in the Army (n=5), and enlisted (n=6). One ACSM was medically evacuated for exertional rhabdomyolysis and dehydration in January 2023 (data not shown).

FIGURE 2. Annual Incidence Rates of Exertional Rhabdomyolysis, by Service, Active Component, U.S. Armed Forces, 2019–2023

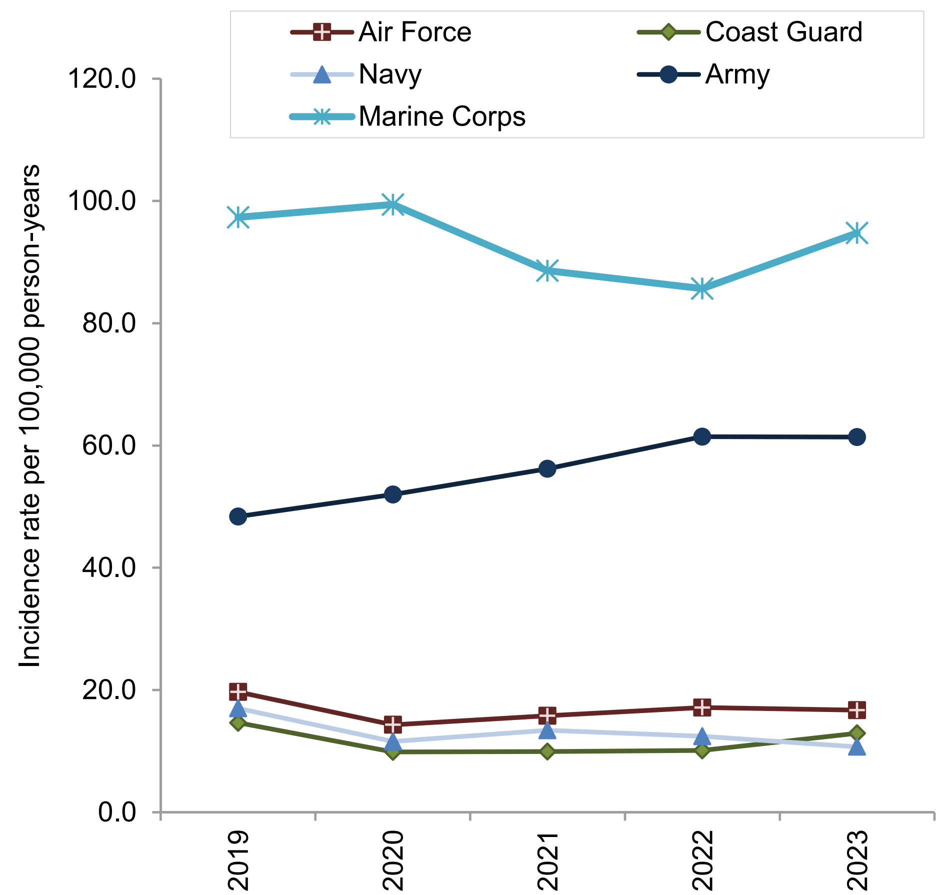
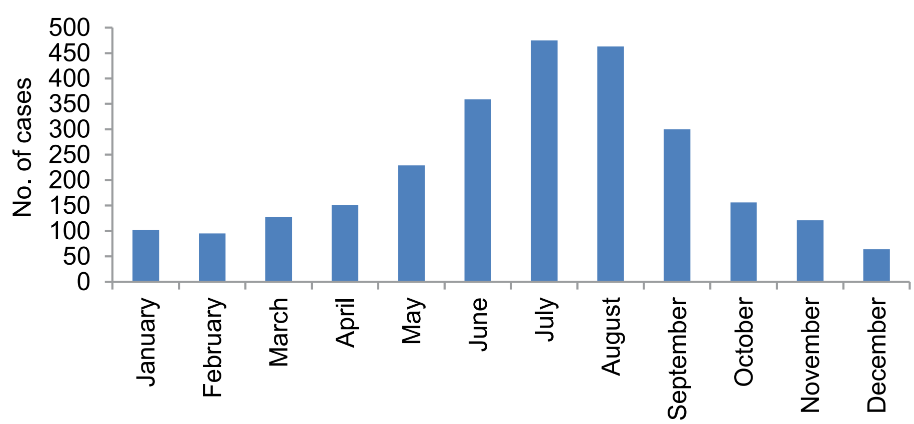


FIGURE 3. Cumulative Numbers of Exertional Rhabdomyolysis Cases, by Month of Diagnosis, Active Component, U.S. Armed Forces, 2019–2023



Discussion

This report presents findings that indicate total crude incidence rates of exertional rhabdomyolysis remained relatively stable between 2019 and 2023, ranging from 38.0 to 40.5 cases per 100,000 p-yrs. The lowest rate was observed in 2020, coinciding with the height of COVID-19 pandemic restrictions. Rates began to rise thereafter, reaching a peak increase of 6.6% in 2023 in comparison to the nadir year of 2020.

