UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND READINESS

NOV 2 8 2023

The Honorable Mike D. Rogers
Chairman
Committee on Armed Services
U.S. House of Representatives
Washington, DC 20515

Dear Mr. Chairman:

The Department's response to House Report 117–118, page 174, accompanying H.R. 4350, the National Defense Authorization Act for Fiscal Year 2022, "Heat Illness Report," is enclosed.

Exertional heat illness is a reportable condition for which ongoing Department of Defense attention and resources are required to reduce the incidence of cases. Over 11,000 cases of heat exhaustion and heatstroke have been diagnosed in the U.S. military since 2018. Over half of these cases were not captured as reportable medical events, indicating that case follow-up by installation public health authorities may not have occurred. Sufficient education, policies, and training resources are in place to prevent heat injuries among Service members. However, deficient reporting limits the necessary investigation of cases to determine if mitigation strategies are being followed.

Thank you for your continued strong support for the health and well-being of our Service members. I am sending a similar letter to the Senate Armed Services Committee.

Sincerely,

Ashish S. Vazirani
Acting

Enclosure:
As stated

cc:
The Honorable Adam Smith
Ranking Member

UNDER SECRETARY OF DEFENSE
4000 DEFENSE PENTAGON
WASHINGTON, D.C. 20301-4000

PERSONNEL AND READINESS

NOV 28 2023

The Honorable Jack Reed
Chairman
Committee on Armed Services
United States Senate
Washington, DC 20510

Dear Mr. Chairman

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Exertional heat illness is a reportable condition for which ongoing Department of Defense attention and resources are required to reduce the incidence of cases. Over 11,000 cases of heat exhaustion and heatstroke have been diagnosed in the U.S. military since 2018. Over half of these cases were not captured as reportable medical events, indicating that case follow-up by installation public health authorities may not have occurred. Sufficient education, policies, and training resources are in place to prevent heat injuries among Service members. However, deficient reporting limits the necessary investigation of cases to determine if mitigation strategies are being followed.

Thank you for your continued strong support for the health and well-being of our Service members. I am sending a similar letter to the House Armed Services Committee.

Sincerely,

Ashish S. Vazirani
Acting

Enclosure:
As stated

cc:
The Honorable Roger F. Wicker
Ranking Member

Report to the Committees on Armed Services of the Senate and the House of Representatives

Heat Illness Report

November 2023

The estimated cost of this report or study for the Department of Defense (DoD) is approximately $6,800 in Fiscal Years 2020 - 2022. This includes $0 in expenses and $6,800 in DoD labor.

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I: EXECUTIVE SUMMARY

Report to Committees on Armed Services of the Senate and House of Representatives Regarding Exertional Heat Illness in the Military

Defense Centers for Public Health–Aberdeen

Heat stroke and heat exhaustion are conditions required to be reported through the Disease Reporting System internet (DRSi) according to Department of Defense Directive (DoDD) 6490.02E, "Comprehensive Health Surveillance," February 8, 2012, as amended. From 2018-2022, a total of 11,218 heat-related illnesses were diagnosed at more than 230 military installations and geographic locations worldwide; 52.6 percent of 2,103 incident heat stroke encounters lacked a corresponding reportable medical event (RME) recorded in the DRSi. Heat stroke cases were more likely to be missing a corresponding report in the DRSi if the case had been diagnosed in an outpatient setting (58.6 percent), in a privately sourced clinic (77.9 percent), or at a non-training installation (56.8 percent).

During the same 5-year period, 64.6 percent of 9,115 medical encounters for heat exhaustion did not have an associated report identified in DRSi. Consistent with patterns for heat stroke, clinically diagnosed cases of heat exhaustion were more likely not to have been reported as a heat-illness event in the DRSi if care was provided in an outpatient setting (64.7 percent), a private clinic (92.9 percent), or at a non-training installation (69.5 percent).

The populations with the highest rates of heat stroke and heat exhaustion were most often reported appropriately in the DRSi. These included male, Active Component Service members (ACSMs) under the age of 20; trainees; and personnel in combat-related military occupations. Underreporting of exertional heat illness (EHI) was more common in older ACSMs, senior enlisted or senior officer grades, and occupations other than field and combat. Heat exhaustion was underreported more often among female ACSMs than their male counterparts; however, this disparity was not observed in heat stroke reporting.

Potential reasons for underreporting of diagnosed heat illness in the DRSi, as required by regulation, include lack of awareness of the reporting requirements among health care providers, health care provider inattentiveness to the reporting requirements for heat illnesses because of ambiguity in interpreting the criteria (e.g., the heat illness did not result in a change in duty status, or the core body temperature measured during or immediately after exertion or heat exposure was not available), a (misguided) belief among health care providers that reporting is not required for non-severe illness (appropriate reporting is most consistent for hospitalized heat stroke compared to outpatient encounters for less severe illness), and insufficient personnel resources available to carry out the mission of public health surveillance and reporting at some military medical treatment facilities (MTFs). The diagnosis codes for mandatory reporting of heat illness do not require updating. The diagnostic codes are specific to heat exhaustion and heat stroke and are consistent with the current Department of Defense (DoD) case definitions, and to use for evaluation of underreporting.

Technical Bulletin, Medical (TB MED 507), published in April 2022 provides the latest evidence-based guidance for the prevention and treatment of heat illness. It provides guidance to

U.S. and allied military and civilian leaders, safety and occupational health professionals, unit safety officers, and health care providers. In the process of revising TB MED 507, the authors compiled policy and guidance documents from each of the Military Departments. This document includes specific guidance for application to recruit training environments. Military Service-specific guidance has been updated or undergoing revisions since the publication of this document.

Military Service-specific guidance documents contain instructions for unit commanders to conduct heat illness prevention training annually. Fort Moore has historically had the highest frequency of heat illness among DoD installations, and for this reason was chosen as the location for the U.S. Army Heat Center, which hosts the annual Fort Moore Heat Forum with Tri-Service participation, specifically including recruit training center representatives. Heat Center personnel conduct training for clinical and non-clinical audiences across the Services on topics including heat illness prevention, recognition, response, and return-to-duty considerations. Since the Heat Center's creation in 2019, the frequency of exertional heat stroke at Fort Moore has been reduced by 47 percent (DeGroot et al. 2022).

A "black flag" corresponds with Heat Category 5 on military installations, declared when a Wet Bulb Globe Thermometer (WBGT) reading is over 90° F. There is no definition of a "black flag day" in military doctrine. For the purpose of this report, a "black flag day" represents a day when the maximum hourly WBGT value is greater than 90°F, calculated from a retrospective analysis of outdoor weather conditions using archived meteorological data from weather stations in closest proximity to each military installation of interest.

Between 1996 and 2019, 84 percent of heat illness events experienced by ACSMs stationed in the continental United States (CONUS) occurred at conditions other than black flag. Further, 20 percent of heat illness cases occurred when the daily maximum WBGT was below 78°F, corresponding to no flag conditions. A review of daily flag conditions at 15 CONUS training installations between 2008 and 2022 showed higher annual average heat stress days (yellow, red, and black flag conditions) in the last 5 years of the 15-year period. This suggests that elevated heat stress conditions are more frequent in recent years compared to the previous 15 years.

Currently, there is no standardized tracking or archiving of WBGT readings or heat stress flag conditions at U.S. military training locations. This is due to existing military doctrine that requires heat stress measurements only when ambient temperatures are high, and then only for the purpose of acutely guiding situational risk management. Further, the preponderance of heat illness cases occurring under moderate conditions suggests that factors other than heat stress are playing an unaddressed role in these outcomes.

No standardized and validated survey instruments for military populations were available during the preparation of this report. This gap highlights the need for development of surveys on heat illness prevention and mitigation knowledge, attitudes, and practices among Armed Forces personnel. To address this, a sample methodology to assess military leaders' understanding of, and adherence to, medical protocols and best practices for the prevention of heat illness was developed.

Multiple public-facing resources currently exist. Among these are the Warrior Heat- and Exertion-Related Event Collaborative (WHEC) website, which provides a variety of informational products for clinicians and Service members, including treatment algorithms, training and education products, clinical practice guidelines, Defense Health Agency (DHA)-approved practice recommendations, and a variety of research reports. In Calendar Year (CY) 2022, the site recorded over 36,000 unique pageviews with more than 400 document downloads. The Defense Centers for Public Health-Aberdeen maintains a Heat Illness Prevention and Sun Safety public-facing website, and the Armed Forces Health Surveillance Division (AFHSD) maintains an online archive of the *Medical Surveillance Monthly Report*. Each year, the April issue includes an update on the incidence of, and risk factors for, EHI, exercise-associated hyponatremia, and exertional rhabdomyolysis.

II. ACKNOWLEDGMENTS

DHA compiled this report with contributions from the U.S. Army Research Institute of Environmental Medicine, the U.S. Army Heat Center, and the Uniformed Services University of Health Sciences.

The research physiologists, dietitians, medical providers, scientific advisors, and leaders who contributed to this report remain committed to minimizing the risk of EHI within the military training environment.

III: ASSESSMENT OF EFFORTS TO REDUCE HEAT-RELATED ILLNESSS AT U.S. MILITARY INSTALLATIONS

This report is in response to House Report 117–118, page 174, accompanying H.R. 4350, the National Defense Authorization Act for Fiscal Year 2022, "Heat Illness Report," which requests the Secretary of Defense "to submit a report…detailing the efforts to reduce heat-related illnesses at U.S. military installations."

House Report 117–118 requested that the DoD heat illness report include information and recommendations based on, but not limited to:

> (1) An analysis of the number of heat stroke and heat exhaustion cases that did not prompt mandatory reports through the Reportable Medical Events System, and how the guidelines for mandatory reporting, including diagnosis codes, of heat illnesses should be updated.
>
> (2) An analysis of whether the Department of Defense should update heat-related health guidelines to better reflect current risks and projections of worsening extreme heat, especially whether specific guidelines are needed for recruit training centers.
>
> (3) A description of the training and education on the detection and prevention of heat-related illnesses that are taking place across the military services.
>
> (4) An accounting of how many black flag days were declared at each military training location over the last five years, as well as a plan to track black flag days

on military installations and compile the data in a central location, accessible to the public.

(5) A survey of military leaders' understanding of and adherence to medical protocols and best practices when personnel fall ill due to extreme heat.

(6) An assessment of whether a public-facing online resource center with scientific and educational resources that provide data and guidance on heat-related illness would be valuable to increase servicemember knowledge and help reduce the frequency of heat-related illnesses.

This document summarizes the information, findings, and recommendations of the DoD, which addresses the six House Armed Services Committee requests cited above.

Definition of Heat Illness

Heat illness refers to a group of disorders that occur when the elevation of core body temperature surpasses the compensatory limits of thermoregulation. Heat illness is the result of environmental heat stress and/or exertion and represents a set of conditions that exist along a continuum from less severe (heat exhaustion) to potentially life threatening (heat stroke). Effective countermeasures are available and are being utilized, however heat illness utilized remains a significant threat to the health and operational effectiveness of military members and their units.

Background

From 2018 to 2022, a total of 11,218 heat-related illnesses were diagnosed at more than 230 military installations and geographic locations worldwide (Table 3 and Table 4). The 15 training locations in this analysis (Table 2) accounted for 29 percent of heat stroke encounters and 36 percent of all heat exhaustion encounters. In general, training locations had more encounters with an associated RME than non-training locations.

i: Analysis of the Number of Heat Stroke and Heat Exhaustion Cases

DoDD 6490.02E requires reporting of notifiable medical conditions (DoD 2012). The guidelines and specific case definitions for all medical conditions that are required to be reported are described in the *Armed Forces Reportable Medical Events Guidelines & Case Definitions* (AFHSD 2020). Notifiable medical conditions, such as heat exhaustion and heat stroke, are reported through a single electronic system, the DRSi, available at all MTFs (AFHSD 2019).

