MSMR

Medical Surveillance Monthly Report

April 2023 | Vol. 30 | No. 4

In this issue:

A Publication of the Armed Forces Health Surveillance Division

www.health.mil/MSMR

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 high heat environments. Military training and operation environments create a constellation of circumstances that make service members highly susceptible to heat illnesses and their associated morbidities of exertional hyponatremia and exertional rhabdomyolysis. Leaders and medical staff must be attuned to the inherent health risks for operations in a high heat environment, especially for service members who are deconditioned or pushed to the limits of their physical endurance.

The mantra "train as you fight" requires service members to be frequently exposed to harsh environmental conditions. During initial recruit training, large amounts of time are spent outdoors, often in high heat; training installations are generally located in the southern U.S. for perennial use. The environmental stresses of heat and humidity at these installations that are experienced by individuals encumbered with heavy gear, unconditioned for the duration and intensity of the physical activity required during training, combine to create the perfect conditions for heat illness.

The first topic of this *MSMR* issue, heat illnesses, focuses on heat exhaustion and heat stroke. These conditions present 2 different occasions when the body can no longer rid itself of heat, either generated through activity or absorbed from the environment. Internal body temperature begins to rise during the earlier stage, heat exhaustion, 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 organs begin to fail from heat overload. Heat stroke is distinguished by 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 required.

This issue's second and third topics, exertional rhabdomyolysis and exertional hyponatremia, are both commonly associated with heat illness, but represent organ damage (rhabdomyolysis) or unintended side effects from over-aggressive rehydration (hyponatremia). Both of these conditions can result in rapid deterioration or death if 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 and implementation of appropriate heat countermeasures. Leaders, as part of their risk assessments, must balance mitigation efforts against the requirements of their operations or trainings. The most effective countermeasures against heat illness include restricting activity to early morning or evening 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 a local heat environment.

Update

Heat Exhaustion and Heat Stroke Among Active Component Members of the U.S. Armed Forces, 2018–2022

The most serious types of heat illness, heat exhaustion and heat stroke, are occupational hazards of the military's training and operational environments. These conditions can be mitgated with appropriate situational awareness and effective countermeasures. In 2022, the crude incidence rates of heat stroke and heat exhaustion among active component service members were 32.1 and 147.7 per 100,000 person-years, respectively. The rates of incident heat stroke and heat exhaustion generally declined during the 2018 to 2022 surveillance period. In 2022, those at highest risk were men, those younger than age 20, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations. Leaders, training cadres, and supporting medical personnel must inform their supervised and supported service members of heat illness risks, preventive measures, early signs and symptoms, and first-responder actions.

What are the new findings?

The crude annual incidence rates of heat stroke and heat exhaustion decreased 30.0% and 15.1%, respectively, from 2018 to 2022. The annual number of heat illnesses diagnosed in the CENTCOM AOR dropped from a high of 73 in 2019 to 48 in 2022, likely due to the reduction in forces deployed there. Only about half of heat stroke and heat exhaustion cases were identified in mandatory reports submitted to the Disease Reporting System internet.

What is the impact on readiness and force health protection?

Heat illness can be fatal, even with prompt recognition and treatment. Situational awareness and implementation and enforcement of appropriate countermeasures by commanders at all levels are the most effective means of reducing incidence of these preventable illnesses. Complete, timely submission of mandatory reports of heat illness events ensures that local public health and command leaders have ready access to surveillance data, to identify trends and guide preventive measures.

Heat-related illness remains a persistent threat to the health and operational effectiveness of military members and their units, and accounts for considerable annual morbidity. Strenuous physical activity for extended durations during operational and training exercises exposes service members to considerable heat stress due to the absorption of high environmental heat along with elevated rates of metabolic heat production.[1,2] Although numerous effective countermeasures are available, operational necessity may preclude their full employment. Deconditioned and unacclimated service members are at particularly high risk, as exemplified by the rates of heat injuries during U.S. military recruit training.[1,3-5]

Heat illness refers to a group of disorders that result from core body temperature surpassing the compensatory limits of thermoregulation[6] due to environmental heat stress, usually accompanied by heavy exertion. Heat illness constitutes a set of conditions along a continuum, from less severe (heat cramps, rash, edema, and syncope) to potentially life-threatening (heat stroke). The DOD definition of reportable heat illness includes only heat exhaustion and heat stroke, the 2 conditions covered in this report. Heat exhaustion and heat stroke are reportable medical events (RMEs) in the U.S. Military Health System (MHS), and all cases of heat illness that require medical intervention or result in change of duty status are reportable.[7]

To be confirmed, a case of heat exhaustion must fulfill 3 conditions, during or immediately following exertion or heat exposure: 1) a core body temperature greater than 100.5°F/38°C and less than 104°F/40°C, 2) short-term physical collapse or debilitation during or shortly after physical exertion, and 3) no significant central nervous system dysfunction.[5] 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.[5,8]

Heat stroke is a debilitating and potentially life-threatening condition characterized by severe hyperthermia. A probable case of heat stroke requires, concomitant to the setting of exertion or heat exposure, 1) evidence of elevated core body temperature and 2) central nervous system dysfunction (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 clinical treatment featuring rapid cooling and supportive therapy such as fluid resuscitation to stabilize organ function.[8-10] Multiorgan system failure is the ultimate cause of mortality from heat stroke.[9]

Heat illnesses represent a threat to the health of individual service members during military training and operations, but are frequently preventable. Mitigation methods include heat acclimatization, sufficient hydration, mandated work-rest cycles, uniform modifications to improve evaporative heat loss, limiting weight loads during training, and scheduling high intensity exercise during cooler times of day.[3,11-14]

Since 2001, the *MSMR* has published regular updates on the incidence of heat illness among U.S. active duty service members. This report presents the case counts and incidence rates of heat illnesses between 2018 and 2022 as well as the locations of heat illness case occurrences during this period. Heat stroke and heat exhaustion are summarized separately.

Methods

The surveillance population for this analysis includes all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period of January 1, 2018 through December 31, 2022. All data used to determine incident heat illness diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS), which documents both ambulatory care encounters and hospitalizations of active component service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through MHS) treatment facilities worldwide. In-theater diagnoses of heat illness were identified from medical records of deployed service members whose health care encounters were documented in the Theater Medical Data Store. Because they are an occupational hazard of rigorous outdoor training intrinsic to the military, and often preventable, heat illnesses are RMEs recorded within service-specific electronic reporting systems that are routinely transmitted and incorporated into the DMSS.

In this update, the same definition for heat illness was used as in *MSMR* reports since 2018. 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; International Classification of Diseases, 10th Revision [ICD-10]: T67.0*) or heat exhaustion (ICD-9: 92.3–992.5; ICD-10: T67.3*–T67.5*) or 2) an RME record of heat exhaustion or heat stroke.[15] Because of a July 2017 update to the Disease Reporting System internet (DRSi) medical event reporting system, the type of heat illness (i.e., heat stroke or heat exhaustion) could not be distinguished using RME records in DMSS data. Instead, information on the type of RME for heat illness during the entire 2018-2022 surveillance period was extracted directly from DRSi records. *MSMR* analyses 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 an "other heat illnesses" category; these codes were excluded from this report.

