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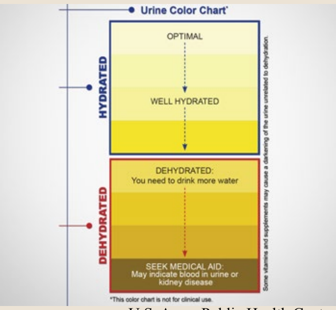

U.S. Army Public Health Center

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Diagnoses of Traumatic Brain Injury Not Clearly Associated with Deployment, Active Component, U.S. Armed Forces, 2001–2016

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From 2001 through 2016, a total of 276,858 active component service members received first-time diagnoses of traumatic brain injury (TBI). Person-time and incident cases of TBI were assigned to one of three groups. *Group 1* included only service members' person-time before their first-ever deployments. *Group 2* included service members' person-time during their overseas deployments and the 30 days after their return from deployment. *Group 3* included only service members' person-time more than 30 days after return from deployment. The crude overall incidence rate of TBI among deployed service members (1,690.5 cases per 100,000 person-years [p-yrs]) was 1.5 times that of service members in group 1 (1,141.3 cases per 100,000 p-yrs), and 1.2 times that of service members in group 3 (1,451.2 cases per 100,000 p-yrs). The portion of the surveillance period during which the annual incidence rates of TBI in groups 3 and 2 exceeded the rates in group 1 likely represents, at least in part, the increased risk of service in an active combat zone. For group 2, this period extended from 2007 through 2013. For group 3, this period lasted from 2007 through 2016. Examination of the TBI case-defining encounters with recorded injury causes yielded leading causes similar to those of TBIs in same-aged civilians (land transport and slips, trips, and falls). Factors that may explain why the TBI incidence rates among the previously deployed were higher than those of the never-deployed group are discussed.

Traumatic brain injury (TBI) is structural alteration of the brain or physiological disruption of brain function caused by an external force.[1] TBI, particularly mild TBI or concussion, is the most common traumatic injury in the U.S. military.[2] Since 2000, combat injuries and injuries in non-deployed settings have resulted in more than 350,000 TBI cases among active component service members, National Guard members, and reservists.[3] The estimated prevalence of deployment-related TBI among those who returned from the conflicts in Afghanistan or Iraq (Operation Enduring Freedom/Operation Iraqi Freedom [OEF/OIF]) has ranged from 12% to 23%.[4-10]

The Department of Defense (DoD) has estimated that, during the later stages of the conflicts in Iraq and Afghanistan, approximately 85% of the injuries resulting in TBIs were diagnosed in non-deployed clinical settings.[3,11] Non-deployed settings are locations where the U.S. military maintains permanent bases (e.g., U.S., Western Europe, Japan). However, it remains unclear what fraction of the TBIs diagnosed in non-deployed settings were delayed diagnoses of injuries that occurred while deployed (OEF/OIF). Results of one recent study using administrative data from the Defense Medical Surveillance System (DMSS) suggested that a greater proportion of TBIs occurred in theater than previously estimated, and that a significant number of deployment-related TBIs were not diagnosed until several weeks or months after return from deployment.[12]

The objective of this analysis was to estimate the rates of incident TBIs among service members before their first-ever deployment, and separately among service members during deployments and after deployments. The analysis used data from standardized records of medical encounters of U.S. military members, including records of treatment in combat theaters. In addition, this report describes the demographic and military characteristics of service members diagnosed as TBI cases either before or after deployment as well as the distribution of causes of TBIs in these groups.

METHODS

The surveillance period was 1 January 2001 through 31 December 2016. The surveillance population included all individuals who served in the active component of the Army, Navy, Marine Corps, or Air Force at any time during the surveillance period. For surveillance purposes, a case of TBI was defined as any hospitalization or ambulatory visit of an active component service member with a diagnosis (in any position) indicative of a TBI.[13] This definition included skull fractures, intracranial injuries, injuries to optic nerve and pathways, unspecified head injuries, and personal history of TBI. These codes included a range of severity of TBI, from mild to severe or penetrating. An individual was considered a case only once per lifetime. All data used for analyses were extracted from records routinely maintained in the DMSS.