Heat illness is defined as a diagnosed case of either heat exhaustion or heat stroke. Heat exhaustion is an acute reaction to excessive heat often accompanied by profuse sweating, dizziness, nausea, headache, and fatigue. Heat stroke is a more serious form of hyperthermia, in which the core body temperature measured immediately following collapse during strenuous activity is elevated above 104ºF/40ºC and accompanied by central nervous system dysfunction (i.e., disorientation, headache, irrational behavior, irritability, emotional instability, confusion, altered consciousness, or seizure). Heat stroke is considered a medical emergency that can be fatal if not properly treated (DoD 2012).

An analysis of the number of heat stroke and heat exhaustion cases from 2018 to 2022 and associated demographic characteristics that did not prompt mandatory reports through DRSi was conducted using standardized surveillance methods. The AFHSD uses standard surveillance case definitions for routine surveillance and reporting. These case definitions have been designed for use with administrative health care data derived from the Military Health System (MHS) electronic health record (I) and contained in the Defense Medical Surveillance System (DMSS) and other available datasets (DoD 2012).

The DMSS contains administrative records for all medical encounters of ACSMs (i.e., Army, Navy, Air Force, and Marine Corps) who are hospitalized (inpatient) or receive ambulatory (outpatient) care at MTFs or through civilian, privately sourced care. Records of health care encounters from both sources of care were included in this analysis. All ACSM inpatient or outpatient medical encounters occurring between January 1, 2018 and December 21, 2022 were searched for diagnoses in the primary (first listed) diagnostic position or secondary (second listed) diagnostic position using the *International Classification of Diseases, 10th Revision, Clinical Modification* (ICD-10-CM; CDC 2000) codes for heat exhaustion or heat stroke (Table 1). If an individual received a diagnosis of both heat stroke and heat exhaustion during a given year, only one diagnosis was selected, prioritizing heat stroke before heat exhaustion. Individual encounters within each CY were prioritized in terms of record source with hospitalizations prioritized over ambulatory visits.

Incident cases of notifiable medical events as defined by the criteria specified above were matched to RMEs for heat exhaustion or heat stroke by the closest event date. The total numbers of incident heat exhaustion and heat stroke encounters and the percentage with a corresponding RME were computed for each heat-related medical condition by encounter type (inpatient or outpatient), age, category, sex, race/ethnicity group, grade, military occupation, training location, and care type (direct or privately sourced). Descriptive statistics were used to calculate the percentage of heat illness encounters without a corresponding RME in DRSi.

Table 1. ICD-10-CM Codes Included in Heat Stroke and Heat Exhaustion Case Definitions

<table>
<tr><th>Heat Illness Condition</th><th>ICD 10 Code and Clinical Modification</th></tr>
<tr><td rowspan="2">Heat stroke</td><td>T67.0 Heat stroke and sunstroke [also exertional heat stroke, other heat stroke, and sunstroke]</td></tr>
<tr><td>T67.0XX [includes initial encounter, subsequent encounter, sequalae]</td></tr>
<tr><td rowspan="6">Heat exhaustion</td><td>T67.3 Heat exhaustion, anhidrotic</td></tr>
<tr><td>T67.3XX [includes initial encounter, subsequent encounter, sequelae]</td></tr>
<tr><td>T67.4 Heat exhaustion due to salt depletion</td></tr>
<tr><td>T67.4XX [includes initial encounter, subsequent encounter, sequelae]</td></tr>
<tr><td>T67.3Heat exhaustion, unspecified</td></tr>
<tr><td>T67.5XX [includes initial encounter, subsequent encounter, sequelae]</td></tr>
</table>

For this analysis, 15 installations across the four Military Services were categorized as training locations for officers or enlisted ACSMs. However, whether the heat illnesses at these installations occurred among trainees or other ACSMs could not be determined. A list of the 15 training installations appears in Table 2.

Table 2. DoD Military Training Bases by Service, State, and Mission

Service	Base	State	Training Mission
Army	Fort Moore	Georgia	Basic
Army	Fort Jackson	South Carolina	Basic
Army	Fort Knox	Kentucky	Cadet
Army	Fort Leonard Wood	Missouri	Basic
Army	Fort Sill	Oklahoma	Basic
Army	United States Military Academy	New York	Service Academy
Air Force	Lackland Air Force Base	Texas	Basic
Air Force	Maxwell Air Force Base	Alabama	Officer Candidate
Air Force	United States Air Force Academy	Colorado	Service Academy
Marine Corps	Marine Corps Base Quantico	Virginia	Officer Candidate
Marine Corps	Marine Corps Recruit Depot Parris Island	South Carolina	Basic
Marine Corps	Marine Corps Recruit Depot San Diego	California	Basic
Navy	Naval Station Great Lakes	Illinois	Basic
Navy	Naval Station Newport	Rhode Island	Officer Candidate
Navy	United States Naval Academy	Maryland	Service Academy

Over the study period, 52.6 percent of 2,103 incident heat stroke encounters lacked a corresponding RME (Table 3). Heat stroke cases were more likely to be missing a corresponding RME in DRSi if the case had been diagnosed in an outpatient setting (58.6 percent), in a privately sourced clinic (77.9 percent), or at a non-training installation (56.8 percent).

Senior officers had the highest percentage of diagnosed heat stroke encounters without an associated RME (75.0 percent). The range of heat stroke encounters lacking an RME was higher than the average of 52.6 percent for ACSMs older than 34 years (56.3 percent–69.8 percent) and among military occupations other than infantry or combat (52.0 percent–75.0 percent). Hispanic ACSMs were slightly more likely to have an RME associated with a heat stroke encounter (55.5 percent). There were no differences by sex.

Table 3. Summary of Heat Stroke Encounters with and without RME Records for Heat Stroke, ACSMs, 2018–2022

	Heat stroke encounters	Heat stroke encounters with RME	Heat stroke encounters without an RME	Percent heat stroke encounters without an RME
Total	2,103	997	1,106	52.6%
Encounter type				
Inpatient	628	387	241	38.4%
Outpatient	1,475	610	865	58.6%
Sex				
Male	1,896	901	995	52.5%
Female	207	96	111	53.6%
Age (years)				
< 20	327	178	149	45.6%
20–24	941	431	510	54.2%
25–29	501	237	264	52.7%
30–34	211	103	108	51.2%
35–39	80	35	45	56.3%
40+	43	13	30	69.8%
Race/ethnicity				
Non-Hispanic White	1,223	588	635	51.9%
Non-Hispanic Black	306	144	162	52.9%
Hispanic	330	147	183	55.5%
Other/Unknown	244	118	126	51.6%
Grade				
Junior enlisted (E1-E4)	1,270	615	655	51.6%
Senior enlisted (E5-E9)	459	211	248	54.0%
Junior officer (O1–O3)	331	158	173	52.3%
Senior officer (O4-O10)	36	9	27	75.0%
Warrant officer (W1–W5)	7	4	3	42.9%
Military occupation				
Infantry/artillery/combat engineering	810	436	374	46.2%
Armor/motor transport	57	16	41	71.9%
Pilot/air crew	16	4	12	75.0%
Repair/engineering	234	99	135	57.7%
Communications/intelligence	294	141	153	52.0%
Healthcare	123	53	70	56.9%
Other	569	248	321	56.4%
Training location				
Yes	601	348	253	42.1%
No	1,502	649	853	56.8%
Care type				
Direct	1,840	939	901	49.0%
Privately sourced	263	58	205	77.9%

There were 9,115 medical encounters for heat exhaustion; 64.6 percent of which were not associated with an RME (Table 4). Consistent with patterns for heat stroke, clinically diagnosed cases of heat exhaustion were more likely not to have an associated RME for care provided in an outpatient setting (64.7 percent), a privately sourced clinic (92.9 percent), or at a non-training installation (69.5 percent).

The demographic pattern of heat exhaustion encounters that did not result in an RME for ACSMs mirrors the patterns seen for heat stroke encounters, i.e., increasing age, senior enlisted or senior officer rank, or non-infantry/combat military occupation. The differences based on sex were more apparent with heat exhaustion than heat stroke. The frequency of heat exhaustion encounters without an RME for male ACSMs and female ACSMs was 63 percent and 73 percent, respectively.

Table 4. Summary of Heat Exhaustion Encounters with and without RME Records for Heat Exhaustion, ACSMs, 2018–2022

	Heat exhaustion encounters	Heat exhaustion encounters with an RME	Heat exhaustion encounters without an RME	Percent encounters without an RME
Total	9,115	3,227	5,888	64.6%
Encounter type				
Inpatient	189	77	112	59.3%
Outpatient	8,926	3,150	5,776	64.7%
Sex				
Male	7,707	2,851	4,856	63.0%
Female	1,408	376	1,032	73.3%
Age (years)				
< 20	2,415	971	1,444	59.8%
20-24	4,070	1,487	2,583	63.5%
25-29	1,558	494	1,064	68.3%
30-34	628	188	440	70.1%
35-39	283	58	225	79.5%
40+	161	29	132	82.0%
Race/ethnicity				
Non-Hispanic White	5,074	1,810	3,264	64.3%
Non-Hispanic Black	1,498	494	1,004	67.0%
Hispanic	1,594	603	991	62.2%
Other/Unknown	949	320	629	66.3%
Grade				
Junior enlisted (E1-E4)	6,986	2,613	4,373	62.6%
Senior enlisted (E5-E9)	1,402	376	1,026	73.2%
Junior officer (O1-O3)	634	221	413	65.1%
Senior officer (O4-O10)	58	5	53	91.4%
Warrant officer (W1-W5)	35	12	23	65.7%
Military occupation				
Infantry/artillery/combat engineering	2,874	1,375	1,499	52.2%
Armor/motor transport	251	73	178	70.9%
Pilot/air crew	34	5	29	85.3%
Repair/engineering	1,230	248	982	79.8%
Communications/intelligence	1,292	419	873	67.6%
Healthcare	489	168	321	65.6%
Other	2,945	939	2,006	68.1%
Training location				
Yes	3,297	1,453	1,844	55.9%
No	5,818	1,774	4,044	69.5%
Care type				
Direct	7,547	3,115	4,432	58.7%
Privately sourced	1,568	112	1,456	92.9%

During the 5-year surveillance period, a total of 11,218 heat-related illnesses were diagnosed at more than 230 military installations and geographic locations worldwide (Table 3 and Table 4). The 15 training locations in this analysis (Table 2) accounted for 29 percent of heat stroke encounters and 36 percent of all heat exhaustion encounters. In general, training locations had more encounters with an associated RME than non-training locations.

The ICD-10 codes for heat stroke and heat exhaustion are specific enough to use for evaluation of underreporting. Results from this analysis are consistent with annual surveillance updates of heat illness in the DoD. In prior studies, incident heat stroke and heat exhaustion have been found to be highest among male ACSMs, those less than 20 years old, trainees, and those in combat-specific occupations (AFHSD 2022). In the present analysis, ACSMs in these demographic groups at higher risk for heat illness had better reporting rates in DRSi. In contrast, underreporting of heat illness was more commonly seen for subpopulations with lower frequency of heat illness.

There are several potential reasons for underreporting of diagnosed heat illness. One reason is that some health providers are not aware of reporting requirements. It is possible that cases of heat illness, whether diagnosed during an inpatient or outpatient encounter, were not documented as RMEs because treatment providers were not attentive to the criteria for reporting or because of ambiguity in interpreting the criteria (e.g., the heat illness did not result in a change in duty status, or the body core temperature measured during or immediately after exertion or heat exposure was not available). Underreporting is also influenced by severity of illness, as indicated by the data reflecting that reporting is most consistent for hospitalized heat stroke compared to outpatient encounters. The personnel resources available to carry out the mission of public health surveillance and reporting also vary widely from one MTF to another.