An individual could be considered a case of heat illness only once per calendar year. If a service member had a diagnosis for both heat stroke and heat exhaustion during a given year, the more severe (heat stroke) diagnosis was selected. Order of precedence for encounter selection followed: 1) hospitalization (inpatient record), 2) RME (report in DRSi), then 3) ambulatory visit (outpatient record). Incidence rates were calculated as incident cases of heat illness per 100,000 person-years (p-yrs) of active component service. Percent change in incidence was calculated using unrounded rates.

For health surveillance purposes, recruit trainees were identified as active component members assigned to service-specific training locations during coincident service-specific basic training periods. Recruit trainees were considered a separate category of enlisted service members in summaries of heat illnesses by overall military grade.

In-theater diagnoses of heat illnesses were analyzed separately using the same case-defining criteria and incidence rules that were applied to identify cases at fixed treatment facilities. Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) to a medical treatment facility outside their 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 2022, the MHS reported 415 cases of heat stroke, resulting in a crude overall incidence rate of 32.1 per 100,000 p-yrs **(Table 1)**. Subgroup-specific incidence rates of heat stroke were highest among men, those younger than 20 years, Marine Corps and Army members, recruit trainees, and those in combat-specific occupations. The 25 cases of heat stroke reported among recruit trainees resulted in incidence rates 3 and 6 times higher than other enlisted service members and officers, respectively.

The crude annual incidence rate of heat stroke decreased 30.0% **(Figure 1)** from 2018 through 2022, and was associated with an overall reduction in the proportion of heat stroke cases with hospitalization, which dropped most markedly from 2021 to 2022. Of the heat stroke cases identified from inpatient data, 55.7% were also reported as RMEs. Half (50.7%) of cases identified from outpatient data were also recorded as RMEs.

The 1,912 cases of heat exhaustion in 2022 correspond to a crude overall incidence rate of 147.7 per 100,000 p-yrs **(Table 1)**. The rate of heat exhaustion among women was 16.6% lower than the rate among men. Notably higher overall rates of heat exhaustion were recorded for service members younger than age 20, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations when compared to their respective counterparts.

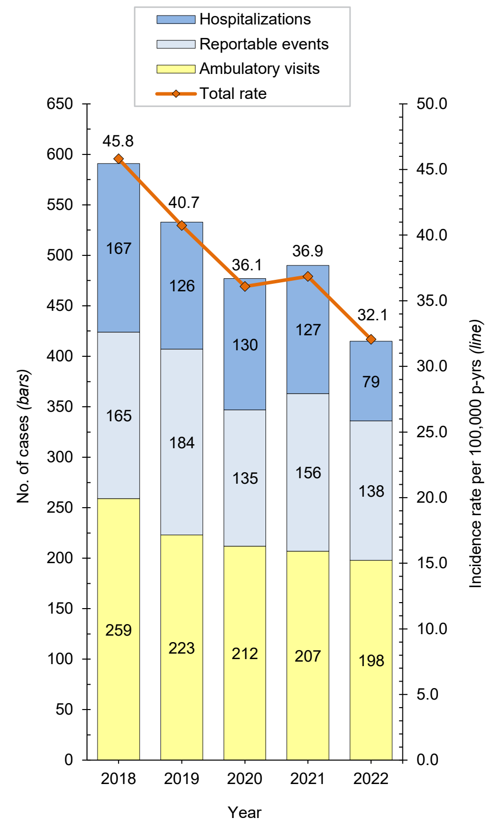
Between 2018 and 2020, the crude annual rate of heat exhaustion decreased 27.4%, followed by a 16.8% increase from 2020 to 2022 **(Figure 2)**. The increase in heat exhaustion cases during the last 2 years of the surveillance period was accompanied by an increase in the proportion of cases recorded as RMEs. Of the heat exhaustion cases identified from inpatient data, 54.5% were also RMEs, while only 39.2% of heat exhaustion cases identified from outpatient data were recorded as RMEs.

TABLE 1. Incident Cases[a] and Incidence Rates[b] of Heat Illness, Active Component, U.S. Armed Forces, 2022

	Heat Stroke		Heat Exhaustion		Total Heat Illness Diagnoses	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	415	32.1	1,912	147.7	2,327	179.8
Sex						
Male	380	35.6	1,598	149.6	1,978	185.1
Female	35	15.5	314	138.9	349	154.3
Age group, y						
<20	66	81.6	503	622.0	569	703.6
20–24	173	42.0	834	202.6	1,007	244.7
25–29	107	35.2	333	109.6	440	144.8
30–34	50	23.7	153	72.6	203	96.3
35–39	11	6.9	58	36.3	69	43.2
40+	8	6.3	31	24.3	39	30.5
Racial/ethnic group						
Non-Hispanic White	232	33.2	999	143.0	1,231	176.3
Non-Hispanic Black	73	34.9	325	155.5	398	190.5
Hispanic	62	26.2	380	160.8	442	187.0
Other/unknown[c]	48	31.8	208	137.9	256	169.7
Service						
Army	228	49.4	993	215.2	1,221	264.6
Navy	28	8.3	142	42.0	170	50.3
Air Force	27	8.4	201	62.6	228	71.1
Marine Corps	132	75.9	576	331.0	708	406.9
Military status						
Recruit trainees	25	117.0	420	1,966.3	445	2,083.3
Enlisted	338	32.5	1,335	128.3	1,673	160.8
Officer	52	22.3	157	67.4	209	89.7
Military occupation						
Combat-specific[d]	146	81.7	613	343.1	759	424.8
Motor transport	9	23.0	49	125.3	58	148.3
Pilot/air crew	5	10.7	6	12.9	11	23.6
Repair/engineering	55	14.6	236	62.7	291	77.3
Communications/intelligence	62	22.5	278	100.7	340	123.2
Health care	20	18.5	86	79.7	106	98.2
Other/unknown	118	43.8	644	238.9	762	282.6

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

FIGURE 1. Incident Cases[a] and Incidence Rates of Heat Stroke, by Report Source and Year of Diagnosis, Active Component, U.S. Armed Forces, 2018-2022

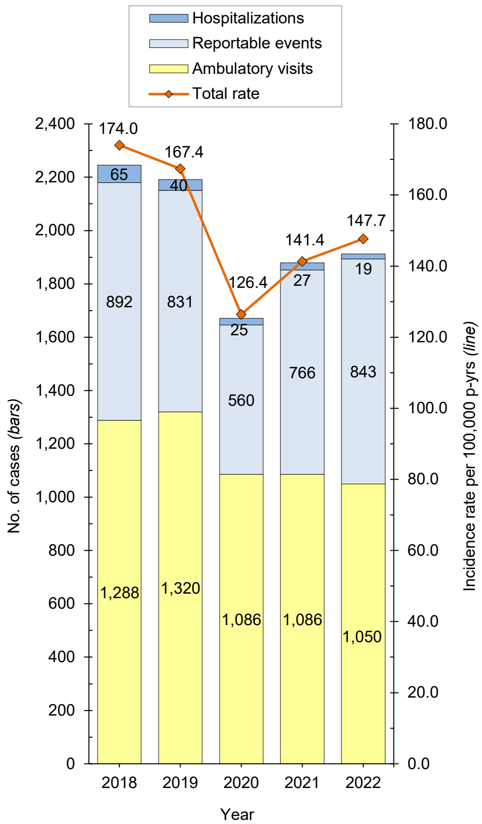


Abbreviations: No., number; p-yrs, person-years.
[a]Diagnosis codes were prioritized by severity and record source (heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits).