Incidence rates and trends of TBI were based on the first documented TBI-related medical encounter per service member during the surveillance period. Causes and circumstances of injuries that resulted in TBI-related hospitalizations were assessed based on NATO Standardization Agreement "cause of injury" (STANAG 2050) and ICD-9/ICD-10 "external cause of injury" codes. External causes of TBI were classified into categories based on intent (e.g., unintentional sports injury, self-inflicted injury) and the circumstances, mechanisms, or activities (e.g., motor vehicle, fall) associated with the injuries. A "miscellaneous" category under unintentional injury included codes for mechanisms (e.g., struck by or against an object) and activities not included elsewhere (e.g., building and construction). An "undocumented cause" category included all encounters that lacked an external cause code (missing).

Person-time and incident cases of TBI were assigned to one of three groups **(Figure 1)**. *Group 1* included only service members' person-time before their first-ever deployments. *Group 2*, the deployed group, included service members' person-time during their overseas deployments and the 30 days after their return from deployment. *Group 3* included only service members' person-time more than 30 days after deployment. To illustrate, a service member could contribute person-time to group 1 until the start of his or her first deployment; person-time to group 2 during, and for 30 days after, that first deployment and any subsequent deployments; and only group 3 time after the first (and any subsequent) deployment. Service members who had no record of any deployment during or before the surveillance period contributed only group 1 person-time. Follow-up of each service member in the surveillance population ended on the date of his or her first-incident TBI diagnosis, the termination of active component military service (e.g., death, retirement, discharge), or the end of the surveillance period. For each service member who was diagnosed with an incident TBI, that diagnosis was attributed to the group during the period associated with the date of the diagnosis.

RESULTS

During the 16-year surveillance period, a total of 276,858 active component service members received first-time diagnoses of TBI **(data not shown)**. The greatest proportion (44.0%) of the total TBI cases was contributed by service members in group 3 (n=121,923; crude overall incidence rate: 1,451.2 cases per 100,000 person-years [p-yrs]) **(Table 1)**. Service members in group 1 contributed 42.8% (n=118,587) of the total TBI cases (crude overall incidence rate: 1,141.3 cases per 100,000 p-yrs). Service members in group 2 had the lowest number of TBI cases (n=36,348) but the highest overall incidence rate (crude rate: 1,690.5 cases per 100,000 p-yrs) **(data not shown)**. The incidence rate of TBI among service members in group 2 was 1.5 times that of service members in group 1 and 1.2 times that of service members in group 3.

Among service members in group 1, overall TBI incidence rates were highest among those aged 24 years or younger **(Table 1)**. Compared to females, males had slightly higher overall incidence rates during the surveillance period. In group 1, white, non-Hispanic service members had the highest overall incidence rate of TBI relative to their counterparts in other race/ethnicity groups. Subgroup-specific incidence rates were highest among service members in the Army and the Marine Corps (1,481.8 cases per 100,000 p-yrs and 1,350 cases per 100,000 p-yrs, respectively), and those in combat-specific or armor/motor transport occupations (1,638.5 cases per 100,000 p-yrs and 1,489.8 cases per 100,000 p-yrs, respectively). Among those in group 1, the overall crude incidence rate among enlisted service members was more than twice the rate among officers (1,247 cases per 100,000 p-yrs and 521.5 cases per 100,000 p-yrs, respectively) **(Table 1)**.

FIGURE 1. Examples of categorization of person-time for groups 1, 2, and 3, by date of first deployment and censoring by incident diagnosis of traumatic brain injury (TBI), active component, U.S. Armed Forces, 2001–2016