This analysis included encounters from MTFs and from privately sourced care, and there was a much higher frequency of privately sourced care encounters without documented RMEs. The referring MTFs may have missed some privately sourced care encounters for notifiable medical conditions due to lack of follow-up, resulting in a missed reporting opportunity. Lastly, the frequency of underreporting of heat exhaustion in female ACSMs cannot be explained by this analysis.

The findings of this analysis should be interpreted cautiously in view of the methodological limitations. First, the use of administrative data from health records likely overestimates the number of heat illness cases eligible for an RME report because some cases may be subsequently ruled out, resulting in the appearance of underreporting. The *Armed Forces Reportable Medical Events Guidelines* uses core temperature in the case definitions, and the presence or absence of core temperature data may influence the decision to submit an RME. Second, this analysis only evaluated inpatient and outpatient cases of heat illness. Heat illnesses treated in field medical facilities during training exercises and deployments are not included in this report due to underreporting of events. In addition, medical data from sites using MHS GENESIS, the new MHS electronic health record, between July 2017 and October 2019 are not available in the DMSS. Therefore, medical encounter data for individuals seeking care at any of those sites from January 2018 through October 2019 were not included.

This analysis does not suggest that the diagnosis codes for mandatory reporting of heat illness need to be updated. The diagnostic codes are specific to heat exhaustion and heat stroke and consistent with the current DoD case definitions. However, the direct comparison of health encounters to subsequent RMEs identifies areas for further exploration or intervention. This analysis shows that efforts to identify heat illness and report heat illness in those most at risk are occurring. However, understanding the underreporting of heat illness in other subpopulations is necessary. Heat exhaustion in female ACSMs provides an opportunity to explore contributing factors. Similarly, heat stroke and heat exhaustion among older ACSMs, ACSMs receiving outpatient or privately sourced care, or those receiving care at a non-training installation, provide opportunities for root-cause analysis that could foster greater awareness, training, prevention, and risk communication.

ii: Analysis of the DoD Heat-Related Health Guidelines

Each Military Department publishes guidance for the prevention, treatment, and return to duty of heat illness casualties. Considering that heat illness prevention guidance is often provided at the battalion or squadron level and below, based on guidance from higher-level service-specific policy, it is important that those higher-level documents reflect the latest best practices.

Service-specific guidance documents were identified, and the contents were reviewed by subject matter experts. To ensure that all relevant documents were identified, we contacted colleagues in each of the Military Departments for their input. Additionally, internet searches were conducted to further ensure that appropriate documents were identified.

The foundational Army guidance document is Technical Bulletin Medical 507 (TB MED 507), *Heat Stress Control and Heat Casualty Management* (DA 2022). This document was recently updated to include the most recent best practices for the prevention, identification, treatment, and return to duty of EHI casualties. Published on April 12, 2022, the revised TB MED 507 is available on the U.S. Army Publishing Directorate website (https://armypubs.army.mil/) and the WHEC website (https://www.hprc-online.org/resources-partners/whec. (The response in section vi provides additional information about the WHEC).

The revised TB MED 507 includes new and updated information regarding the influence of hot environments on physical work capacity and illness risk. A new category of "very heavy work" has been added to the guidance regarding work-rest cycles and fluid replacement in hot environments (DA 2022, Tables 3-2, 3-3, and 3-5). Guidance now encompasses a wider range of intensities to cover military-relevant activities more comprehensively. Updated guidance to minimize risk of heat illness or improve recovery from collapse during activities in the heat is also provided. This includes use of arm immersion cooling during rest breaks, and a standard operating procedure for the use of iced sheets following collapse in the heat. This updated guidance will ensure that cooling procedures are optimized in suspected heat casualties.

With respect to specific guidance for recruit training centers, TRADOC Regulation 350-29 applies to all Army schools, including initial entry training. Due to the recent revision of TB MED 507, TRADOC Reg 350-29 is currently in revision, with publication anticipated in early spring 2023. The intent of the revision is to ensure that policy, procedures, and best practices are in alignment with TB MED 507.

Department of the Air Force Instruction (DAFI) 48-151, *Aerospace Medicine Thermal Stress Program* (DAF 2022a), implements Air Force Policy Directive 48-1, *Aerospace & Operational Medicine Enterprise.* The most recent version of the former, dated May 2, 2022, includes references to guidance contained in the updated TB MED 507. DAFI 48-151 provides supporting guidance to commanders, supervisors, medical personnel, and individuals at every level for establishing and implementing an effective local Thermal Stress Program. This DAFI encompasses thermal stress education, environmental monitoring, and guidance charts. Signs and symptoms of thermal illness are provided in section 23.10 of Air Force Tactics, Techniques, and Procedures (AFTTP) 3-4, *Airman's Manual* (DAF 2022b). AFTTP 3-4 applies to the entire

Department of Air Force, including all civilian employees and uniformed members of the Regular Air Force, Air Force Reserve, Air National Guard, and the United States Space Force.

The U.S. Navy has published several relevant guidance documents, including *The Manual of Preventive Medicine, Chapter 3, Heat and Cold Stress Injuries (Ashore, Afloat and Ground Forces)*, last updated in 2009 (DON 2009). This chapter provides heat and cold prevention and treatment guidance, including descriptions of the physical and physiological measurements necessary to assess the effects of heat stress. The former Navy Environmental Health Center (now the Defense Centers for Public Health – Portsmouth (DCPH-P)) last updated Technical Manual NEHC-TM-EORM 6260.6A, *Prevention and Treatment of Heat and Cold Stress Injuries*, in June 2007 (NEHC 2007). OPNAV Instruction 5100.19E Volume 1, *Navy Safety and Occupational Health (SOH) Program Manual for Forces Afloat*, was also last updated in 2007 (DON 2007). Chapter B2 of the latter doctrine is dedicated to heat stress and contains special reference to Physiological Heat Exposure Limits tables, which incorporate both the heat stress of the environment, as determined by the WBGT Index, and the physical demands of a particular job.

As the Marine Corps relies upon the U.S. Navy for medical support, the guidance outlined above applies, as does additional guidance contained in Marine Admin (MARADMIN) message 111/15, published in March 2015 (USMC 2015). This message provided interim guidance for commanders and officers-in-charge for planning and executing heat and cold stress injury prevention programs. The guidance contained in MARADMIN 111/15 has been incorporated into the *Marine Corps Heat and Cold Stress Injury Prevention Program*, currently in review; publication is anticipated in spring 2023. Information on the responsibilities for prevention programs, heat stress physiology, risk factors for heat illness, first aid for heat illness, and preventive measures is included in the program. Guidance for physical conditioning and acclimatization for the prevention of heat casualties is provided, as is extensive information on the use of the WBGT Index for determining risk, work-rest ratios, and fluid replacement requirements.

Each Military Department has published high-quality guidance for the prevention of heat illness casualties. While the Army has published additional guidance for recruit training centers (TRADOC Reg 350-29), the other departments rely on their respective service-wide documents for recruit training centers.

iii: Description of the Training and Education on the Detection and Prevention of Heat-Related Illnesses

Each of the Military Departments' guidance documents reviewed above contain information for a heat illness prevention program. For example, Appendix C of Army TB MED 507 is entitled "Commander's, Senior NCO's, and Instructor's Guide to Risk Management for Prevention of Heat Casualties." This appendix outlines the five steps of the risk assessment process as it applies to heat illness prevention.

The Army Heat Center at Fort Moore was created in 2019 with the mission to provide education and training, develop and model clinical best practices, and support a research agenda to further the goal of decreasing EHI incidence to maximize medical readiness and return to duty. Army Heat Center personnel provide training to numerous target audiences, as detailed below. Heat illness surveillance activities by the Army Heat Center allow for unique insights that influence training and education programs. For example, over 90 percent of all exertional heat stroke casualties at Fort Moore occur during foot march or running events (DeGroot et al. 2022). With this knowledge, Army Heat Center staff work with unit leaders to implement targeted risk reduction strategies during these events.

DHA reviewed service-specific resources relevant to heat illness prevention training and education. A member of the writing group for this report is the Director of the Army Heat Center, who provides in-person training to a variety of target audiences and contributes to a website with resources for clinicians and unit leaders. Information obtained from site assistance visits conducted by Army Heat Center staff at numerous DoD installations was also utilized in this analysis.

Service-specific guidance documents reviewed in section ii of this report contain instructions for unit commanders to conduct heat illness prevention training annually. To assist units in meeting this requirement, the Defense Centers for Public Health – Aberdeen (DCPH-A) website provides heat illness prevention and treatment training slides for download.

The foundation of the Army Heat Center's prevention program is the annual Fort Moore Heat Forum. The 7th Annual Heat Forum, held on February 22, 2023, included presentations on recent policy updates, best practices for the prevention of heat illness, the roles of hydration and fueling to sustain performance and mitigate heat risk, pre-hospital care of heat illness casualties, prevention and treatment of exertional hyponatremia, and return-to-duty considerations. Over 700 individuals attended the event, either in person or virtually, including personnel from the Army, Navy, Marine Corps, and Air Force, as well as personnel from the United Kingdom, Canada, and other allied nations.

The Army Heat Center conducts several prevention training programs at the Maneuver Center of Excellence, Fort Moore. A component of the Drill Sergeant Orientation Program, which all newly-arrived drill sergeants must attend, is a block of instruction on the prevention, recognition, and response for heat illness casualties. Training is also provided during the 194th Armored Brigade Cadre Training Course, to attendees of brigade-specific Company Commander and First Sergeants Courses, and to other audiences upon request. Over 6,000 individuals have received training from Army Heat Center staff since its inception in 2019.

The Army Heat Center also routinely provides training to audiences outside of Fort Moore. At the Medical Center of Excellence, Joint Base San Antonio-Lackland, heat illness prevention and treatment course content are provided to attendees of the Preventive Medicine Senior Leaders Course, the Division Surgeon's Course, the Brigade Healthcare Providers Course, and to students in the Inter-service Physician Assistant Program.

The reviewed service-specific policies and guidelines direct commanders to conduct heat illness prevention training. During Command-requested site assistance visits, Army Heat Center staff have reviewed programs and policies at the U.S. Air Force Officer Training School, Maxwell Air

Force Base (AFB), Alabama; Officer Candidate School, Marine Corps Base-Quantico, Virginia; and Initial Entry Training, Lackland AFB, Texas. There are heat illness prevention, identification, and response training programs for cadre and trainees at each location.

Each Military Department publishes guidance directing annual heat illness prevention training prior to the start of the "heat season." Training resources may be obtained from the DCPH-A and the Army Heat Center, or locally developed training resources may be utilized.

Since the creation of the Army Heat Center at Fort Moore in 2019, the frequency of exertional heat stroke has been reduced by 47 percent, suggesting that the training and education efforts at that installation have been effective (DeGroot et al. 2022). Otherwise, historical trends across the DoD suggest that other training and education effects have had minimal impact on reducing the frequency of heat illness.

iv: Accounting of Black Flag Days at Military Training Installations

Globally, 2022 was the 7th hottest year on record based on annual average land temperatures, and the past 8 years have been the hottest recorded during the period 1880-2020 (NOAA 2023a). In the United States, the annual average temperature has increased by 1.8 degrees Fahrenheit (°F), or 1.0 degrees Celsius (°C), over the period 1901-2016, with most of this increase taking place in the last 30 years. One illustration of changes occurring over the last 30 years is shown in Figure 1, which compares the number of days during heat season (May-September) when the daily maximum heat index was higher than 90°F for the years 1991 and 2021 (CDC 2023).