Heat illnesses by location

During the 5-year surveillance period, 12,404 heat-related illnesses were diagnosed at more than 250 military installations and geographic locations worldwide **(Table 2)**. Of these total heat illness cases, 5.7% occurred outside the U.S., including 321 in Okinawa. Between 2018 and 2022, 20 locations reported at least 100 cases of heat illness, and those locations accounted for over three-quarters (75.7%) of all active component cases. Four Army installations in the U.S. accounted for more than one-third (34.9%) of all heat illnesses during the period: Fort Benning, GA; Fort Bragg, NC; Fort Campbell, KY; and Fort Polk, LA. Of the 20 locations with at least 100 cases of heat illness, 9 are in the southeastern U.S.

FIGURE 2. Incident Cases[a] and Incidence Rates of Heat Exhaustion, by Report Source and Year of Diagnosis, Active Component, U.S. Armed Forces, 2018–2022

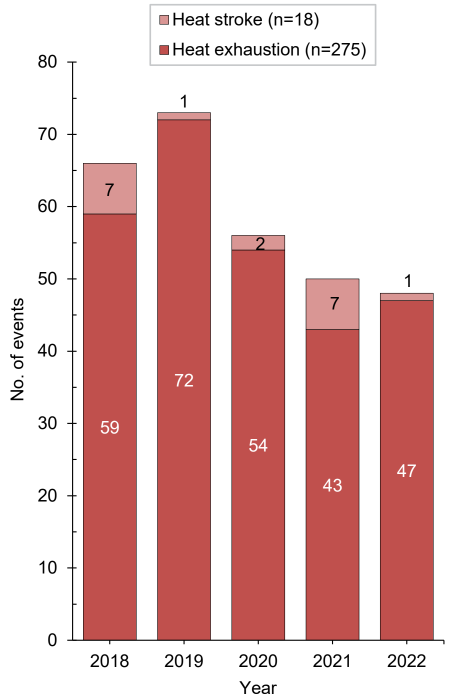


Abbreviations: No., number; p-yrs, person-years.
[a]Diagnosis codes were prioritized by severity and record source: heat stroke > heat exhaustion; hospitalizations > reportable events > ambulatory visits.

Heat illnesses in the CENTCOM AOR

During the 5-year surveillance period, 293 heat illnesses were diagnosed and treated in the CENTCOM AOR **(Figure 3)**. Of the total cases of heat illness, 6.1% (n=18) were diagnosed as heat stroke. Deployed service members affected by heat illnesses were most frequently male (n=225; 76.8%), non-Hispanic White (n=153; 52.2%), 20-24 years old (n=153; 52.2%), in the Army (n=113; 38.6%), enlisted (n=280; 95.6%), and in repair/engineering (n=96; 32.8%) occupations **(data not shown)**. During the surveillance period, 2 service members were medically evacuated for heat illnesses from the CENTCOM AOR; 1 evacuation occurred in November 2020 and 1 in August 2022 **(data not shown)**.

FIGURE 3. Heat Illnesses Diagnosed in CENTCOM AOR, Active Component, U.S. Armed Forces, 2018–2022



Abbreviation: No., number

Discussion

Among service members in the active component, the crude incidence rate of heat stroke decreased 30.0% between 2018 and 2022, accompanied by an overall reduction in the proportion of heat stroke cases resulting in hospitalization. While between 2018 and 2020 the rate of heat exhaustion also declined by approximately 30%, rates then increased through 2022. This increase in heat exhaustion cases observed in the last 2 years of the surveillance period coincides with an increase in the proportion of cases identified from RMEs.

As has been noted in previous *MSMR* heat illness updates, results indicate that a sizable proportion of cases identified through DMSS records (hospitalizations and ambulatory visits) did not prompt mandatory reports through the reporting system.[12] In 2022, only about half of heat illness cases were accompanied by RMEs. It is possible that cases of heat illness, whether diagnosed during an inpatient or outpatient encounter, were not documented as RMEs either because treatment providers were unaware of the reporting criteria, or due to ambiguities in their criteria interpretation. Underreporting is especially concerning for cases of heat stroke due to its severity and potential necessity of timely local intervention for preventing additional cases.

In 2022, rates of heat stroke and heat exhaustion were slightly higher among men

TABLE 2. Heat Injury Events[a] by Location of Diagnosis or Report (with at least 100 cases during period of surveillance), Active Component, U.S. Armed Forces, 2018-2022

Location of diagnosis	No.	% Total
Fort Benning, GA	2,075	16.7
MCB Camp Lejeune/ Cherry Point, NC	936	7.5
Fort Bragg, NC	935	7.5
Fort Campbell, KY	741	6.0
Fort Polk, LA	579	4.7
MCRD Parris Island/ Beaufort, SC	572	4.6
NMC San Diego, CA	491	4.0
Fort Hood, TX	436	3.5
MCB Camp Pendleton, CA	409	3.3
MCB Quantico, VA	368	3.0
JBSA-Lackland AFB, TX	340	2.7
NH Okinawa, Japan	321	2.6
Fort Jackson, SC	216	1.7
Fort Stewart, GA	176	1.4
Fort Irwin, CA	163	1.3
Fort Sill, OK	142	1.1
Fort Leonard Wood, MO	137	1.1
Fort Schafter, HI	135	1.1
Fort Bliss, TX	111	0.9
Fort Riley, KS	110	0.9
Outside U.S.[b]	385	3.1
All other locations	2,626	21.2
Total	12,404	100.0

Abbreviations: No., number; MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NMC, Naval Medical Center; JBSA, Joint Base San Antonio; NH, Naval Hospital.
[a]One heat injury per person per year.
[b]Excluding Okinawa, Japan.
Note: Recruit training locations include Fort Benning, MCB Camp Lejeune/Cherry Point, MCRD Parris Island/Beaufort, MCB Camp Pendleton, JBSA-Lackland AFB, Fort Jackson, Fort Sill, and Fort Leonard Wood. Fort Polk is the Joint Readiness Training Center (JRTC) and Fort Irwin is the National Training Center (NTC).

than women, which is not consistent with published observational studies of military personnel that reported elevated risk of exertional heat illness among women.[13] Because this finding may be due to variation in true exposure time rather than physiologic or morphologic differences in body temperature responses between men and women, further investigation is warranted.

Of all members of the military, Marine Corps and Army recruit trainees, particularly those training at installations in the southeastern U.S., along with those in combat-specific occupations, suffered the highest rates of heat stroke and heat exhaustion. Army and Marine Corps members in combat units often engage in intense physical training, field training exercises, as well as personal fitness training in varied environmental conditions, which may account, at least in part, for this finding. The annual numbers of heat illnesses diagnosed in the CENTCOM AOR have declined since 2019, likely due to the reduction in forces deployed to that area.

There are limitations to this update that should be considered when interpreting these results. Because management and coding of similar heat-related clinical illnesses are often location-specific, direct rate comparisons of nominal heat stroke and heat exhaustion events could be imprecise when comparing cases from different locations and settings. Heat illnesses during training exercises and deployments treated in field medical facilities were potentially not fully ascertained as cases for this report. Recruit trainees were identified using an algorithm based on age, rank, location, and time in service. This method was only an approximation and likely resulted in some misclassification of recruit training status. At the time of the analysis, Army personnel data were not available for November and December 2022. Therefore, personnel data were imputed from previous months, which likely resulted in the underestimation of Army recruits and periods of recruit training during the last 2 months of 2022. Due to this data discrepancy, recruit rates should be interpreted with caution.