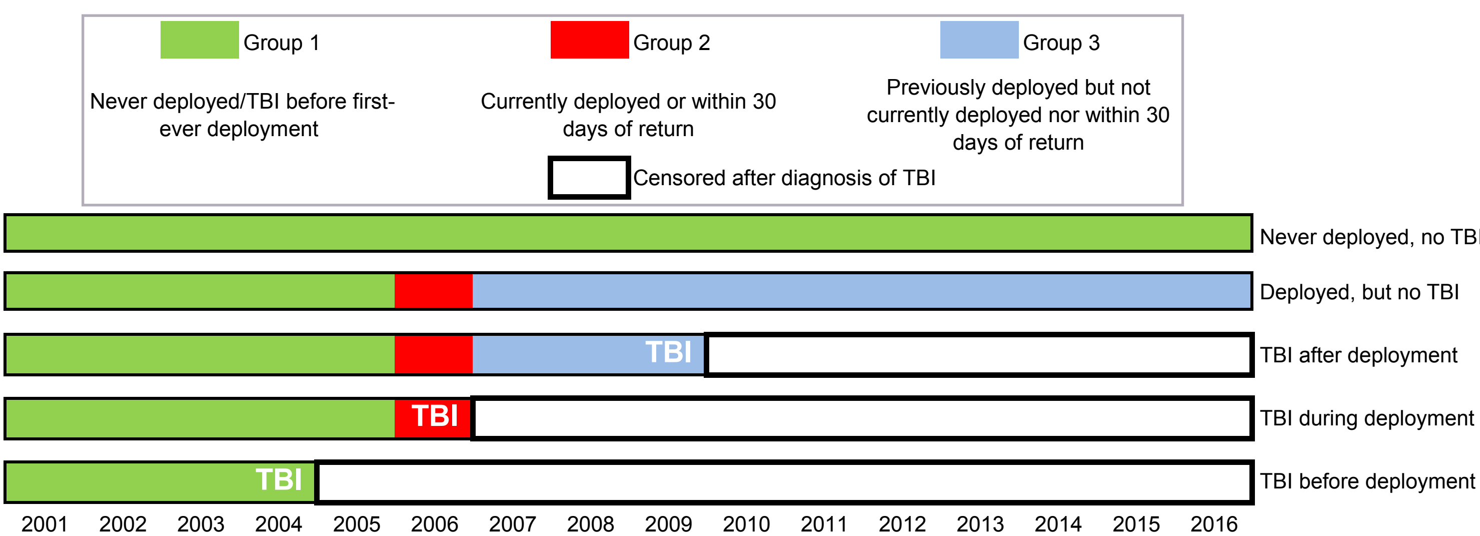


TABLE 1. Incident diagnoses and incidence rates of traumatic brain injury (TBI), by demographic characteristics, active component, U.S. Armed Forces, 2001–2016

	Total 2001–2016			
	Group 1[a]		Group 3[b]	
	Count	Rate[c]	Count	Rate[c]
Total	118,587	1,141.3	121,923	1,451.2
Sex				
Male	97,687	1,147.7	111,434	1,507.4
Female	20,900	1,112.3	10,489	1,039.3
Age group				
<20	21,557	1,504.2	624	2,499.2
20–24	64,417	1,430.6	36,702	2,308.8
25–29	19,299	933.1	33,388	1,608.1
30–34	6,665	659.2	20,496	1,157.0
35–39	3,672	507.1	15,623	1,003.1
40+	2,977	457.2	15,090	1,092.1
Race/ethnicity				
White, non-Hispanic	76,675	1,198.2	78,426	1,537.3
Black, non-Hispanic	17,436	1,042.1	18,409	1,196.3
Other	24,476	1,055.8	25,088	1,424.5
Service				
Army	50,599	1,481.9	73,915	2,378.4
Navy	23,049	871.9	16,368	750.0
Air Force	22,870	847.7	14,155	649.7
Marine Corps	22,069	1,350.0	17,485	1,874.0
Rank				
Enlisted	110,636	1,247.9	109,410	1,630.0
Officer	7,951	521.5	12,513	740.8
Military occupation				
Combat-specific	19,488	1,638.5	36,438	3,057.7
Armor/motor transport	4,392	1,489.8	5,534	2,196.4
Pilot/air crew	1,519	577.8	2,063	445.7
Repair/engineering	34,045	1,164.1	29,260	1,116.6
Communications/intelligence	23,142	1,025.8	24,672	1,234.7
Health care	9,536	884.9	7,665	1,291.5
Other	26,465	1,109.5	16,291	1,269.8

[a]Group 1, never deployed/TBI before first-ever deployment

[b]Group 3, previously deployed but not currently deployed nor within 30 days of return

[c]Rate per 100,000 person-years

A similar pattern in subgroup-specific overall incidence rates was observed among service members in group 3. Relative to their respective counterparts, the highest incidence rates of TBI among service members in group 3 affected males (1,507.4 cases per 100,000 p-yrs); those aged 24 years or younger; and those of white, non-Hispanic race/ethnicity (1,537.3 cases per 100,000 p-yrs) **(Table 1)**. Overall incidence rates were highest among group 3 service members in the Army and the Marine Corps (2,378.4 cases per 100,000 p-yrs and 1,874.0 cases per 100,000 p-yrs, respectively), those in combat-specific or armor/motor transport occupations (3,057.75 cases per 100,000 p-yrs and 2,196.4 cases per 100,000 p-yrs, respectively), and enlisted members (1,630.0 cases per 100,000 p-yrs).