Exertional rhabdomyolysis continues to occur most frequently from mid-spring through early fall in the Northern Hemisphere, at installations that support basic combat and recruit training or major Army and Marine Corps combat units. Recruits can be exposed to environmental situations that require acclimatization to high heat and humidity during the warmer months, while Soldiers and Marines in combat units often perform rigorous unit physical training, personal fitness training, and field training exercises regardless of weather conditions.

The annual incidence rates for exertional rhabdomyolysis among non-Hispanic Black service members were higher, by approximately 1.8 times, than the rates among members of other races and ethnicities. This observation has been attributed, at least in part, to an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait (SCT),[13-16] for which the carrier frequency is approximated at 1 in 13 non-Hispanic Blacks in the U.S.[17] A significant association between SCT and the risks of exertional rhabdomyolysis is supported by studies among U.S. service members.[18,19] The rhabdomyolysis-related deaths of 2 SCT-positive service members (an Air Force member and Navy recruit) in 2019 after physical training stress this potential risk.[20,21] Although previous studies showed that SCT was associated with a 54% increase in exertional rhabdomyolysis risk, no similar association was found with risk of death. According to some experts, however, these studies missed deaths due to exertional sickling, and controversies with defining exertional rhabdomyolysis, its associations with disease progression and severity, and its prevention and management evince the need for further research.[22,23] Nevertheless, changes to the 2023 TRADOC Regulation include adding "sickle cell trait as a risk factor" and updated recommendations for screening, early recognition and prevention of exercise collapse associated with sickle cell trait (ECAST).[24]

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

Recruits were identified using an algorithm based on age, rank, location, and time in service, which was only an approximation and likely resulted in some misclassification of recruit training status.

Management after treatment for exertional rhabdomyolysis, including the decision to return to physical activity and duty, is a persistent challenge for both athletes and military members.[21] Service members who experience a clinically-confirmed exertional rhabdomyolysis event should be further evaluated and risk-stratified for recurrence before return to activity or duty.[6,25,26] Service-specific guidelines may require temporary or permanent duty restriction following rhabdomyolysis, as recently diagnosed individuals remain at a higher risk for future heat illnesses.

The most severe consequences of exertional rhabdomyolysis are preventable with effective mitigation measures and heightened suspicion of probability when environmental conditions favor muscular injury. Commanders and supervisors at all levels should ensure that guidelines for heat illness prevention are consistently implemented, maintain vigilance for early signs of exertional heat injury, and intervene aggressively when exertional rhabdomyolysis is suspected.[1]

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Update

Exertional Hyponatremia Among Active Component Members of the U.S. Armed Forces, 2008–2023

Exertional hyponatremia, or exercise-associated hyponatremia, occurs within 24 hours after physical activity due to a serum, plasma, or blood sodium concentration (Na+) below the normal reference range of 135 mEq/L. If not detected early and managed properly, hyponatremia can be fatal. From 2008 to 2023, 1,812 cases of exertional hyponatremia were diagnosed among U.S. active component service members (ACSMs), with an overall incidence rate of 8.3 cases per 100,000 person-years (p-yrs). In 2023 there were 153 cases of exertional hyponatremia diagnosed among ACSMs, resulting in a crude incidence rate of 11.7 per 100,000 p-yrs. Female service members, those older than 40, non-Hispanic Black service members, Marine Corps members, recruits, those in combat-specific occupations, and ACSMs stationed in the Northeast U.S. region had higher incidence rates of exertional hyponatremia diagnoses than their respective counterparts. During the surveillance period, annual rates of incident exertional hyponatremia diagnoses peaked in 2010 (12.8 per 100,000 p-yrs) and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. Thereafter the incidence rate fluctuated but has increased from 6.2 per 100,000 p-yrs in 2017 to its second-highest level in 2023. Service members and their supervisors should be aware of the dangers of excessive fluid consumption and prescribed limits for consumption during prolonged physical activity including field training exercises, personal fitness training, or recreational activities, particularly in hot, humid weather.

What are the new findings?

The incidence rate of exertional hyponatremia in 2023 increased from 2022, reaching the second highest incidence rate since 2008.

What is the impact on readiness and force health protection?

Exertional hyponatremia, which can be fatal if not promptly recognized and appropriately treated, has been increasing among U.S. service members over the past decade to a near record high, posing a significant health risk to U.S. military members. Military members, leaders, and trainers must be vigilant for early signs of hyponatremia, intervene immediately and appropriately, and observe the published guidelines for proper hydration during physical exertion, especially during warm weather conditions.