The guidelines for mandatory heat illness reporting were modified in the 2017 revision of the Armed Forces guidelines and RME case definitions and remained in the 2020 revision.[7] This updated version of the guidelines and case definitions removed the heat injury category, leaving only case classifications for heat stroke and heat exhaustion. To compensate for possible reporting variation, 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-10 codes for the entire surveillance period. The exclusion of diagnosis codes for other and unspecified effects of heat and light (formerly included within the "other heat illnesses" category) in the current analysis precludes direct comparison of numbers and rates of cases of heat exhaustion to numbers and rates of "other heat illnesses" reported in *MSMR* updates before 2018. It should be noted that medical data from July 2017 to October 2019 at sites using the new MHS electronic health record, MHS GENESIS, are not available in the DMSS and thus not included in this report—these sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center.

Heat illnesses, which are largely preventable, remain a persistent threat to both the health of U.S. military members and the effectiveness of military operations. Appropriate command emphasis, recognition, and employment of preventive countermeasures for heat illness are crucial steps in effective risk reduction.

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Update
Exertional Rhabdomyolysis Among Active Component Members of the U.S. Armed Forces, 2018–2022

Exertional rhabdomyolysis is a pathologic muscle breakdown associated with strenuous physical activity. A largely preventable condition, it persists as an occupational hazard of military training and operations, especially in high heat environments among individuals exerting themselves to endurance limits. During the 5-year surveillance period, unadjusted incidence rates of exertional rhabdomyolysis among U.S. service members declined by approximately 15%, from 43.1 cases per 100,000 person-years (p-yrs) in 2018 to 36.5 cases per 100,000 p-yrs in 2022. Consistent with prior reports, subgroup-specific rates in 2022 were highest among men, those younger than 20 years, non-Hispanic Black service members, Marine Corps or Army members, and those in combat-specific and "other" occupations. Recruit trainees had the highest rates of exertional rhabdomyolysis in 2021 and 2022, with incidence rates 10 times higher than all other service members. Prompt recognition of the symptoms of exertional rhabdomyolysis (muscular pain or swelling, limited range of motion, or the excretion of darkened urine after strenuous physical activity, especially in hot, humid weather) by health care providers is crucial to avoid the most severe consequences of this potentially life-threatening condition.

What are the new findings?

The 473 incident cases in 2022 of exertional rhabdomyolysis represent an unadjusted annual incidence rate of 36.5 cases per 100,000 p-yrs among the active component, the lowest rate observed between 2018 and 2022. Exertional rhabdomyolysis occurred most frequently from mid-spring until early autumn 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?

Exertional rhabdomyolysis is a potentially serious condition requiring vigilance for early diagnosis and aggressive treatment to prevent severe consequences. Service members who experience exertional rhabdomyolysis may be at risk for recurrence, which could limit their military efficacy and potentially predispose them to serious injury. The risk of exertional rhabdomyolysis can be reduced by command awareness of environmental conditions and troop fitness levels, with emphasis on graded, individual preconditioning for more strenuous training, and adhering to recommended work and rest ratios with appropriate hydration schedules, especially in hot, humid weather.

Rhabdomyolysis is characterized by the breakdown of skeletal muscle cells and subsequent release of intracellular contents into the circulatory system. This damage to skeletal muscle is generally caused by high-intensity, protracted, or repetitive physical activity, usually after strenuous exercise at unaccustomed intensity or duration.[1] Initiation of a new strenuous activity during high levels of environmental heat stress heightens risk of exertional rhabdomyolysis.[1] Among members of the U.S. military, this condition is most commonly identified at recruit training and combat installations, where physiological adaptation and environmental acclimatization required for the first 90 days of basic training may predispose new recruits.[2,3] Even carefully monitored athletes who are accustomed to intense training are at risk of exertional rhabdomyolysis,[4] especially when exerting themselves to endurance limits.[5] A history of heat illness and prior heat stroke have also been described as significant risk factors for recruits who sustained rhabdomyolysis,[3,6] revealing the potential for comorbid conditions.

Rhabdomyolysis severity ranges from asymptomatic elevation in serum muscle enzyme levels to life-threatening disease associated with extreme enzyme elevations, electrolyte imbalances, acute kidney failure, disseminated intravascular coagulation, compartment syndrome, cardiac arrhythmia, and liver dysfunction.[1,7-9] The characteristic triad of rhabdomyolysis symptoms are weakness, muscle pain, and red-to-brown urine due to high levels of myoglobin, which are accompanied by an elevated serum concentration of creatine kinase.[7,8] Diagnostic criteria for exertional rhabdomyolysis include severe muscle symptoms (e.g., pain, stiffness, and/or weakness) with laboratory results indicating myonecrosis (usually defined as a serum creatine kinase level 5 or more times the upper limit of normal) following recent exercise.[10]

Each year, the *MSMR* summarizes the numbers, rates, trends, risk factors, and locations of exertional heat injury occurences including exertional rhabdomyolysis. This report includes data from 2018 to 2022. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of the *MSMR*.[2]

Methods

The surveillance period ranged from January 2018 through December 2022 and includes all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps during that time. All data used to determine incident exertional rhabdomyolysis diagnoses were derived from routine Defense Medical Surveillance System (DMSS) records. 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 or the Middle East whose health care 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) with 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*).[2] Each individual could be considered an incident case of exertional rhabdomyolysis only once per calendar year.

To exclude secondary cases of rhabdomyolysis due to either traumatic injury, intoxication, or adverse drug reaction, 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.[11]

For health surveillance purposes, recruit trainees were identified as active component members assigned to service-specific training locations during coincident service-specific basic training periods. Because of the lack of Army personnel data in November and December 2022, soldiers who started basic training during this period were not counted as recruits. Recruit trainees were considered a separate category of enlisted service members in summaries of exertional rhabdomyolysis by overall military grade.

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.

Medical data from sites using the new electronic health record for the Military Health System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS—these sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Medical encounter data for individuals seeking care at any of these facilities from July 2017 through October 2019 were not included in the current analysis.

Results

In 2022, there were 473 cases of rhabdomyolysis likely associated with physical exertion and/or heat stress (i.e., exertional rhabdomyolysis), with 35.3% (n=167) resulting in hospitalization **(Table 1)**. Consistent with prior annual reports, crude incidence rates remained highest among men, those younger than 20 years of age, non-Hispanic Black service members, Marine Corps or Army members, and those in combat-specific and "other" occupations. Recruit trainees continued to present the highest rates of exertional rhabdomyolysis in 2022, at a rate 10 times higher than officers and enlisted members.

During the surveillance period, from 2018 through 2022, crude rates of exertional rhabdomyolysis declined by approximately 15% **(Figure 1)**. This reduction was observed among all services except the Army **(Figure 2)**. Since 2020, less than 40% of cases resulted in hospitalization, a notable decline from the proportions identified from inpatient data records in 2018 (47.3%) and 2019 (42.3%) **(Figure 1)**. During 2018-2022, approximately three-quarters (75.9%) of cases occurred in the warmer months (May through October) **(Figure 3)**.