Among service members in group 1, annual incidence rates of TBI increased from a low of 841.6 cases per 100,000 p-yrs in 2001 to a high of 1,489.1 cases per 100,000 p-yrs in 2014 (76.9% increase) **(Figure 2)**. The increases in annual rates during this period were driven largely by increases in incidence rates of TBI among group 1 service members in the Marine Corps and the Army **(data not shown)**. During the surveillance period, among service members in group 1, annual incidence rates of TBI among members in the Navy were slightly higher than those among members in the Air Force **(data not shown)**. Annual incidence rates among members of these Services were relatively stable throughout the surveillance period. For the first 9 years of the surveillance period, females in group 1 had annual incidence rates lower than their male counterparts. In 2010, and again during 2012–2016, females had higher annual incidence rates of TBI than males **(Figure 3)**.

From 2001 through 2006, annual incidence rates of TBI among group 3 service members were lower than those among group 1 service members. In 2007, the annual incidence rate among group 3 service members exceeded that of group 1 service members (1,247.1 cases per 100,000 p-yrs and 1,178.0 cases per 100,000 p-yrs, respectively). Non-deployment-associated annual incidence rates in group 3 peaked in 2012 (2,032.7 cases per 100,000 p-yrs) and then decreased during the subsequent 4-year period **(Figure 2)**. As with the annual incidence rates of TBI among group 1 service members, the increases in rates among group 3 service members throughout the surveillance period were driven largely by increases in the Army and the Marine Corps **(data not shown)**. During the surveillance period, annual incidence rates among group 3 members of the Navy and the Air Force were similar and relatively stable. Throughout the surveillance period, group 3 males had higher annual incidence rates of TBI than group 3 females. The divergence in rates between the sexes was most apparent after 2004 **(Figure 3)**.

Between 2001 and 2005, annual incidence rates of TBI among service members

FIGURE 2. Annual incidence rates of traumatic brain injury (TBI), by group, active component, U.S. Armed Forces, 2001–2016

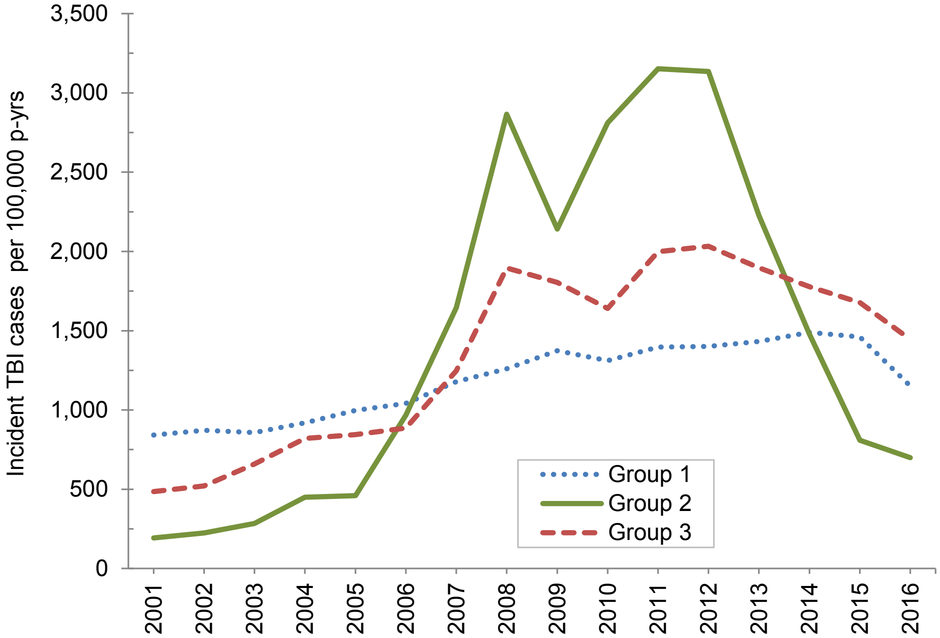
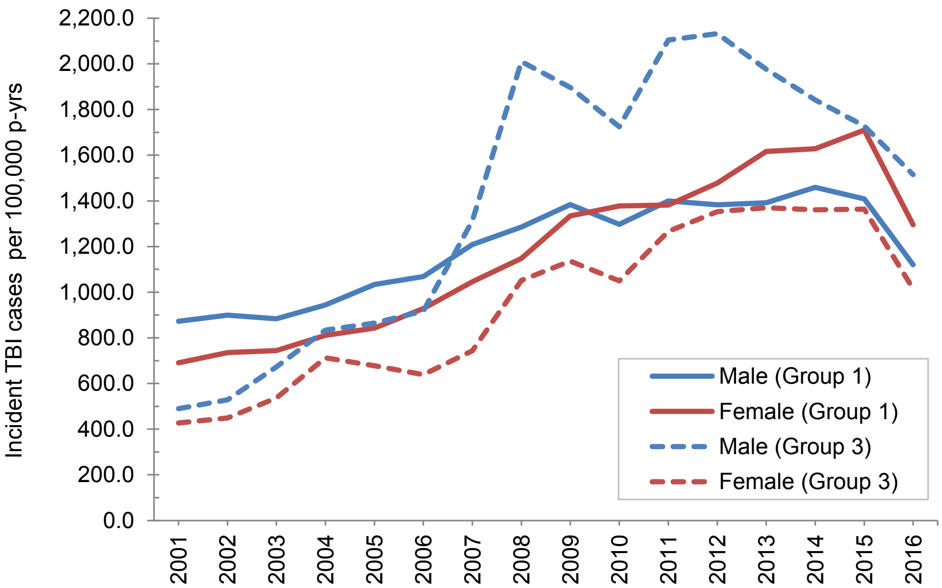