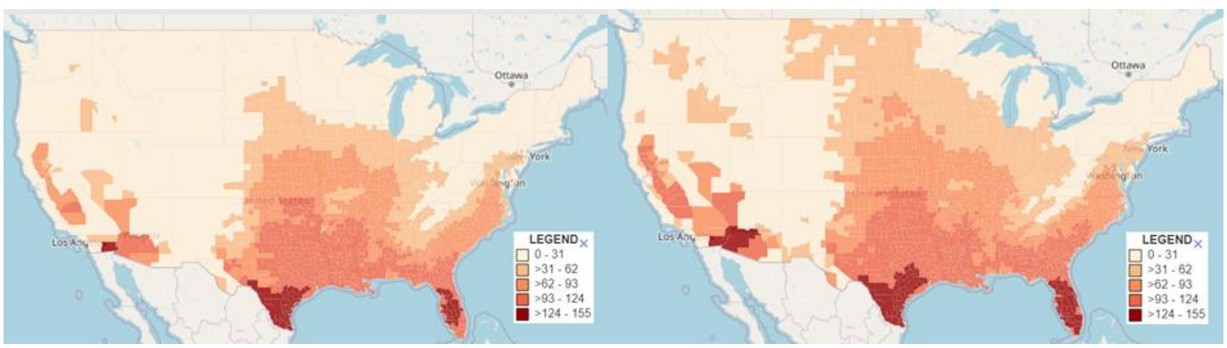


Figure 1. Annual Number of Extreme Heat Days from May to September in CONUS: Days when the Daily Maximum Heat Index was Greater than 90°F: 1991 (left); 2021 (right).

Over the next few decades, the annual average temperature over the contiguous United States is projected to increase by about 2.2°F (1.2°C) relative to 1986-2015, regardless of future scenarios. As a result, the recent record-setting hot years are projected to become a common event in the United States. (USGCRP 2018). As an example, 2022 was among the top 20 hottest years on record, with the 12 hottest years on record occurring since 2000 (NOAA 2023b).

Health concerns associated with rising ambient temperatures include heat illness due to extreme weather events, exacerbation of respiratory illness, and adverse effects on cardiovascular disease and behavioral health. Data from the National Weather Service (NWS) indicate that heat has been the leading cause of weather-related fatalities in the United States every year during 2018-2021 and in 15 of the last 30 years (NWS 2023). Increases in outdoor air pollution, seasonal allergens, and weather-related mental health stress are also associated with rising temperatures (USGCRP 2016).

In military training settings, heat stress categories are used to communicate risk of adverse health effects associated with exposure to ambient conditions. Categories are defined according to the WBGT Index and assigned a color (flag) that represents varying levels of heat risk (DA 2022, DAF 2022a, DON 2009). The WBGT Index is a measure of heat stress in direct sunlight, and is a function of temperature, humidity, wind speed, sun angle, and cloud cover. Flag colors include white, green, yellow, red, and black; white represents less risk (lower WBGT values), and black represents more risk (higher WBGT values). "Black flag" status refers to ambient conditions when the WBGT value is greater than 90°F. There is no formal definition of a "black flag day" in military doctrine; for the purposes of this report, a black flag day was defined as a day when the maximum hourly WBGT value is greater than 90°F.

Although the WBGT Index has been designated as the doctrinal metric for heat stress in each of the Services, there are no archives of WBGT readings at DoD military bases, and WBGT is seldom reported by civilian weather services. As a result, black flag days documented in this report were calculated from a retrospective analysis of outdoor weather conditions, using archived meteorological data from weather stations in closest proximity to the military bases of interest. To characterize military training locations, the installations evaluated for this report included basic training locations, officer candidate schools, and Military Service Academies (see Table 2).

According to annual updates published in the DHA's *Medical Surveillance Monthly Report* (*MSMR*), several of the bases shown in Table 2 are among those with the highest recurring burden of heat illness: Fort Moore, Fort Jackson, Fort Leonard Wood, Fort Sill, Marine Corps Recruit Depot Parris Island, Marine Corps Recruit Depot San Diego, Marine Corps Base Quantico, and Lackland AFB. However, many other installations in the United States with a significant burden of heat illness are not among those identified in Table 2 (AFHSD 2022).

Although black flag conditions can be a significant risk factor for heat illness, recent studies show that far more military heat illness occurs during other heat stress categories, such as red and yellow flag conditions (Lewandowski and Shaman 2022). Figure 2 summarizes heat illness events (i.e., heat exhaustion or heat stroke) experienced by ACSMs serving at bases in the CONUS between 1996 and 2019, according to the maximum heat stress category (flag) on the day of the event. This assessment revealed that 16 percent of heat illness cases occurred on days that experienced a black flag condition, but 84 percent of heat illness cases occurred on days that did not experience black flag conditions. Further, 20 percent of heat illness cases occurred when the daily maximum WBGT was below 78°F, corresponding to no flag condition. Possible reasons for these outcomes include more exposure to moderate conditions compared to extreme conditions; underestimation of the effects of heat stress in moderate conditions; or lack of, or reduced attention to, work-rest cycle and heat illness prevention measures when temperatures are moderate.

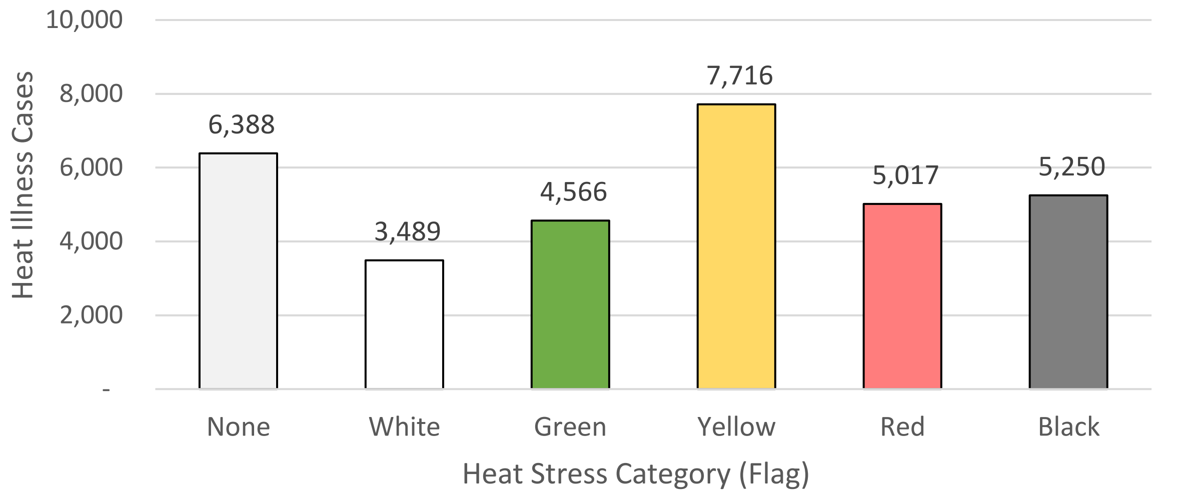
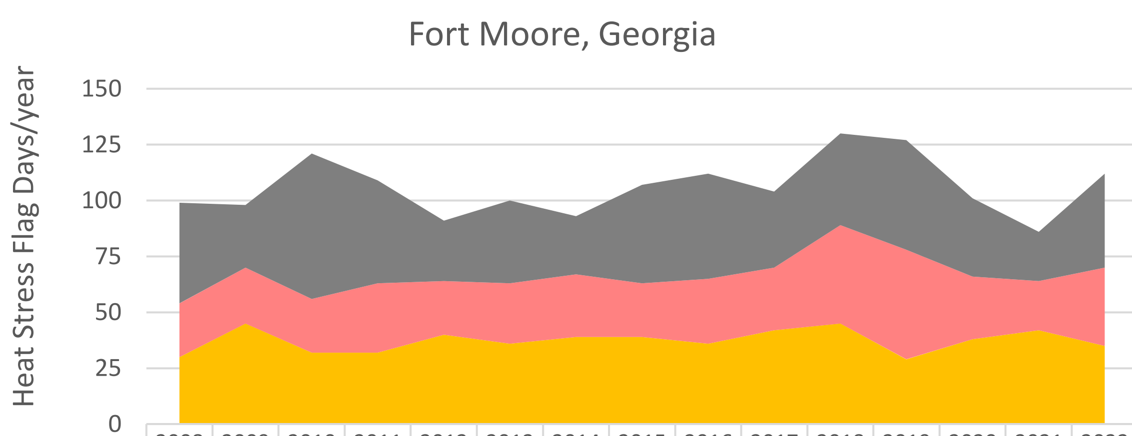


Figure 2. Distribution of Heat Illness Cases among ACSMs Serving in CONUS, 1996–2019 (n=32,426).

Given the burden of heat illness events occurring at conditions other than black flag, and to evaluate trends over time, the number of yellow, red, and black flag days were assessed for each of the chosen training bases over a 15-year interval (2008–2022). Results for one training base are presented in a graphical and tabular summary in Figure 3 (see Appendix C for all training bases). Heat stress conditions at these bases align with their geographic locale; training bases in southern and southeastern States averaged more than 100 days per year at yellow, red, and black flag conditions, while those in western States experienced almost none. One unifying trend among these bases was the incremental rise in the number of yellow, red, and black flag days over the interval; for all but 2 bases, the 5-year average of yellow, red, and black flag days was higher than the 15-year average. This suggests that heat stress conditions are more frequent in recent years compared to the past 15 years.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	45	28	65	46	27	37	26	44	47	34	41	49	35	22	42
Red Flag	24	25	24	31	24	27	28	24	29	28	44	49	28	22	35
Yellow Flag	30	45	32	32	40	36	39	39	36	42	45	29	38	42	35

Figure 3. Heat Stress Flag Days at Fort Moore, Georgia, 2008-2022.

Currently, there is no standardized tracking or archiving of WBGT readings or heat stress flag conditions at military training locations. This is likely due to several factors. Military doctrine on heat stress management typically directs the capture of WBGT values only when the ambient temperature exceeds certain thresholds, and then only for the purpose of guiding situational risk management during training or maneuvers. The lack of comprehensive tracking of weather conditions during military training events makes it impossible to determine what proportion of training occurs under various flag conditions, or whether heat illnesses are occurring disproportionately during "black flag" days. A pilot program currently in development at Fort Moore will add 3-4 additional weather stations at the installation with the capability to store/archive data for future use.

It is important to note that WBGT readings are time- and site-specific and do not represent area-wide conditions or conditions over the course of an entire day. As an example, black and yellow flag conditions can co-exist on an installation depending on the underlying terrain and cloud cover. Since the utility of a WBGT reading is limited to the time and place of the measurement, the declaration of a "black flag day" is a guide to heighten surveillance and manage heat risk, rather than a definitive statement of local conditions. Training exercises are typically conducted over a wide area that may or may not experience the same conditions as those present at the site of the controlling risk measurement. The singularity of the controlling measurement could misrepresent conditions where an actual heat casualty occurs, or the aggregate exposures that led to the casualty. Further, we are not aware of any existing DoD archive containing environmental exposure or environmental hazard data that are publicly accessible.

Retrospective review of military heat illness cases from 1996 through 2019 found that the majority (84 percent) of heat exhaustion and heat stroke outcomes occurred on days that did not experience black flag heat stress conditions. A sizeable portion (20 percent) of heat illness cases occurred on days when ambient conditions did not rise to the level of heat stress addressed by military doctrine. This suggests that increased attention needs to be paid to heat risk and behavior modifications during conditions other than black flag heat stress. It also suggests that factors other than ambient heat are contributing to heat illness during military training.