Rhabdomyolysis by location

During the 5-year surveillance period, 12 installations diagnosed at least 50 cases each; combined, those 12 installations diagnosed more than half (56.7%) of all cases **(Table 2)**. Four of these 12 installations support recruit/basic combat training centers: Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC; Fort Benning, GA; Joint Base San Antonio-Lackland, TX; and Fort Leonard Wood, MO; while 7 installations support large combat troop populations: Fort Bragg, NC; MCB Camp Lejeune/Cherry Point, NC; Marine Corps Base (MCB) Camp Pendleton, CA; Fort Hood, TX; Fort Shafter, HI; Fort Campbell, KY; Fort Carson, CO. From 2018 to 2022, MCRD Parris Island/Beaufort and Fort Bragg together accounted for about one-fifth (20.7%) of all cases **(Table 2)**.

Rhabdomyolysis in Iraq and Afghanistan

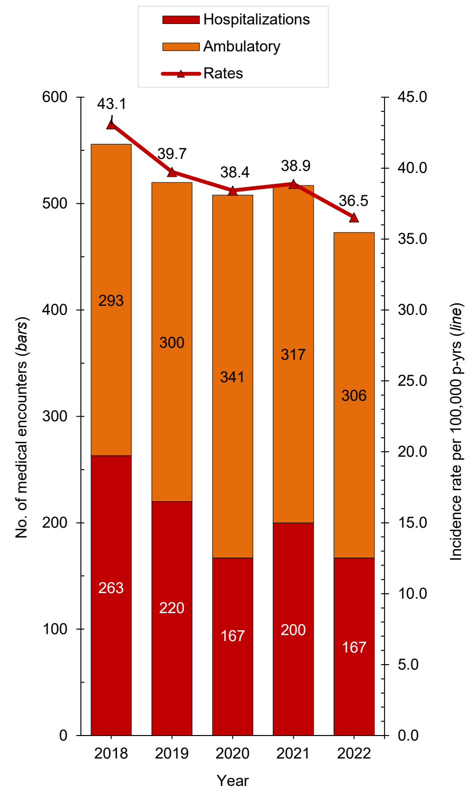
Six cases of exertional rhabdomyolysis were diagnosed and treated in Iraq/Afghanistan during the 5-year surveillance period; half were diagnosed in 2018, with with 1 case each year from 2019 to 2021 and none in 2022 **(data not shown)**. The majority of those deployed service members affected by exertional rhabdomyolysis

TABLE 1. Incident Diagnoses and Incidence Rates[a] of Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2022

	Hospitalizations		Ambulatory Visits		Total	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	167	12.9	306	23.6	473	36.5
Sex						
Male	158	14.8	282	26.4	440	41.2
Female	9	4.0	24	10.6	33	14.6
Age group, y						
<20	33	21.1	87	55.5	120	76.6
20–24	51	15.2	77	22.9	128	38.1
25–29	46	15.1	83	27.3	129	42.5
30–34	17	8.1	31	14.7	48	22.8
35–39	12	7.5	20	12.5	32	20.0
40+	8	6.3	8	6.3	16	12.5
Racial/ethnic group						
Non-Hispanic White	80	11.5	136	19.5	216	30.9
Non-Hispanic Black	49	23.4	67	32.1	116	55.5
Hispanic	20	8.5	64	27.1	84	35.5
Other/unknown[c]	18	11.9	39	25.9	57	37.8
Service						
Army	82	17.8	160	34.7	242	52.4
Navy	16	4.7	24	7.1	40	11.8
Air Force	24	7.5	23	7.2	47	14.6
Marine Corps	45	25.9	99	56.9	144	82.8
Military status						
Recruit	15	70.2	66	309.0	81	379.2
Enlisted	122	11.7	209	20.1	331	31.8
Officer	30	12.9	31	13.3	61	26.2
Military occupation						
Combat-specific[d]	44	24.6	72	40.3	116	64.9
Motor transport	5	12.8	6	15.3	11	28.1
Pilot/air crew	5	10.7	0	0.0	5	10.7
Repair/engineering	31	8.2	31	8.2	62	16.5
Communications/intelligence	33	12.0	46	16.7	79	28.6
Health care	8	7.4	18	16.7	26	24.1
Other/unknown	41	15.2	133	49.3	174	64.5
Home of record[e]						
Midwest	29	13.5	51	23.7	80	37.2
Northeast	16	10.0	42	26.2	58	36.2
South	82	14.5	143	25.2	225	39.7
West	33	10.6	61	19.7	94	30.3
Other/unknown	7	16.5	9	21.2	16	37.6

Abbreviation: No., number.
[a]One case per person per calendar year.
[b]Rate per 100,000 person-years.
[c]Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.
[d]Infantry/artillery/combat engineering/armor.
[e]As self-reported at time of entry into service.

FIGURE 1. Incident Cases and Incidence Rates of Extertional Rhabdomyolysis, by Report Source and Year of Diagnosis, Active Component, U.S. Armed Forces, 2018–2022



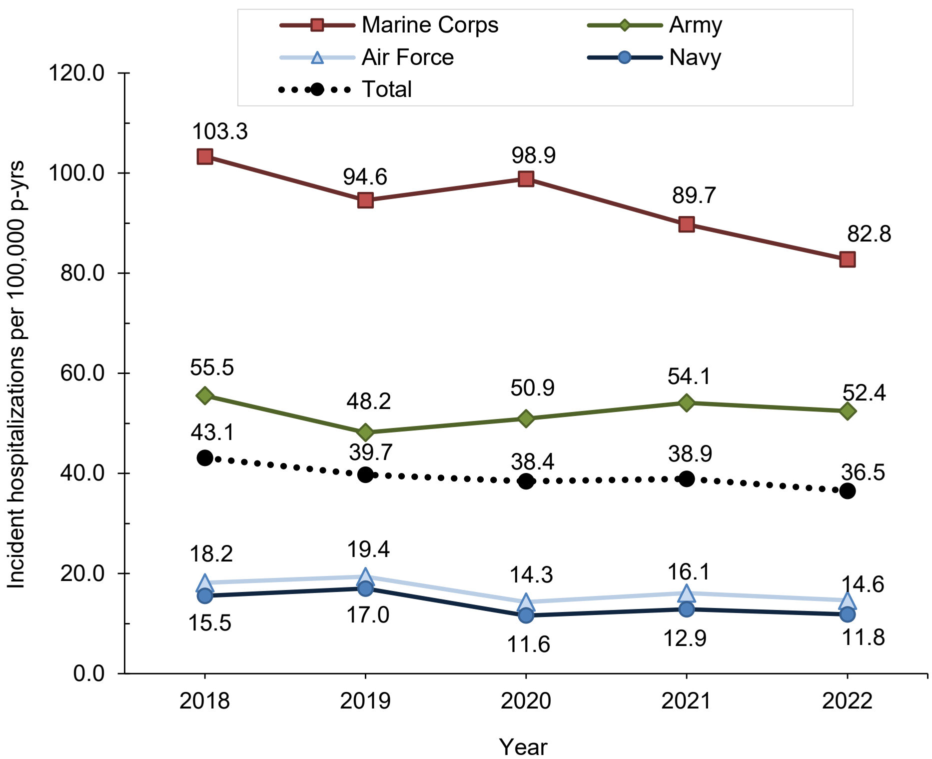
Abbreviations: No., number; p-yrs, person-years.