Exertional hyponatremia is a relatively rare disease that can be fatal if not detected early and managed properly. Exertional hyponatremia is caused by increased consumption of hypotonic fluids such as water or sports drinks before or during strenuous physical activity, including prolonged military field training or combat operations, or it can be caused by inappropriate secretion of a non-osmotic antidiuretic hormone due to physical exertion that results in increased total body water and free water retention.[1] Hyponatremia is particularly problematic in the military, where it can be mistaken for heat exhaustion or heat stroke.

Active component military personnel, who often perform heavy physical activity in hot, remote, or austere environments, during training or under combat conditions, are particularly susceptible to fluid and electrolyte imbalances.[2,3] Normal plasma sodium (Na+) concentration ranges from 135 to 145 mEq/L, and is closely regulated, along with osmolarity, to preserve cell size and function.[4] Excessive intake of sodium stimulates thirst to increase body water to maintain serum (Na^+).[5] When a serum or plasma sodium concentration is less than 135 mEq/L within the 24 hour period following prolonged physical activity, hyponatremia or exercise-related hyponatremia occurs.[6] There is growing evidence that hyponatremia is associated with increased morbidity, mortality, and health costs in a variety of clinical scenarios and diseases.[7]

The incidence of hyponatremia, resulting from a variety of activities including endurance competitions, hiking, police training, American football, fraternity hazing, and military exercises varies widely, is dependent upon activity duration, heat or cold stress, availability of water, and other individual risk factors. Other important risk factors besides excessive fluid intake include exercise duration of greater than 4 hours, inadequate training for an exertional event, and either high or low body mass index.[8] Symptoms depend on the extent and rate of decrease in serum sodium compared to baseline levels. To reduce the risk of exertional hyponatremia, mitigation measures such as fluid and electrolyte replacement guidelines, identification of high-risk individuals, and vigilance during associated activities can be adopted.[9]

Exercising in hot weather continues to cause preventable injuries and deaths in young, healthy people.[3] Considering the characteristics of military environments such as long-term military training and combat operations, exertional hyponatremia may continue to pose a health risk to U.S. military personnel, significantly reducing performance and combat effectiveness. This report summarizes the frequency, rates, trends, demographic, geographic location, and military characteristics of exertional hyponatremia cases among active component service members (ACSMs) from 2008 to 2023.

Methods

The surveillance population for this report consisted of all ACSMs of the U.S. Army, Navy, Air Force, Marine Corps, Space Force, and Coast Guard who served at any time during the surveillance period, from January 1, 2008 to December 31, 2023. Due to the recent establishment of the Space Force, its personnel were categorized as Air Force for this analysis.[10]

All data used to determine incident exertional hyponatremia diagnoses were derived from records routinely collected and maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of ACSMs of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System [MHS]) treatment hospitals and clinics worldwide. In-theater diagnoses of hyponatremia were identified from medical records of service members deployed to Southwest Asia or the Middle East whose health care encounters were documented in the Theater Medical Data Store (TMDS).

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 and 10th revisions, ICD-9:276.1; ICD-10:E87.1) and no other illness or injury-specific diagnoses (ICD-9:001–999; ICD-10:A–U) 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).[11]

Medical encounters were not considered case-defining events if the associated records included the following diagnoses in any diagnostic position: alcohol or illicit drug abuse; psychosis, depression, or other major mental disorders; endocrine disorders; kidney diseases; intestinal infectious diseases; cancers; major traumatic injuries; or complications of medical care. An individual could be considered a case of exertional hyponatremia only once per calendar year. Incidence rates were calculated as cases of hyponatremia per 100,000 person-years (p-yrs) of active component service.

For health surveillance purposes, recruits were identified as active component members assigned to service-specific training locations during coincident service-specific basic training periods. Recruits 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 used to identify incident cases at fixed treatment facilities. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (i.e., Southwest Asia, Middle East) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if the affected service members met the aforementioned criteria in a permanent military medical facility in the U.S. or Europe from 5 days preceding until 10 days following their evacuation dates.

Results

In 2023, there were 153 cases of exertional hyponatremia diagnosed among ACSMs, resulting in a crude incidence rate of 11.7 per 100,000 p-yrs, an increase from 8.8 per 100,000 p-yrs in 2022. From 2008 to 2023, there were 1,812 incident diagnoses of exertional hyponatremia among ACSMs resulting in a crude overall incidence rate of 8.3 cases per 100,000 p-yrs. **Table 1** presents the incident cases and incidence rates of exertional hyponatremia according to demographic characteristics.

In 2023, female ACSMs had a higher annual incidence rate (13.1 per 100,000 p-yrs) than males (11.4 per 100,000 p-yrs); a change from prior years when the rate was similar between sexes. Service members aged 40 and older had the highest incidence rate, followed by those less than 20 years of age (28.8 and 20.0 per 100,000 p-yrs, respectively). Non-Hispanic Black service members had the highest incidence rate (15.0 per 100,000 p-yrs) compared to other race and ethnicity categories. As with overall 2008-2023 rates, Marine Corps members had the highest incidence rate in 2023 (17.8 per 100,000 p-yrs) compared to other services.