Retrospective review of heat stress flag conditions at 15 military training bases from 2008 through 2022 found that on average, there were more yellow, red, and black flag days in the most recent 5 years compared to the prior 15 years. This suggest that outdoor heat stress is increasing over time, which is consistent with the trajectory of temperature measurements in the United States showing that annual average temperatures have risen consistently over the last 30 years. Although there is no standardized tracking and archiving of WBGT Index readings or heat stress flag conditions at U.S. military training locations, it is not clear that availability of such an archive would improve compliance with existing doctrine on heat stress management. Further, the preponderance of heat illness cases occurring under moderate conditions suggest that factors other than heat stress are playing an unaddressed role in these outcomes.

v: Survey of Military Leaders' Understanding and Adherence to Medical Protocols

EHIs are the leading cause of weather-related morbidity among U.S. Army Soldiers. EHIs are a threat to the individual health of Service members, as well as to operational and mission success. Effective integration of EHI prevention by unit leadership and medical staff is critical to preventing and reducing the severity of EHIs that do occur among Service members. To integrate EHI prevention in the training or deployment environment, unit leadership and medical staff must understand the severity of EHIs and the threat they pose to readiness, as well as how to effectively prevent and treat EHIs in the field. To our knowledge, no other surveys have been previously developed to gauge the knowledge, attitudes, and practices of unit leadership or medical staff on the prevention and mitigation of EHIs in the U.S. Armed Forces.

A methodology was developed that could be used to query military leaders' understanding of, and adherence to, medical protocols and best practices for responding to heat illness casualties. The purpose of this proposed assessment is to address the following questions:

- Are unit commanders and unit medical staff aware of their respective roles in the prevention and treatment of EHIs?
- Do unit commanders and medical staff know how to identify individuals at risk of developing EHIs?
- Do unit commanders and medical staff know how to properly treat EHIs?
- Do unit commanders and medical staff have the appropriate resources to prevent EHIs among Service members?

DHA is developing two cross-sectional surveys to assess understanding of, and adherence to, EHI medical protocols and best practices; one survey is specific to unit commanders, and the other is specific to medical officers. These groups were selected to be surveyed because their roles in the management of EHIs are specifically outlined in various U.S. Armed Forces documents. A cross-sectional design was chosen to measure respondents' knowledge, attitudes, and adherence because the analysis does not require follow-up with participants, thereby reducing time needed to complete the project, and requires fewer resources relative to longitudinal assessments (Mann 2003). The surveys were designed to maintain respondents' anonymity, but location data (e.g., installation and region) should be collected.

The recommended unit commander questionnaire consists of five items on knowledge, five items on adherence, and five items on attitudes and beliefs, while the medical staff questionnaire consists of three items on knowledge, five items on adherence, and three items on attitudes and beliefs. Questions/statements to assess knowledge are focused on roles in EHI management; fluid intake; cooling methods; and heat acclimatization. Statements assessing adherence included the frequency of training hazards assessments, adjustments to unit activities when appropriate, follow-up procedures after EHI occurrence, and availability of resources to manage EHIs. Statements assessing attitudes included agreement on adequacy of EHI management training, and the presence of barriers in the prevention and treatment of EHIs. A multiple-choice format was used for questions assessing knowledge, while 5-point Likert scales were used for statements assessing adherence (never, rarely, sometimes, often, always) and attitudes/beliefs (strongly disagree, disagree, undecided, agree, strongly agree). The surveys were designed to include a variety of question formats to encourage participants to provide accurate responses (Kim et al. 2018). Questions were developed using information from TB MED 507, the U.S. Army's comprehensive resource for EHI management protocols and procedures as well as the specific roles in which various staff members should engage to prevent and treat EHIs.

vi: Assessment of an Online Resource Center to Increase Service Members' Knowledge

As several public-facing online resources exist, this section provides a description of the content available at each website rather than assessing the need for such resources. The numerous publicly available resources provide a robust array of heat-related illness data and guidance to ensure clinician awareness of best practices and increase Service member knowledge about preventing heat-related illnesses.

The WHEC was created in 2019 as a program within the Consortium for Health and Military Performance (CHAMP) at the Uniformed Services University of the Health Sciences. The WHEC is positioned along with RX3 (Rehab, Refit, Return to Duty), Go For Green, and Operation Supplement Safety as a human performance resource provided by CHAMP. The WHEC is co-directed by Lieutenant Colonel David DeGroot, Director of the Army Heat Center, and Dr. (Colonel, U.S. Army, retired) Francis O'Connor, CHAMP Medical Director. The mission of the WHEC is to serve as a tri-service resource for prevention, management, and return-to-duty guidance on exertion-related illnesses, including heat illness; hyponatremia; exercise collapse associated with sickle cell trait; sudden cardiac arrest; and rhabdomyolysis.

The WHEC provides a public-facing website (https://www.hprc-online.org/resources-partners/whec) containing heat illness education materials. The Clinical Care-Provider Resources section contains several DHA-approved Practice Recommendations, a Clinical Practice Guideline for exertional rhabdomyolysis, training videos, and treatment algorithms for non-medical first responders, Emergency Medical Services personnel, and Emergency Medicine providers. The Education Tools section contains a variety of infographics, training videos, a heat acclimatization guide, and service-specific doctrine and policy related to EHI. The Research section includes links to numerous peer-reviewed research papers authored or co-authored by WHEC-affiliated team members. The WHEC website features an Ask-the-Expert function for military providers and warfighters; questions posed by users are answered within 24 hours. The WHEC's Multidisciplinary Care Consortium offers clinical care recommendations and facilitates care across the MHS.

The DCPH-A maintains a public-facing website, "Heat Illness Prevention and Sun Safety" (https://phc.amedd.army.mil/topics/discond/hipss/Pages/default.aspx). This site contains links to downloadable factsheets and training aids (e.g., a video, slides, tip cards, and posters) that are designed to educate ACSMs about heat-related illness prevention, risk factors, warning signs and symptoms, and treatment. The DCPH-A encourages awareness of these and other public health products through news articles (typically published in March) that are broadly disseminated to military audiences via Army.mil, DVIDS, and military social media. These articles also reside on the DCPH-A website.

Links to DCPH-A monthly Weather-Related Illness Reports (https://phc.amedd.army.mil/news/Pages/PublicationDetails.aspx?type=Weather-Related%20Injury%20Surveillance) are also available on the DCPH-A website. These resources include Army installation-specific heat illness and cold-weather injury reports that describe reported cases of heat stroke and health exhaustion by installation. The reports highlight installations with the highest EHI cases and provide trends over time.

The DCPH-A reports health-related conditions and trends annually in the *Health of the Force* report (https://phc.amedd.army.mil/topics/campaigns/hof/Pages/default.aspx). Military leaders and others can use this tool to maintain awareness of a broad set of environmental and health metrics, including heat casualties and related environmental (heat risk) conditions.

The Navy and Marine Corps Public Health Center (now known as DCPH-P) website (https://www.med.navy.mil/Navy-Marine-Corps-Public-Health-Center/Environmental-Health/Occupational-and-Environmental-Medicine/Occupational-and-Environmental-Medicine-Division/Resource-Information/) contains a heat illness prevention infographic, a question-and-answer sheet, and training videos.

The AFHSD publishes the *MSMR*, and each year, the April issue contains annual updates on the incidence of, and risk factors for, EHI, exercise-associated hyponatremia, and exertional rhabdomyolysis. Past *MSMR* reports are publicly available at: https://www.health.mil/Military-Health-Topics/Health-Readiness/AFHSD/Reports-and-Publications/Medical-Surveillance-Monthly-Report.

IV: CONCLUSIONS

EHI is a reportable condition for which ongoing DoD attention and resources are required to reduce the incidence of cases. Over 11,000 cases of heat exhaustion and heat stroke have been diagnosed in the U.S. Military since 2018. Over half of these cases were not captured as RMEs, indicating that case follow-up by installation public health authorities may not have occurred.

Sufficient education, policies, and training resources are in place to prevent heat injuries among Service members. However, deficient reporting limits the necessary investigation of cases to determine if mitigation strategies are being followed. In fact, 84 percent of heat illnesses occur on non-black flag days, indicating a review of proper mitigation strategies is warranted for those cases. Additionally, leadership needs to be aware of heat illness risk factors that are not necessarily temperature-related.

A comprehensive assessment of knowledge related to heat injuries is warranted for military leadership and medical support personnel. This report includes one potential methodology for conducting such an investigation.

APPENDIX A – GLOSSARY OF TERMS

Exertional Heat Illness (EHI): A broad categorical term that encompasses a spectrum of specific heat-related conditions, including heat exhaustion, heat injury, and exertional heat stroke.

Exertional Heat Stroke (EHS): The most severe form of EHI; may be fatal if not treated appropriately and immediately. EHS is characterized by profound central nervous system dysfunction (e.g., delirium, change in gait during activity, agitation, inappropriate aggressiveness, convulsions, or coma) that occurs in the presence of severe hyperthermia, with body core temperature often but not always over 104°F. In the absence of rapid pre-hospital cooling and in the presence of other health conditions, the mortality rate can reach 85 percent (Tustin et al. 2018). When best practices for pre-hospital cooling are followed, the mortality rate is near zero. However, recovery time is prolonged, with considerable lost duty time. EHS is the least common but most serious condition on the EHI spectrum.

Heat Exhaustion: Occurs when the body cannot sustain the level of cardiac output necessary to meet the combined demands of increased skin blood flow for heat dissipation and for the metabolic requirements of exercising skeletal muscle. There is no end-organ damage, and the casualty can safely return to duty the next day. Heat exhaustion is on the less severe and more frequent end of the EHI spectrum.

Heat Injury: Heat exhaustion with evidence of end-organ (e.g., liver, kidney, muscle, and/or cardiac) injury. A period of reduced activity and work is necessary while the individual recovers; return to unrestricted duty usually occurs within 2 weeks. On the EHI spectrum, heat injury is intermediate in severity.

Heat Strain: The physiological responses that result from heat stress.

Heat Stress: The combination of relevant environmental conditions and work factors which increase the body's heat load.

Hypohydration: The state of reduced body water content.

Minor Heat Illnesses: Conditions which typically resolve spontaneously, do not result in lost duty time, and are not considered a risk factor for more serious heat illness. Examples include heat cramps, parade syncope, miliaria rubra (i.e., heat rash), heat edema, and sunburn.

APPENDIX B – RISK FACTORS FOR EHI

Established risk factors for EHI can be grouped into three broad categories: environmental, mission-related, and individual.

Environmental Risk Factors

- Ambient air temperature: When temperatures rise, the body reacts by increasing blood flow to the extremities to move heat away from the body core. Increased air temperature makes it harder for the body to reject internal heat by reducing the temperature gradient between the air and the surface of the skin and interfering with the cooling effect of sweat evaporation.

- Humidity: On humid days when the air is saturated with water, sweat evaporates more slowly, which interferes with the body's ability to reject internal heat through the evaporation of sweat at the surface of the skin.

- Radiant heat: Radiant heat is transferred from one object to another without contact between the objects. The sun is the greatest source of radiant heat during daylight hours. When solar radiation is absorbed and retained by the human body, body heat content is increased.

- Conductive heat: Conduction is the transfer of heat between surfaces of objects that are touching each other. The body can gain heat through conduction if the surfaces it touches are hotter than the skin. The body can also lose heat directly through the skin if the surfaces it touches are cooler than the skin.