were non-Hispanic Black (n=3) or non-Hispanic White (n=3), male (n=4), in the Army (n=5), enlisted (n=5), and in health care occupations (n=3). One active component service member was medically evacuated for exertional rhabdomyolysis during the surveillance period, in November 2020 **(data not shown).**

Discussion

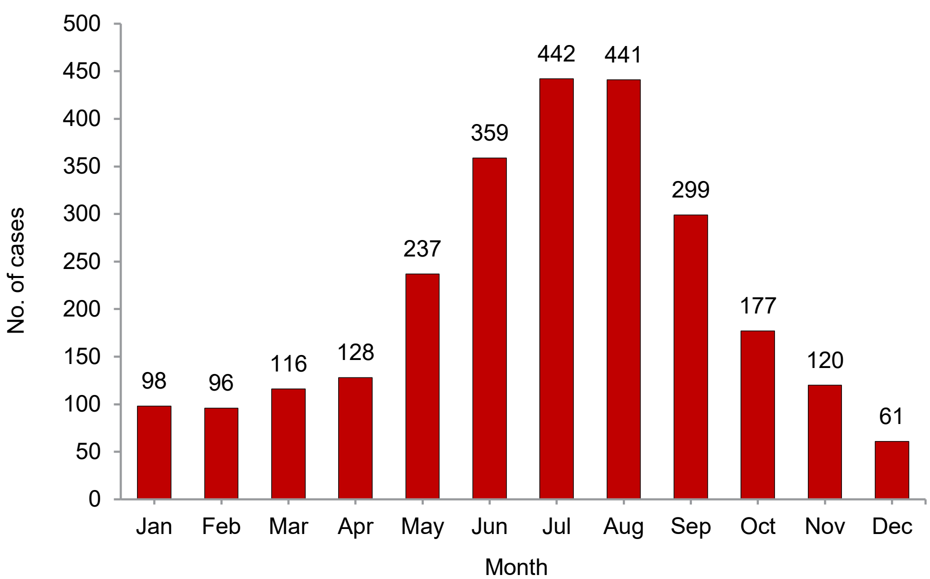
The results of this report document a crude reduction of approximately 15% in exertional rhabdomyolysis rates from 2018 to 2022. Exertional rhabdomyolysis continues to occur most frequently from mid-spring through early autumn at installations that support basic combat/recruit training or major Army or Marine Corps combat units. Recruits can be exposed to environmental situations that require

FIGURE 2. Annual Incidence Rates of Exertional Rhabdomyolysis, by Service, Active Component, U.S. Armed Forces, 2018–2022



Abbreviation: P-yrs, person-years.

FIGURE 3. Cumulative Numbers of Exertional Rhabdomyolysis Cases, by Month of Diagnosis, Active Component, U.S. Armed Forces, 2018–2022



Abbreviation: No, number.

TABLE 2. Incident Cases of Exertional Rhabdomyolysis by Installation (with at least 30 cases during period of surveillance), Active Component, U.S. Armed Forces, 2018–2022

Location of diagnosis	No.	% Total
MCRD Parris Island/ Beaufort, SC	268	10.4
Fort Bragg, NC	264	10.3
Fort Benning, GA	157	6.1
MCB Camp Lejeune/ Cherry Point, NC	133	5.2
MCB Camp Pendleton, CA	111	4.3
Fort Campbell, KY	90	3.5
Fort Hood, TX	86	3.3
NMC San Diego, CA	75	2.9
JBSA-Lackland AFB, TX	73	2.8
Fort Shafter, HI	70	2.7
Fort Leonard Wood, MO	64	2.5
Fort Carson, CO	57	2.2
MCB Quantico, VA	46	1.8
Fort Belvoir, VA	41	1.6
Fort Bliss, TX	40	1.6
Fort Polk, LA	40	1.6
Fort Jackson, SC	38	1.5
NH Okinawa, Japan	37	1.4
Fort Gordon, GA	33	1.3
NH Twentynine Palms, CA	34	1.3
Other/unknown locations	817	31.7
Total	2,574	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.

acclimatization to high heat and humidity during the warmer months, while Soldiers and Marines in combat units often perform rigorous unit physical training, field training exercises, and personal fitness training regardless of weather conditions.

The annual incidence rates of exertional rhabdomyolysis observed among non-Hispanic Black service members were higher than rates observed among members of other racial/ethnic groups. This observation has been attributed, at least in part, to increased risk of exertional rhabdomyolysis among individuals with sickle cell trait (SCT),[12–15] for which the U.S. carrier frequency is approximately 1 in 13 Black/African Americans.[16] A significant association between SCT and a risk of exertional rhabdomyolysis is supported by studies among U.S. service members.[17,18] The rhabdomyolysis-related deaths of 2 SCT-positive service members (a Navy recruit and an Air Force member) in 2019 after physical training stress this potential risk.[19,20]

Although previous studies have established that SCT is associated with a 54% increase in risk of exertional rhabdomyolysis,[17,18] its association with disease progression and severity is unclear and warrants further study.

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 through 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.

Recruit trainees 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. The imputation used to address the gap in Army personnel data from November and December 2022 is another potential source of misclassification, which may have resulted in an underestimation of Army recruits and periods of recruit training during the last quarter of 2022. Due to this data discrepancy, recruit rates should be interpreted with caution.

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.[10,21,22] The Defense Health Agency publishes practice recommendations that provide a synopsis of care for initial management of exertional rhabdomyolysis, high-risk or recurrent exertional rhabdomyolysis, and inpatient care.[23,24] The most severe consequences of exertional rhabdomyolysis are preventable with effective mitigation measures and hightened awareness 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.[10]

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Update

Exertional Hyponatremia Among Active Component Members of the U.S. Armed Forces, 2007–2022

Exertional hyponatremia occurs either during or following periods of heavy exertion, when losses of water and electrolytes due to the body's normal cooling mechanisms are replaced only with water. Hyponatremia can lead to death or serious morbidity if left untreated. Between 2007 and 2022, there were 1,690 diagnoses of exertional hyponatremia among active component service members, for an overall incidence rate of 7.9 cases per 100,000 person-years (p-yrs). Those younger than 20 years or older than 40, non-Hispanic White service members, Marine Corps members, and recruit trainees had higher overall rates of exertional hyponatremia diagnoses. Between 2007 and 2022, annual rates of incident exertional hyponatremia diagnoses peaked (12.7 per 100,000 p-yrs) in 2010 and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013. During the last 9 years of the surveillance period, rates fell between a range of 6.1 and 8.6 cases per 100,000 p-yrs. Service members and their supervisors must know the dangers of excessive water consumption and prescribed limits for water intake during prolonged physical activity, such as field training exercises, personal fitness training, as well as recreational activities, particularly in hot, humid weather.

What are the new findings?

The vast majority of exertional hyponatremia cases were treated in outpatient settings, suggesting that most cases were identified during the early and less severe stages.

What is the impact on readiness and force health protection?

Exertional hyponatremia continues to pose a health risk to U.S. military members and can be fatal if not promptly recognized and appropriately treated. 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 hot weather.