There were 21 cases of exertional hyponatremia among recruits in 2023, an incidence rate 10 and nearly 6 times higher than those of other enlisted service members and officers, respectively. Combat-specific military occupations (infantry/artillery/combat engineering/armor) had the highest incidence rate (13.8 per 100,000 p-yrs) in 2023, excluding the other/unknown group.

The Northeast region of the U.S. had a higher incidence rate of exertional hyponatremia (14.6 per 100,000 p-yrs) compared to other regions in 2023.

Figure 1 presents annual incident cases and rates of exertional hyponatremia among ACSMs by year. Between 2008 and 2023, crude annual rates of incident exertional hyponatremia diagnoses peaked in 2010 (12.8 per 100,000 p-yrs) and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. During the last 10 years of the surveillance period, rates fluctuated but generally increased from 6.2 cases per 100,000 p-yrs in 2013 to 11.7 cases per 100,000 p-yrs in 2023. The annual incidence of exertional hyponatremia diagnosis was significantly higher in the Marine Corps than in any other service **(Figure 2)**. During the 16-year period, 87.4% (n=1,584) of all cases were diagnosed and treated without hospitalization (data not shown).

TABLE 1. Incident Cases[a] and Incidence Rates[b] of Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2008–2023

	2023		Total 2008–2023	
	No.	Rate[b]	No.	Rate[b]
Total	153	11.7	1,812	8.3
Sex				
Male	123	11.4	1,524	8.2
Female	30	13.1	288	8.4
Age group, y				
<20	16	20.0	226	16.0
20–24	33	8.3	501	7.2
25–29	24	7.8	346	6.6
30–34	24	11.0	231	6.6
35–39	17	10.1	214	8.2
40+	39	28.8	294	12.8
Race and ethnicity				
White, non-Hispanic	75	10.9	1,153	9.0
Black, non-Hispanic	31	15.0	239	6.9
Hispanic	30	12.0	216	6.7
Other/unknown	17	10.6	204	8.1
Service				
Army	57	12.7	637	8.0
Navy	27	8.3	283	5.4
Air Force	38	11.8	362	7.0
Marine Corps	30	17.8	483	16.1
Coast Guard	1	2.6	47	7.5
Military status				
Enlisted	93	8.9	1,117	6.3
Officer	39	16.0	408	10.6
Recruit	21	90.2	287	64.4
Military occupation				
Combat-specific[c]	23	13.8	311	10.2
Motor transport	2	4.6	37	5.2
Pilot/air crew	4	8.8	46	5.8
Repair/engineering	33	8.9	328	5.1
Communications/intelligence	29	10.4	316	6.7
Health care	11	10.4	140	7.5
Other/unknown	51	17.3	634	14.5

Abbreviation: No., number; y, years.

[a] One case per person per year.

[b] Rate per 100,000 person-years.

[c] Infantry/artillary/combat engineering/armor.

Exertional hyponatremia by location

During the 16-year surveillance period, exertional hyponatremia cases were diagnosed at more than 150 U.S. military installations and geographic locations worldwide, but 16 U.S. installations contributed 20 or more cases each and accounted for 49.2% of the total cases **(Table 2)**. Marine Corps Recruit Depot (MCRD) Parris Island, SC, reported 203 cases of exertional hyponatremia, the highest in the DOD.

Exertional hyponatremia in the CENTCOM AOR

From 2008 to 2023, a total of 35 cases of exertional hyponatremia were diagnosed and treated in the CENTCOM AOR (data not shown). No new cases were diagnosed in 2023. Deployed service members affected by exertional hyponatremia were most frequently male (n=27; 77%), 20–24 years old (n=16; 46%), non-Hispanic White (n=26; 74%), in the Army (n=19; 54%), enlisted (n=27; 77%), and in combat-specific (n=10; 29%) or communications/intelligence (n=10; 29%) occupations (data not shown). Five service members were medically evacuated from the CENTCOM AOR for exertional hyponatremia, all of which occurred between 2009 and 2018 (data not shown).