- Wind: Air movement over the skin facilitates the evaporation of sweat and convection heat loss. However, strong winds, particularly those with very hot, dry air, can be extremely hazardous. Depending on the level of humidity, air flowing over the body can facilitate cooling if the air temperature is cooler than about 95°F, whereas heat gain through convection may occur if the air is warmer than about 95°F.

Mission-Related Risk Factors

- Clothing worn and equipment carried: Clothing increases heat strain by reducing evaporative, radiant, and convective heat loss.

- Level of exertion: Higher-intensity effort will increase metabolic heat production and therefore increase the requirement for heat loss.

- Duration of exertion: Sustained activities due to mission requirements may limit opportunities for heat loss.

- Time of day: Environmental risk factors can be partially mitigated by executing a mission or training event at a time of day when conditions are most favorable for the dissipation of heat.

Individual Risk Factors

On a given day in a particular location, a group of Soldiers will experience the same environmental and mission-related risk factors. Therefore, individual risk factors distinguish those who complete a training event or mission from those who succumb to EHI. The following are the most relevant individual risk factors in the service member population.

- Acclimatization status: Acclimatization to heat is characterized by numerous favorable physiological adaptations that evolve over time to reduce heat strain. Individuals who have spent less time in a new climate will be less acclimatized and therefore at increased risk of EHI.

- Physical (aerobic) fitness: Individuals with lower aerobic fitness are at increased risk of EHI.

- Body composition: Increased adiposity is associated with increased risk of EHI.

- Prior EHI: Individuals who have suffered an EHI in the past are considered to be at increased risk of EHI; however, epidemiological and physiological data are not conclusive on this point.

- Concurrent illness: Any illness that results in fever may increase risk of EHI.

- Medication use: A variety of medication classes have been associated with increased risk of EHI; examples include anticholinergics, antihistamines, tricyclic antidepressants, decongestants, and mood stimulants. A variety of over-the-counter supplements have also been associated with increased EHI risk.

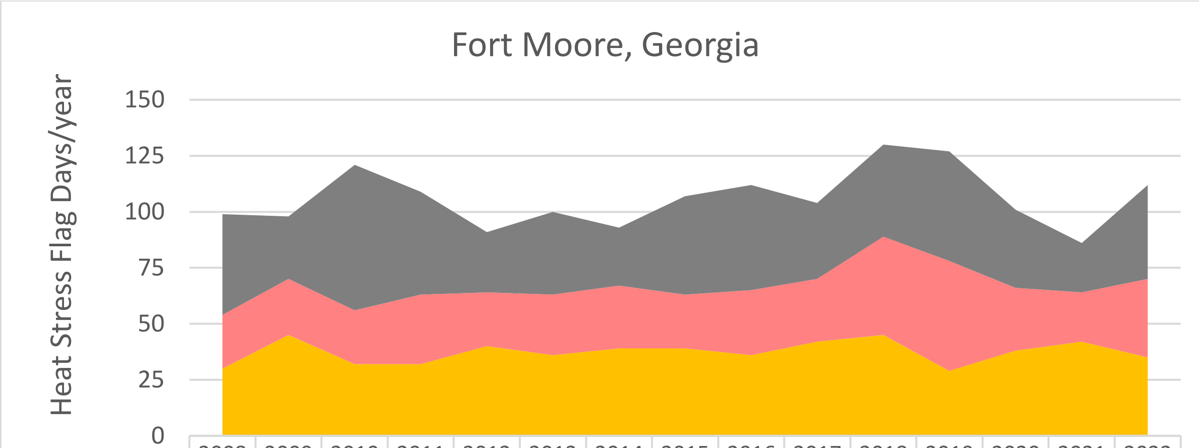
- Motivation: Individuals who push themselves beyond their physical limits to meet a training or mission standard (e.g., to complete a course or earn a skill badge/tab) are at increased risk of EHI.

- Other individual risk factors: These include sleep deprivation, alcohol use, sunburn, grafted skin due to burn injury, and diet/fasting.

- Hydration status: Hypohydration is a risk factor for EHI as discussed in detail in this report.

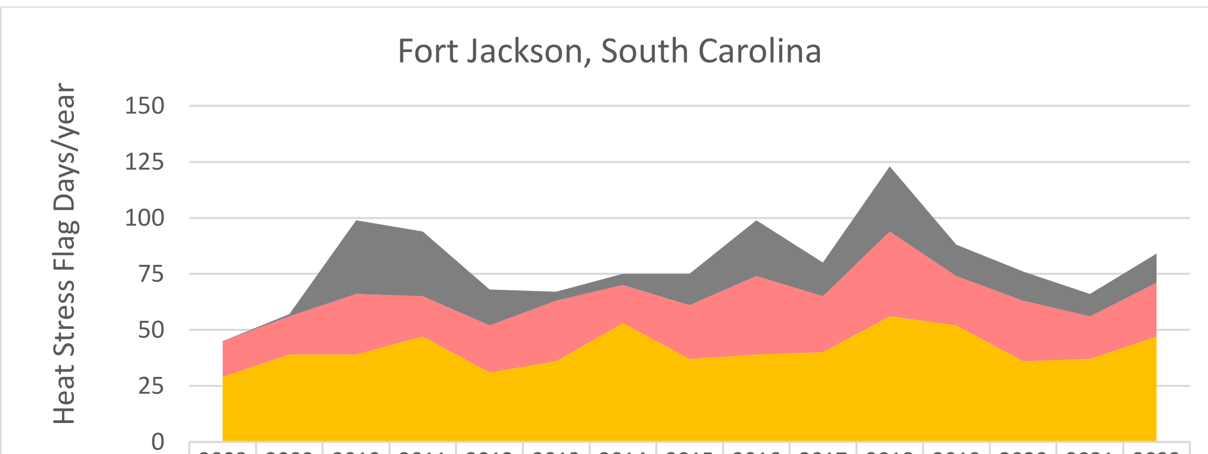
APPENDIX C – HEAT STRESS FLAG DAYS PER YEAR BY INSTALLATION

Figures C-1 through C-15 present annual heat stress flag days (2008–2022) for each of the 15 military training bases shown in Table 2.



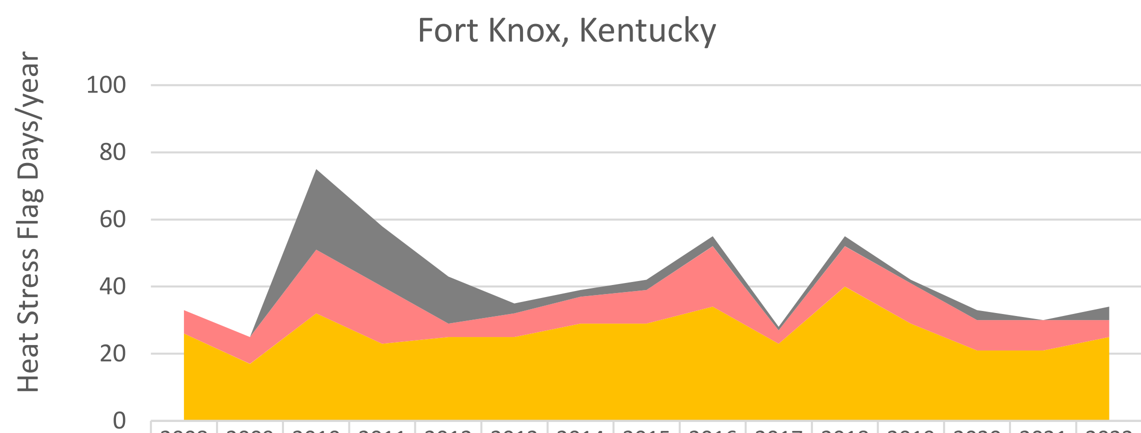
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	45	28	65	46	27	37	26	44	47	34	41	49	35	22	42
Red Flag	24	25	24	31	24	27	28	24	29	28	44	49	28	22	35
Yellow Flag	30	45	32	32	40	36	39	39	36	42	45	29	38	42	35

Figure C-1. Heat Stress Flag Days at Fort Moore, Georgia, 2008-2022.



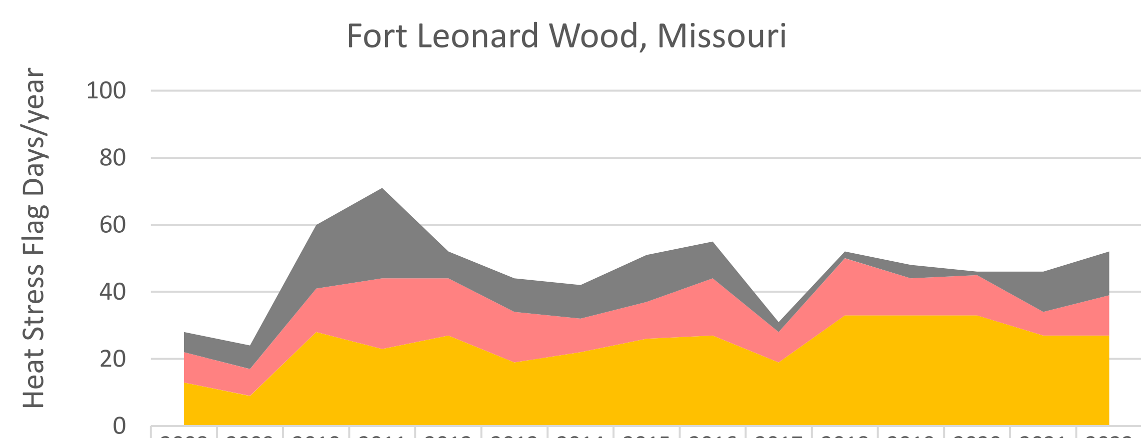
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	1	33	29	16	4	5	14	25	15	29	14	13	10	13
Red Flag	16	17	27	18	21	27	17	24	35	25	38	22	27	19	24
Yellow Flag	29	39	39	47	31	36	53	37	39	40	56	52	36	37	47

Figure C-2. Heat Stress Flag Days at Fort Jackson, South Carolina, 2008-2022.



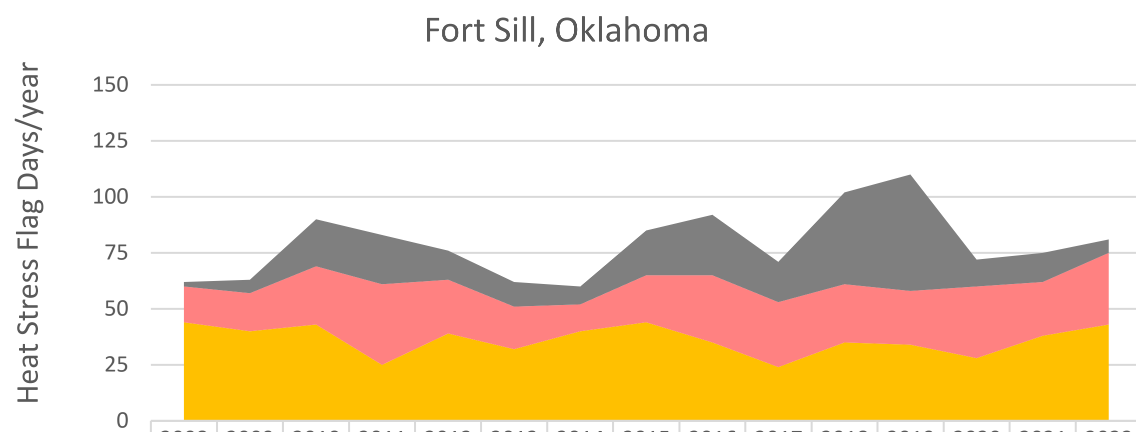
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	24	18	14	3	2	3	3	1	3	1	3	0	4
Red Flag	7	8	19	17	4	7	8	10	18	4	12	12	9	9	5
Yellow Flag	26	17	32	23	25	25	29	29	34	23	40	29	21	21	25

Figure C-3. Heat Stress Flag Days at Fort Knox, Kentucky, 2008-2022.