Exertional hyponatremia, or exercise-associated hyponatremia, refers to a low plasma sodium concentration (below 135 milliequivalents per liter) that develops within 24 hours of prolonged physical activity.[1] Exertional hyponatremia usually results from consumption of large volumes of water in a short time. Acute hyponatremia creates an osmotic gradient that causes water to flow into the cells of various organs, including the lungs and brain, producing serious and sometimes fatal clinical effects.[1,2] Exertional hyponatremia can result from loss of sodium or potassium, relative body water excess, or a combination of both,[3] but overconsumption of fluids and a resultant excess of total body water are the primary factors in the development of exertional hyponatremia.[1,3,4]

Exertional hyponatremia has been described in relation to a variety of activities including endurance competitions, hiking, police training, American football, fraternity hazing, and military exercises.[1] Hyponatremia incidence from these events varies widely, and is dependent upon activity duration, stress from heat or cold, water availability, and other risk factors. Water consumption in volumes greater than its loss through sweat, respiration, and renal excretion remains the single most important risk factor.[1] The amount of excess water consumption required to induce exertional hyponatremia is substantial. In an outbreak among Marine recruits in 1995, between 10 and 22 quarts of water were consumed by each person over a few hours.[5] In endurance sports competitions, lack of acclimatization to local environmental conditions is another risk factor for exertional hyponatremia.[6] Other important risk factors include an exercise duration greater than 4 hours, inadequate event training, and either a high or low body mass index.[1]

Exertional hyponatremia continues to pose a health risk to U.S. military members that can significantly impair performance and reduce combat effectiveness. This report summarizes the frequencies, rates, trends, geographic locations, and both demographic and military characteristics of incident cases of exertional hyponatremia among active component service members, from 2007 to 2022.

Methods

The surveillance population for this report consists of all active component service members of the U.S. Army, Navy, Air Force, or Marine Corps who served at any time during the surveillance period, from January 1, 2007 to December 31, 2022. 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 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 or the Middle East and whose health care encounters were documented in the Theater Medical Data Store (TMDS).

For this report, 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).[7]

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 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. Percent change in incidence was calculated using unrounded rates. At the time of this analysis, Army personnel data were not available for November and December 2022. To calculate person-time for Army members during this period, the October personnel data were used.

For health surveillance purposes, recruit trainees were identified as active component members assigned to service-specific training locations during coincident service-specific basic training periods. Because of the lack of personnel data in November and December 2022, Army members who started basic training during this period were not counted as recruits. Recruit trainees were considered a separate category of enlisted service members in summaries of heat illnesses by overall military grade.

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.

Medical data from sites using the new electronic health record for the Military Health System, MHS GENESIS, between July 2017 and October 2019 are not available in the DMSS and thus not included in this report—these sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center.

Results

In 2022, there were 104 diagnoses of exertional hyponatremia among active component service members, with a crude incidence rate of 8.0 per 100,000 p-yrs **(Table 1)**. The 2022 incidence rate patterns were broadly similar by demographic and military characteristics to those in prior years. Demographic categories are presented as cumulative rates to promote rate stability, since stratification of the annual rates yielded frequencies of less than 20 in more than 40% of the table sub-categories.

Between 2007 and 2022, men represented the vast majority (84.0%) of exertional hyponatremia cases but had an incidence rate comparable to women **(Table 1)**. Subgroup-specific incidence rates were highest among those in the youngest (under 20 years) and oldest (40 years or older) age groups, non-Hispanic White service members, Marine Corps members, and recruit trainees. The rate of hyponatremia among Marine Corps members was markedly higher than the rates of those in other services. Although recruit trainees accounted for approximately one-sixth (16.5%) of all exertional hyponatremia cases, their crude incidence rate was 10.4 and 6.5 times the rates among other enlisted members and officers, respectively. During the 16-year period, 86.8% (n=1,467) of all cases were diagnosed and treated without hospitalization **(Figure 1)**.

Between 2007 and 2022, the crude annual rates of incident exertional hyponatremia diagnoses peaked in 2010 (12.7 per 100,000 p-yrs) and then decreased to a low of 5.3 cases per 100,000 p-yrs in 2013 **(Figure 1)**. During the last 9 years of the surveillance period, rates fluctuated between 6.1 and 8.6 cases per 100,000 p-yrs. With the exception of 2021, annual incidence rates of exertional hyponatremia diagnoses were markedly higher in the Marine Corps than in other services **(Figure 2)**.

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 50.9% of total cases **(Table 2)**. Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC reported 209 cases of exertional hyponatremia, the highest in the DOD.

Exertional hyponatremia in the CENTCOM AOR

Between 2007 and 2022, a total of 23 cases of exertional hyponatremia were diagnosed and treated in the CENTCOM AOR **(data not shown)**. Two new cases were diagnosed in 2022.

TABLE 1. Incident Cases[a] and Incidence Rates[b] of Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2007–2022

	2022		Total 2007–2022	
	No.	Rate[a]	No.	Rate[a]
Total	104	8.0	1,690	7.9
Sex				
Male	87	8.1	1,420	7.8
Female	17	7.5	270	8.1
Age group, y				
<20	12	14.8	218	15.5
20–24	23	5.6	502	7.3
25–29	17	5.6	314	6.2
30–34	17	8.1	204	6.1
35–39	16	10.0	198	7.9
40+	19	14.9	254	11.5
Racial/ethnic group				
Non-Hispanic White	47	6.7	1,106	8.8
Non-Hispanic Black	24	11.5	216	6.3
Hispanic	16	6.8	186	6.2
Other/unknown	17	11.3	182	7.7
Service				
Army	32	6.9	608	7.6
Navy	21	6.2	266	5.1
Air Force	30	9.3	333	6.4
Marine Corps	21	12.1	483	16.1
Military status				
Recruit	10	46.8	279	63.1
Enlisted	68	6.5	1,048	6.1
Officer	26	11.2	363	9.8
Military occupation				
Combat-specific[c]	10	5.6	291	9.4
Motor transport	3	7.7	34	5.3
Pilot/air crew	3	6.4	46	5.8
Repair/engineering	21	5.6	290	4.6
Communications/intelligence	24	8.7	301	6.4
Health care	7	6.5	129	7.0
Other/unknown	36	13.4	599	14.6

Abbreviation: No., number.
[a]One case per person per year.
[b]Rate per 100,000 person-years.
[c]Infantry/artillary/combat engineering/armor.

Deployed service members affected by exertional hyponatremia were most frequently male (n=19; 82.6%), non-Hispanic White (n=19; 82.6%), 20-24 years old (n=10; 43.5%), in the Army (n=14; 60.9%), enlisted (n=19; 82.6%), and in combat-specific (n=7; 30.4%) or communications/intelligence (n=6; 26.1%) occupations **(data not shown)**. Seven service members were medically evacuated from the CENTCOM AOR for exertional hyponatremia, in 2007 or 2018 **(data not shown)**.