Discussion

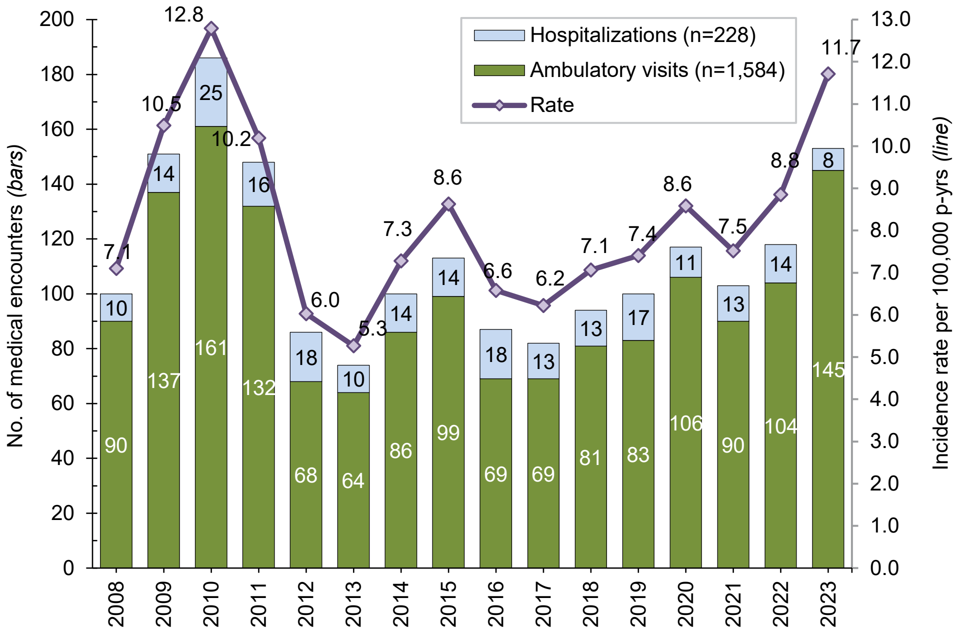
Over the past decade, incidence rates of exertional hyponatremia have fluctuated, while overall increasing from 6.2 to 11.7 per 100,000 p-yrs in 2023. The incidence of exertional hyponatremia fluctuated more in women than in men. Although reports on the association between gender and hyponatremia provide conflicting analyses,[12,13] many studies report that gender is not a significant risk factor for hyponatremia.[14-17] Further investigation and ongoing monitoring may be warranted, however, to effectively prevent exertional hyponatremia in women in particular.

In 2023 the highest age-specific incidence rate was among the 40 years and older age group, which is consistent with the literature, in which increasing age has been reported as a strong independent risk factor for both hyponatremia and hypernatremia.[14] Considering the rapid incidence rate increase in this age group, investigation of the causes of this change, to understand how this condition occurs and how it can be prevented, is warranted.

In *MSMR* analyses before April 2018, in-theater cases included diagnoses of hypo-osmolality and hyponatremia in any diagnostic position, but in 2018 case-defining criteria for inpatient and outpatient encounters were applied to in-theater encounters. As a result, the results of the in-theater analysis are not comparable to those presented in earlier *MSMR* updates.

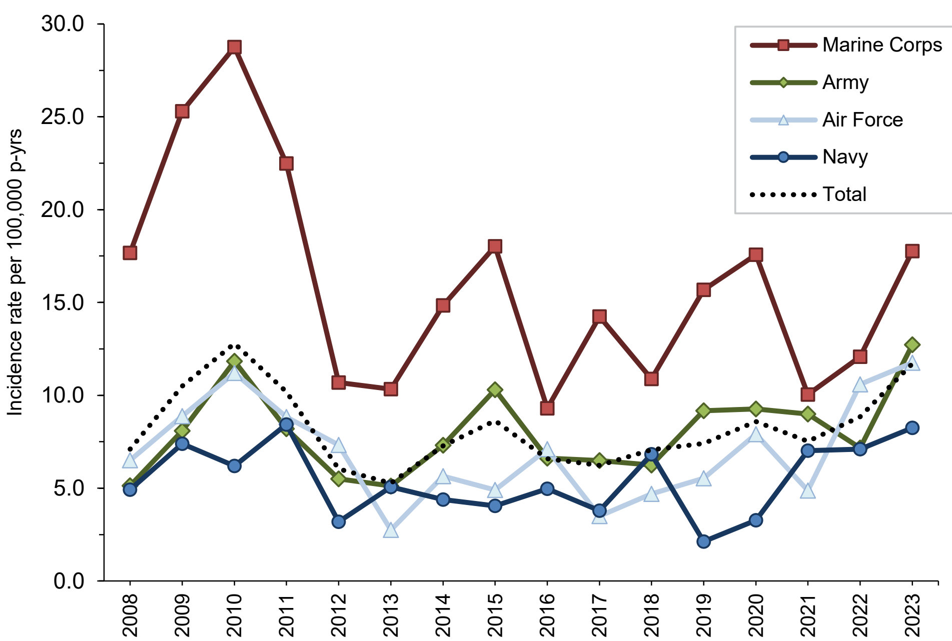
Several important limitations should be considered when interpreting this analysis. First, there is no specific diagnostic

FIGURE 1. Annual Incident Cases and Rates of Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2008–2023



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

FIGURE 2. Annual Incidence Rates of Exertional Hyponatremia, by Service, Active Component, U.S. Armed Forces, 2008–2023



Abbreviation: P-yrs, person-years.
Coast Guard not included as counts are very small and rates are unstable.

code for exertional hyponatremia. This lack of specificity may result in the inclusion of some non-exertional cases of hyponatremia, overestimating the true rate. 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 indicating exertional hyponatremia may reflect, at least in part, increasing awareness, concern, and aggressive management by military supervisors and primary health care providers of incipient cases.