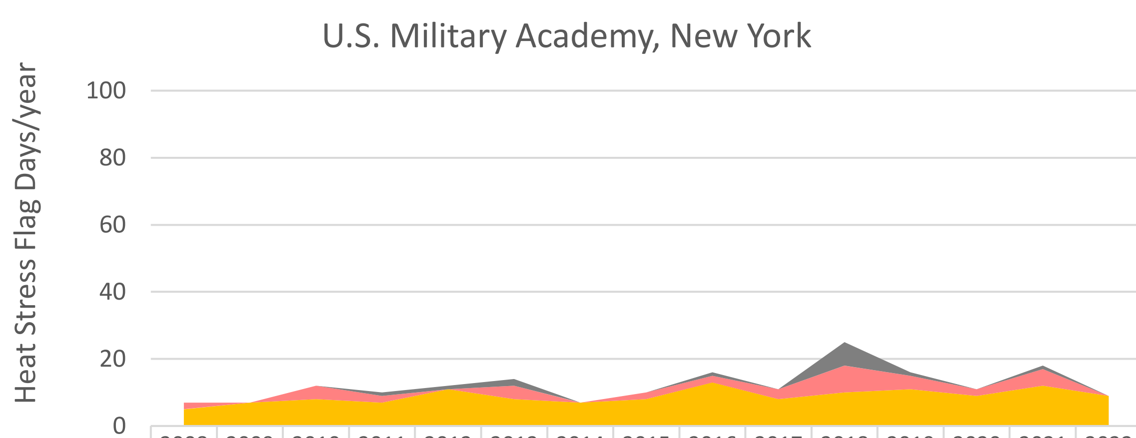
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	6	7	19	27	8	10	10	14	11	3	2	4	1	12	13
Red Flag	9	8	13	21	17	15	10	11	17	9	17	11	12	7	12
Yellow Flag	13	9	28	23	27	19	22	26	27	19	33	33	33	27	27

Figure C-4. Heat Stress Flag Days at Fort Leonard Wood, Missouri, 2008-2022.



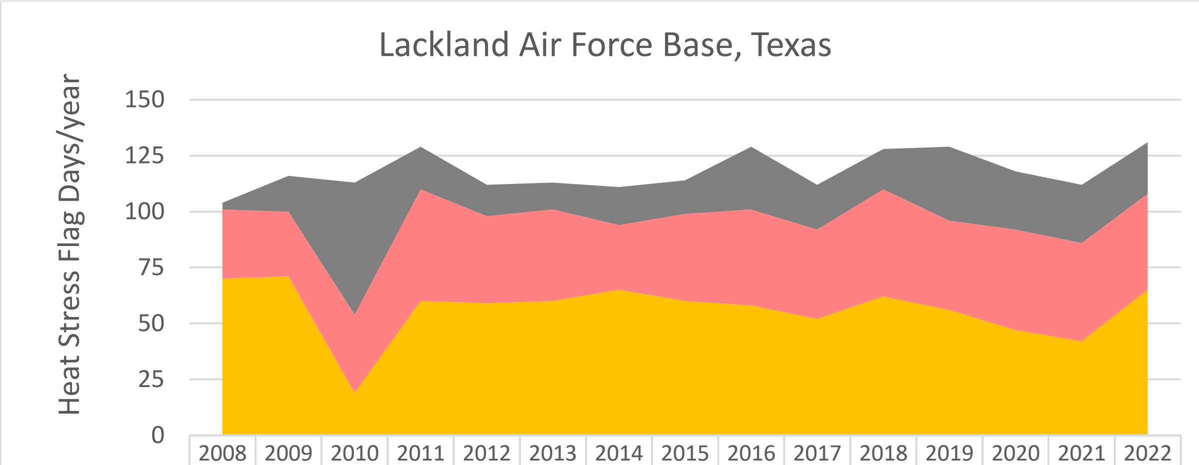
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	2	6	21	22	13	11	8	20	27	18	41	52	12	13	6
Red Flag	16	17	26	36	24	19	12	21	30	29	26	24	32	24	32
Yellow Flag	44	40	43	25	39	32	40	44	35	24	35	34	28	38	43

Figure C-5. Heat Stress Flag Days at Fort Sill, Oklahoma, 2008-2022.



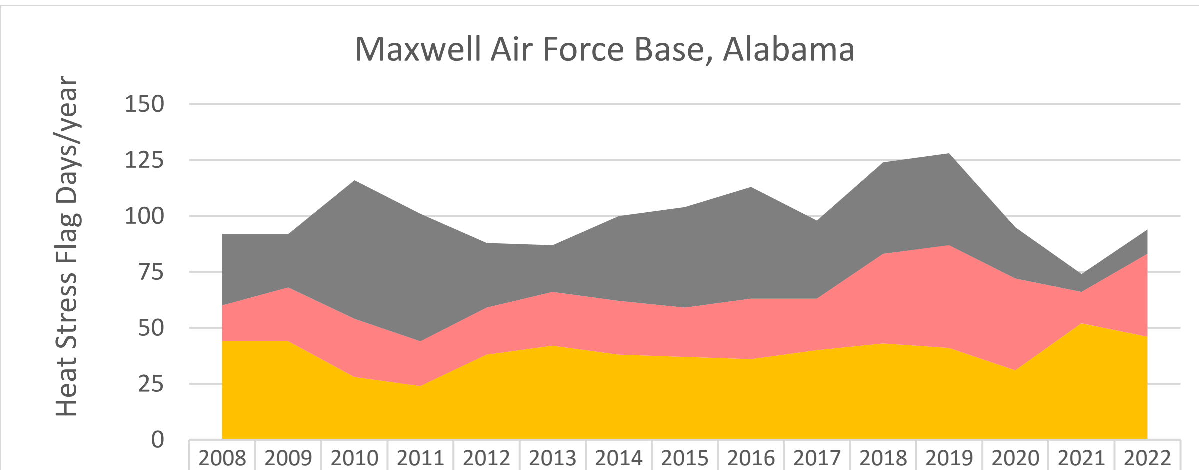
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	0	1	1	2	0	0	1	0	7	1	0	1	0
Red Flag	2	0	4	2	0	4	0	2	2	3	8	4	2	5	0
Yellow Flag	5	7	8	7	11	8	7	8	13	8	10	11	9	12	9

Figure C-6. Heat Stress Flag Days at U.S. Military Academy, New York, 2008-2022.



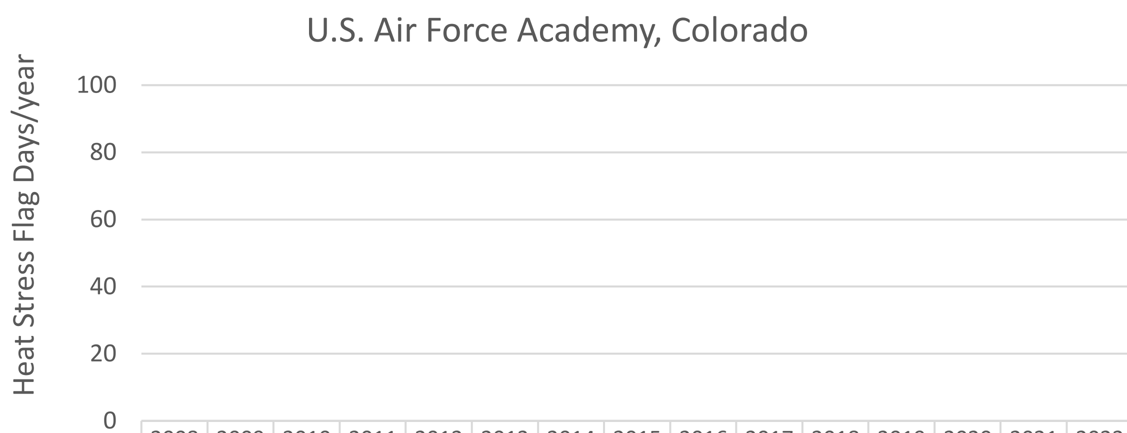
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	3	16	59	19	14	12	17	15	28	20	18	33	26	26	23
Red Flag	31	29	35	50	39	41	29	39	43	40	48	40	45	44	43
Yellow Flag	70	71	19	60	59	60	65	60	58	52	62	56	47	42	65

Figure C-7. Heat Stress Flag Days at Lackland Air Force Base, Texas, 2008-2022.



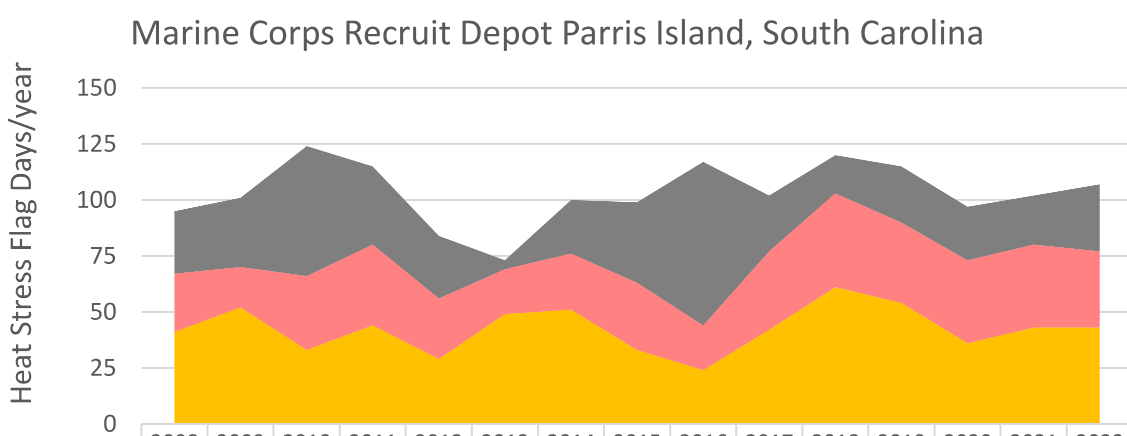
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	32	24	62	57	29	21	38	45	50	35	41	41	23	8	11
Red Flag	16	24	26	20	21	24	24	22	27	23	40	46	41	14	37
Yellow Flag	44	44	28	24	38	42	38	37	36	40	43	41	31	52	46

Figure C-8. Heat Stress Flag Days at Maxwell Air Force Base, Alabama, 2008-2022.



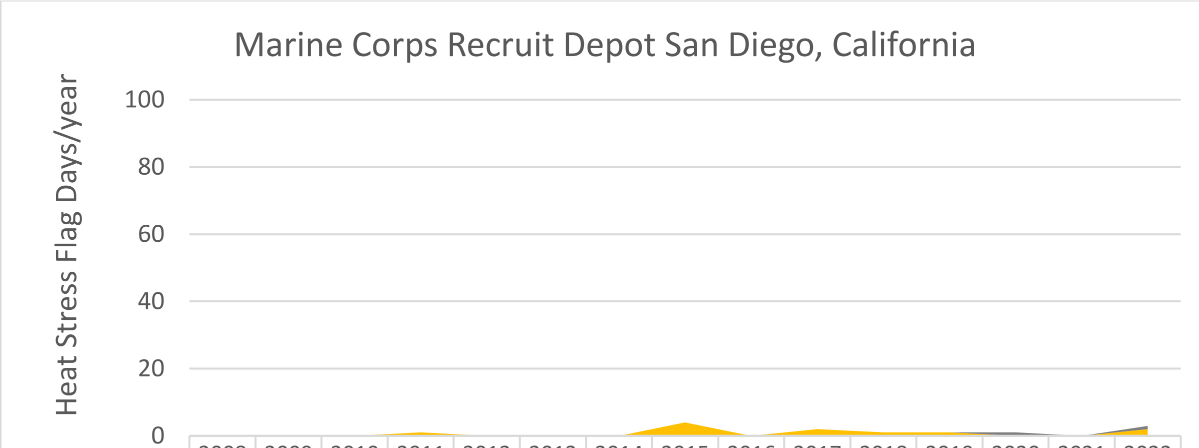
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Red Flag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Flag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Figure C-9. Heat Stress Flag Days at U.S. Air Force Academy, Colorado, 2008-2022.