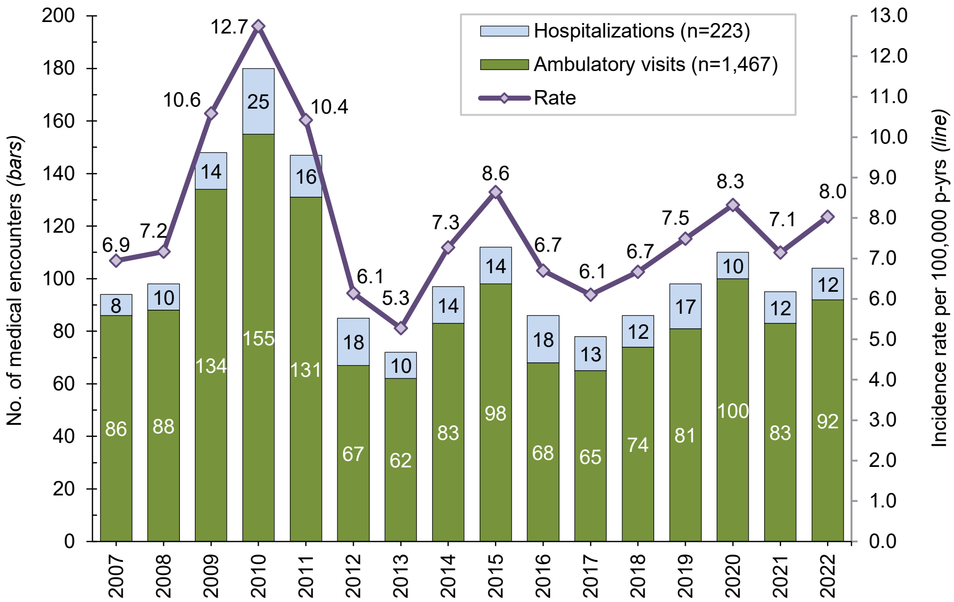
Discussion

For the last decade, incidence rates of exertional hyponatremia have remained relatively stable among active component service members. Subgroup-specific patterns (e.g., age, racial/ethnic group, service, and military status) of overall incidence rates were generally similar to those reported in previous *MSMR* updates.[8] In *MSMR* analyses before April 2018, in-theater cases included diagnoses of hypo-osmolality and/or 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.

Recruits remain at high risk for exertional hyponatremia. In this report, rates were relatively high among the youngest, hence most junior service members, with highest case numbers diagnosed at medical facilities that support large recruit training centers (e.g., MCRD Parris Island/Beaufort, SC; Fort Benning, GA; Joint Base San Antonio–Lackland Air Force Base, TX) and large Army and Marine Corps combat units (e.g., Fort Bragg, NC; Marine Corps Base Camp Lejeune/Cherry Point, NC).

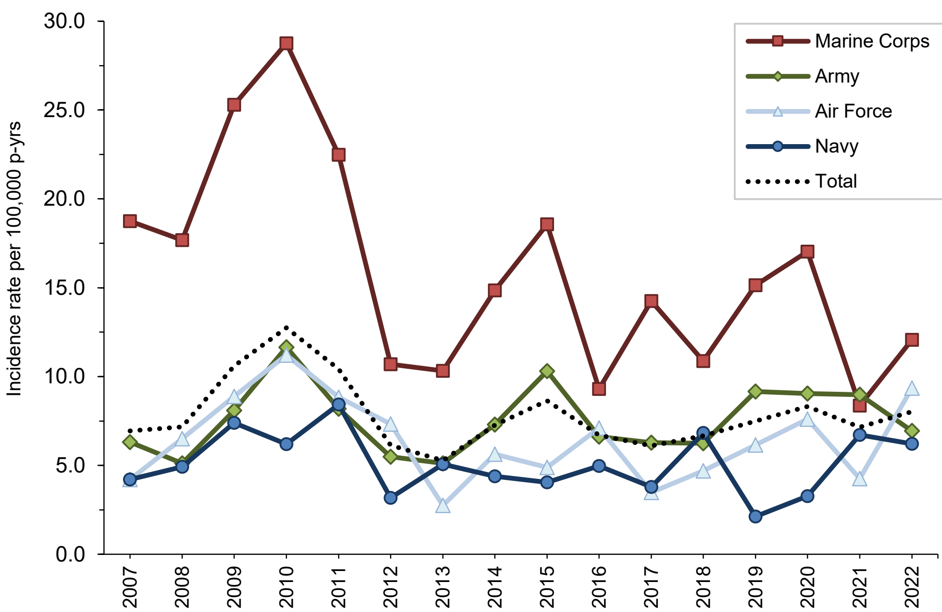
Several important limitations should be considered when interpreting these results. First, there is no diagnostic code specific for exertional hyponatremia. This lack of specificity may result in the inclusion of some non-exertional cases of hyponatremia, thus overestimating the true rate. Consequently, these results should be considered estimates of the actual

FIGURE 1. Annual Incident Cases and Rates of Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2007–2022



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

FIGURE 2. Annual Incidence Rates of Exertional Hyponatremia, by Service, Active Component, U.S. Armed Forces, 2007–2022



Abbreviation: P-yrs, person-years.

TABLE 2. Incident Cases of Exertional Hyponatremia by Installation (with at least 20 cases during period of surveillance), Active Component, U.S. Armed Forces, 2007–2022

Location of diagnosis	No.	% Total
MCRD Parris Island/ Beaufort, SC	209	12.4
Fort Benning, GA	124	7.3
JBSA-Lackland AFB, TX	70	4.1
Fort Bragg, NC	56	3.3
MCB Camp Lejeune/ Cherry Point, NC	55	3.3
Walter Reed NMMC, MD[a]	46	2.7
MCB Camp Pendleton, CA	42	2.5
NMC San Diego, CA	40	2.4
NMC Portsmouth, VA	36	2.1
MCB Quantico, VA	34	2.0
Fort Hood, TX	31	1.8
Fort Campbell, KY	28	1.7
Fort Schafter, HI	26	1.5
Fort Belvoir, VA	22	1.3
Fort Jackson, SC	21	1.2
Fort Carson, CO	20	1.2
Other/unknown locations	830	49.1
Total	1,690	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.

[a]Walter Reed National Military Medical Center (NMMC) is a consolidation of National Naval Medical Center (Bethesda, MD) and Walter Reed Army Medical Center (Washington, DC). This number represents the sum of the 2 sites prior to the consolidation (November 2011) and the number reported at the consolidated location.

Note: Recruit training locations include MCRD Parris Island/Beaufort, Fort Benning, 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.

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 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, concern, and aggressive management for incipient cases by military supervisors and primary health care providers.

Finally, recruit trainees 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. The imputation used to address the gap in Army personnel data from November and

December 2022 is another potential source of misclassification that may have resulted in underestimation of Army recruits and periods of recruit training during the last 2 months of 2022. Due to this data discrepancy, recruit rates should be interpreted with caution.

Military training may have to be conducted in difficult conditions, and during hot and humid weather commanders, supervisors, instructors, and medical support staff must be aware of, monitor, and enforce guidelines for work-rest cycles and water consumption.[2] The continued necessity of training and operations under challenging environmental conditions creates a high-risk environment for exertional hyponatremia and other heat illnesses. While the rates of exertional hyponatremia have remained relatively low over the past 15 years, the Defense Health Agency continues to publish practice recommendations intended to guide the prevention, assessment, and management of exercise associated hyponatremia.[10] Thoughtful risk assessment and planning are necessary for keeping this preventable illness at its current low levels.

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Medical Surveillance Monthly Report (MSMR), in continuous publication since 1995, is produced by the Armed Forces Health Surveillance Division (AFHSD) of the Defense Health Agency (DHA) Public Health Directorate. AFHSD 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 AFHSD and integrated into the Defense Medical Surveillance System for health surveillance purposes.

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ISSN 2158-0111 (print)

ISSN 2152-8217 (online)

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