Finally, recruits were identified using an algorithm based on age, rank, location, and time in service, which was only an approximation and likely resulted in some misclassification of recruit training status.

Exertional hyponatremia must be differentiated from heat illness to avoid inappropriate treatment and adverse outcomes and instead, based on accurately observed signs and symptoms, appropriately diagnose and treat the condition. Well-trained personnel should be able to recognize signs of possible hyponatremia: excessive fluid intake, changes in mental status, vomiting, poor eating habits, abdominal bloating, and large amounts of clear urine.[3,9,18]

Considering the increased incidence rate of exertional hyponatremia in 2023, continued emphasis should be placed on how to effectively manage exertional hyponatremia, including prevention, identification, and treatment methods through close monitoring. Hyponatremia is treated primarily by managing the underlying cause in addition to free water restriction,[19] concentrating on pre-hospital care through rapid on-site emergency medical service assessment in addition to hospital management in emergency and inpatient settings.[20] Depending on the physical demands of military operations and prevailing environmental conditions, the composition of replacement fluids may vary.[21]

Due to the variety of underlying causes, individualized management may be the best approach to prevent exertional hyponatremia. Effective and collaborative management consistent with current policy and guidance to commanders is crucial for prevention of exertional hyponatremia **(Table 3)**.[9] It is critical to recognize exertional hyponatremia, provide appropriate treatment, and emphasize the importance of appropriate hydration practices to ensure service members' health and performance.

TABLE 2. Incident Cases of Exertional Hyponatremia by Installation (with 20 cases minimum), Active Component, U.S. Armed Forces, 2008–2023

Location of Diagnosis	No.	% Total
MCRD Parris Island, SC	203	11.2
Fort Moore, GA	140	7.7
JBSA-Lackland AFB, TX	68	3.8
Fort Liberty, NC	61	3.4
MCB Camp Lejeune/ Cherry Point, NC	59	3.3
Walter Reed NMMC, MD[a]	37	2.0
NMC San Diego, CA	50	2.8
MCB Camp Pendleton, CA	45	2.5
NMC Portsmouth, VA	44	2.4
Fort Cavazos, TX	32	1.8
MCB Quantico, VA	31	1.7
Fort Campbell, KY	30	1.7
Fort Schafter, HI	26	1.4
Fort Carson, CO	22	1.2
Fort Belvoir, VA	22	1.2
Fort Jackson, SC	22	1.2
Other/unknown locations	920	50.8
Total	1,812	100.0

Abbreviations: No., number; MCRD, Marine Corps Recruit Depot; JBSA, Joint Base San Antonio; AFB, Air Force Base; MCB, Marine Corps Base; NMMC, National Military Medical Center; NMC, Naval Medical Center.

Note: Recruit training locations include MCRD Parris Island/ Fort Moore, JBSA-Lackland AFB, MCB Camp Lejeune/Cherry Point, MCB Camp Pendleton, and Fort Jackson. Referral centers include Walter Reed NMMC, NMC San Diego, and NMC Portsmouth.

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TABLE 3. TRADOC Recommendations[a] for Continuous Work Duration and Fluid Replacement in Warm and Hot Environments

		Easy Work		Moderate Work		Heavy Work		Very Heavy Work	
Heat Category	WBGT Index (°F)	Work (min)	Water Intake (qt/hr)	Work (min)	Water Intake (qt/hr)	Work (min)	Water Intake (qt/hr)	Work (min)	Water Intake (qt/hr)
1 (white)	78 - 81.9	NL[b]	½	NL[b]	¾	110	¾	45	¾
2 (green)	82 - 84.9	NL[b]	½	NL[b]	1	70	1	40	1
3 (yellow)	85 - 87.9	NL[b]	¾	NL[b]	1	60	1	25	1
4 (red)	88 - 89.9	NL[b]	¾	180	1¼	50	1¼	20	1¼
5 (black)	>90	NL[b]	1	70	1½	45	1½	20	1½

Notes:
1. Applies to average-sized and heat-acclimatized service member wearing the operational camouflage pattern uniform.
2. Fluid needs can vary based on individual differences (± ¼ qt/hr) and exposure to full sun or shade (± ¼ qt/hr).
3. CAUTION: Hourly fluid intake should not exceed 1½ qts.
4. CAUTION: Daily fluid intake should not exceed 12 qts.

Abbreviations: TRADOC, Training and Doctrine Command; WBGT, wet bulb global temperature; F, Fahrenheit; min, minimum; qt, quart; hr, hour; NL, no limit.