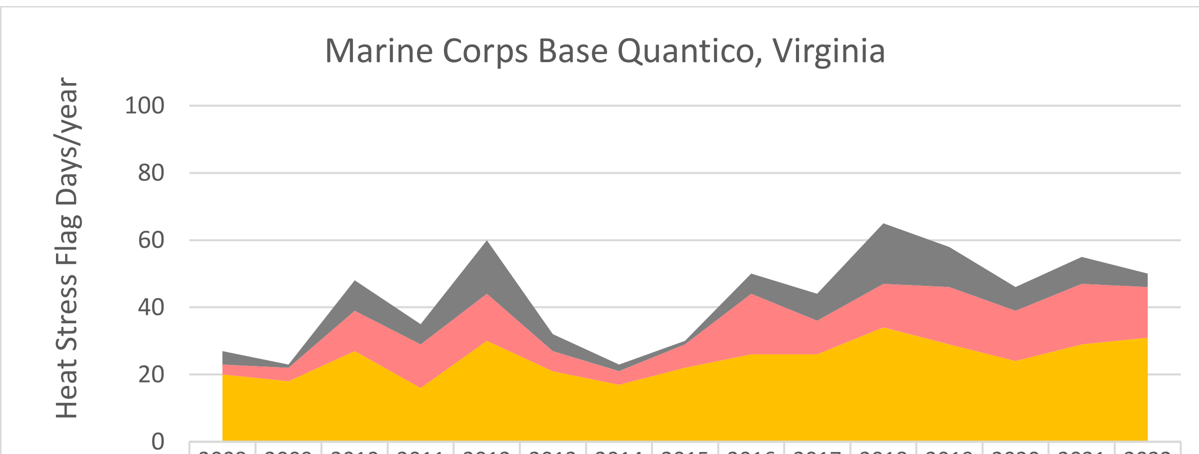
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	28	31	58	35	28	4	24	36	73	25	17	25	24	22	30
Red Flag	26	18	33	36	27	20	25	30	20	35	42	36	37	37	34
Yellow Flag	41	52	33	44	29	49	51	33	24	42	61	54	36	43	43

Figure C-10. Heat Stress Flag Days at Marine Corps Recruit Depot Parris Island, South Carolina, 2008-2022.



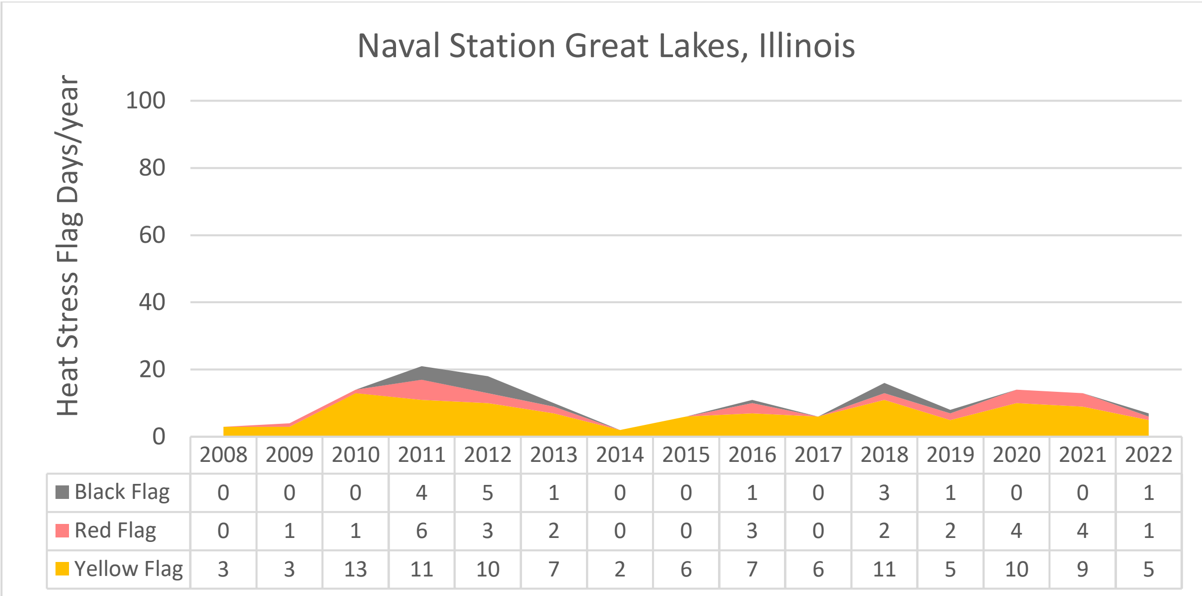
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Red Flag	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Yellow Flag	0	0	0	1	0	0	0	4	0	2	1	1	0	0	2

Figure C-11. Heat Stress Flag Days at Marine Corps Recruit Depot San Diego, California, 2008-2022.



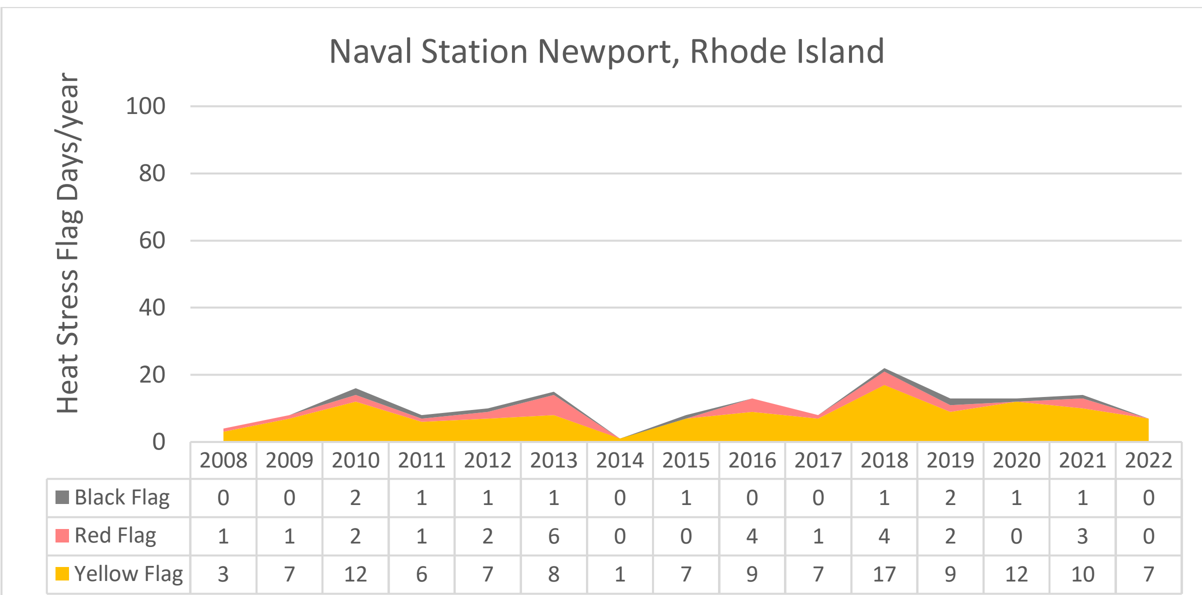
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	4	1	9	6	16	5	2	1	6	8	18	12	7	8	4
Red Flag	3	4	12	13	14	6	4	7	18	10	13	17	15	18	15
Yellow Flag	20	18	27	16	30	21	17	22	26	26	34	29	24	29	31

Figure C-12. Heat Stress Flag Days at Marine Corps Base Quantico, Virginia, 2008-2022.



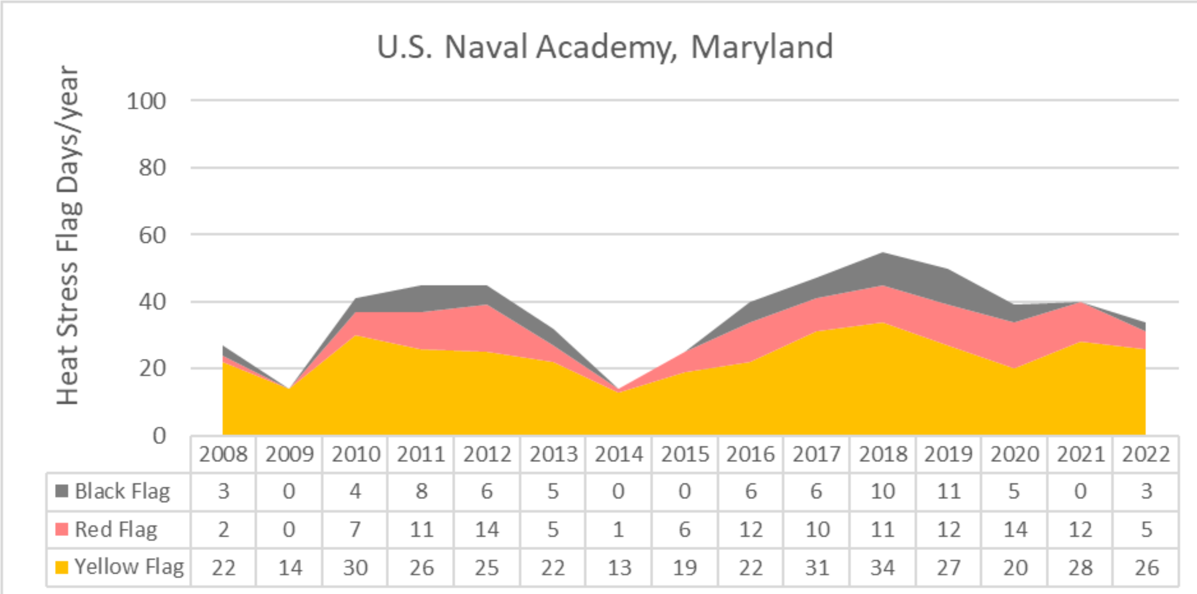
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	0	4	5	1	0	0	1	0	3	1	0	0	1
Red Flag	0	1	1	6	3	2	0	0	3	0	2	2	4	4	1
Yellow Flag	3	3	13	11	10	7	2	6	7	6	11	5	10	9	5

Figure C-13. Heat Stress Flag Days at Naval Station Great Lakes, Illinois, 2008-2022.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	0	0	2	1	1	1	0	1	0	0	1	2	1	1	0
Red Flag	1	1	2	1	2	6	0	0	4	1	4	2	0	3	0
Yellow Flag	3	7	12	6	7	8	1	7	9	7	17	9	12	10	7

Figure C-14. Heat Stress Flag Days at Naval Station Newport, Rhode Island, 2008-2022.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Black Flag	3	0	4	8	6	5	0	0	6	6	10	11	5	0	3
Red Flag	2	0	7	11	14	5	1	6	12	10	11	12	14	12	5
Yellow Flag	22	14	30	26	25	22	13	19	22	31	34	27	20	28	26

Figure C-15. Heat Stress Flag Days at U.S. Naval Academy, Maryland, 2008-2022.

APPENDIX D – REFERENCES

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