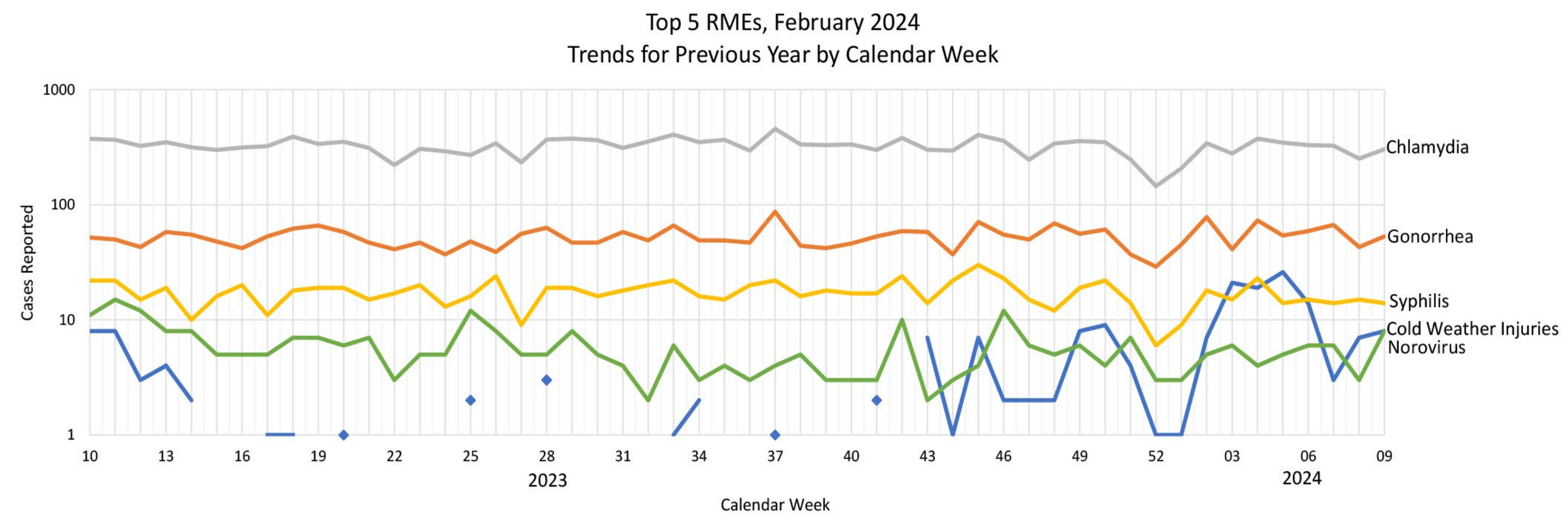
[a]Reference 9, page 24.

[b]No work limit per hour, up to 4 continuous hours.

Reportable Medical Events at Military Health System Facilities Through Week 9, Ending March 2, 2024

Matthew W. R. Allman, MPH; Anthony R. Marquez, MPH; Katherine S. Kotas, MPH

TOP 5 REPORTABLE MEDICAL EVENTS BY CALENDAR WEEK, ACTIVE COMPONENT (MARCH 11, 2023 - MARCH 2, 2024)



Abbreviations: RMEs, reportable medical events; No., number.

[a]Cases are shown on a logarithmic scale.

Note: There were 0 cold weather injuries cases in the following weeks in 2023: 15-16, 19, 21-24, 26-27, 29-32, 35-36, 38-40, 42. Markers added to represent instances of cold weather injuries that were not visible on the log scale graph.

Reportable Medical Events (RMEs) are documented in the Disease Reporting System internet (DRSi) by health care providers and public health officials throughout the Military Health System (MHS) for monitoring, controlling, and preventing the occurrence and spread of diseases of public health interest or readiness importance. These reports are reviewed by each service's public health surveillance hub. The DRSi collects reports on over 70 different RMEs, including infectious and non-infectious conditions, outbreak reports, STI risk surveys, and tuberculosis contact investigation reports. A complete list of RMEs is available in the *2022 Armed Forces Reportable Medical Events Guidelines and Case Definitions*.[1] Data reported in these tables are considered provisional and do not represent conclusive evidence until case reports are fully validated.

Total active component cases reported per week are displayed for the leading 5 RMEs for the previous year. Each month, the graph is updated with the top 5 RMEs, and is presented with the current month's (February 2024) top 5 RMEs, which may differ from previous months. COVID-19 is excluded from these graphs due to changes in reporting and case definition updates in 2023.

For questions about this report, please contact the Disease Epidemiology Branch at the Defense Centers for Public Health–Aberdeen. Email: dha.apg.pub-health-a.mbx.disease-epidemiologyprogram13@health.mil

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TABLE. Reportable Medical Events, Military Health System Facilities, Week Ending March 2, 2024 (Week 9)[a]

Reportable Medical Event[b]	Active Component[c]					MHS Beneficiaries[d]
	January 2024	February 2024	YTD 2024	YTD 2023	Total, 2023	February 2024
	no.	no.	no.	no.	no.	no.
Amebiasis	0	1	1	2	15	0
Arboviral diseases, neuroinvasive and non-neuroinvasive	0	0	0	0	2	0
COVID-19-associated hospitalization and death[e]	7	7	14	38	113	59
Campylobacteriosis	17	8	25	34	268	20
Chikungunya virus disease	0	0	0	1	2	0
Chlamydia trachomatis	1,407	1,293	2,700	3,114	17,491	201
Cholera	0	0	0	0	4	0
Coccidioidomycosis	6	7	13	6	36	4
Cold weather injury[f]	65	40	105	63	148	N/A
Cryptosporidiosis	4	15	19	10	67	0
Cyclosporiasis	0	0	0	0	15	0
Dengue virus infection	1	0	1	0	7	0
E. coli, Shiga toxin-producing	3	2	5	2	70	4
Ehrlichiosis / anaplasmosis	0	0	0	0	28	0
Giardiasis	12	4	16	11	79	2
Gonorrhea	271	232	503	499	2,761	34
Haemophilus influenza,[e] invasive	0	0	0	0	1	0
Hantavirus disease	0	0	0	0	2	0
Heat Illnesses[f]	9	14	23	43	1,254	N/A
Hepatitis A	1	0	1	2	8	0
Hepatitis B, acute and chronic	11	10	21	28	153	11
Hepatitis C, acute and chronic	4	5	9	14	52	8
Influenza-associated hospitalization[g]	18	8	26	5	28	34
Lead poisoning, pediatric[h]	N/A	N/A	N/A	N/A	N/A	2
Legionellosis	0	3	3	1	5	0
Leishmaniasis	0	0	0	1	1	0
Leprosy	0	0	0	0	2	0
Leptospirosis	0	0	0	2	4	0
Lyme disease	7	2	9	12	69	2
Malaria	2	0	2	6	28	0
Meningococcal disease	0	0	0	0	4	0
Mpox	0	0	0	0	4	0
Norovirus	20	23	43	159	418	41
Pertussis	2	2	4	1	15	1
Post-exposure prophylaxis against Rabies	55	32	87	86	594	22
Q fever	0	0	0	1	2	0
Rubella	0	0	0	0	2	0
Salmonellosis	8	6	14	5	129	8
Shigellosis	3	4	7	9	59	1
Spotted fever rickettsiosis	0	0	0	8	31	0
Syphilis (all)	71	62	133	169	943	10
Toxic Shock Syndrome	1	0	1	1	2	0
Trypanosomiasis	1	0	1	1	1	0
Tuberculosis	1	0	1	0	11	0
Tularemia	0	1	1	0	1	0
Typhoid fever	0	0	0	0	2	0
Typhus fever	1	0	1	0	3	1
Varicella	5	0	5	1	12	2
Zika virus infection	1	0	1	0	0	0
Total case counts	2,014	1,781	3,795	4,335	24,946	467

Abbreviations: MHS, Military Health System; YTD, year-to-date; no., number; COVID-19, coronavirus disease 2019; E., Escherichia; N/A, not applicable; RME, reportable medical event; DRSi, Disease Reporting System internet; ACSMs, active component service members; AD, active duty; FMP, family member prefix.

[a] RMEs reported through DRSi as of Mar. 31, 2024 are included in this report. RMEs were classified by date of diagnosis, or where unavailable, date of onset. Monthly comparisons are displayed for the period of Jan. 1, 2024-Jan. 31, 2024 and Feb. 1, 2024-Feb. 29, 2024. YTD comparison is displayed for the period of Jan. 1, 2024-Feb. 29, 2024 for MHS facilities. Previous year counts are provided as the following: previous year YTD–Jan. 1, 2023-Feb. 28, 2023; total 2023–Jan. 1, 2023-Dec. 31, 2023.

[b] RME categories with 0 reported cases among ACSMs and MHS beneficiaries for the time periods covered were not included in this report.

[c] Services included in this report include Army, Navy, Air Force, Marine Corps, Coast Guard, and Space Force, including personnel classified as FMP 20 with duty status of AD, Recruit, or Cadet in DRSi.

[d] Beneficiaries included the following: individuals classified as FMP 20 with duty status of Retired and individuals with all other FMPs except 98 and 99. Civilians, contractors, and foreign nationals were excluded from these counts.

[e] Only cases reported after case definition update on May 4, 2023. Includes only cases resulting in hospitalization or death. Does not include cases of hospitalization or death reported under the previous COVID-19 case definition.

[f] Only reportable for ACSMs.

[g] Influenza-associated hospitalization is reportable only for individuals under 65 years of age.

[h] Pediatric Lead Poisoning is reportable only for children aged 6 years or younger.

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