FIGURE 3. Annual incidence rates of traumatic brain injury (TBI), by group, by sex, active component, U.S. Armed Forces, 2001–2016



in group 2 were lower than those among service members in the other two groups. After 2005, rates among service members in group 2 increased sharply **(Figure 2)**. There was some fluctuation in rates in this group between 2008 and 2010. The annual rates peaked in 2011 at 3,152.3 cases per 100,000 p-yrs and then decreased to the end of the surveillance period. Between 2007 and 2013, annual incidence rates were higher among service members in group 2 than among service members in groups 3 and 1. However, in 2015 and 2016, annual incidence rates of TBI were considerably lower among service members in group 2 than among those in groups 3 and 1 **(Figure 2)**.

Cause of injury codes

During the 16-year surveillance period, more than two-thirds (70.6%) of the records of TBI encounters among service members in group 1 and more than four-fifths (81.2%) of the records of TBI encounters among group 3 service members did not include cause of injury codes **(Tables 2, 3)**. In both groups of service members, the completeness of recording of external causes of TBIs was similar across clinical settings (inpatient vs. outpatient).

Within group 1 in both clinical settings combined, 34,901 service members had TBI case-defining medical encounters with recorded injury causes. Within the group 3 in both clinical settings combined, 22,951 service members had TBI case-defining medical encounters with recorded injury causes. In groups 1 and 3, "land transport"–related causes were the most frequently reported causes of injuries (8.8% and 7.5%, respectively) on records of TBI case-defining hospital visits. "Slips, trips, and falls" were the second most frequently reported causes of injuries (8.2% and 4.7%, respectively) on records of TBI case-defining hospital visits in both groups **(Tables 2, 3)**. "Miscellaneous" causes were the most frequently reported causes of injuries (9.7% and 5.0%, respectively) on records of TBI case-defining ambulatory visits in both groups. Overall, the proportions of TBI case-defining medical encounters that were hospitalizations were 6.1% for service members in group 1 and 4.4% for the service members in group 3. It is noteworthy that, among service members in group 3, a total of 1,133 TBI cases were associated with the code for "war."

A comparison of cause code categories on records of TBI case-defining medical encounters from 2001–2008 to 2009–2016 showed a 12.2% decrease in the proportion of encounters with undocumented causes among service members in group 1. However, among service members in group 3, there was a slight (7.1%) increase in the proportion of encounters with undocumented causes from 2001–2008 to 2009–2016 **(Table 2)**.

TABLE 2. Number and percentage of cause codes on traumatic brain injury case-defining medical encounters among service members in group 1, by clinical setting of treatment and time period, active component, U.S. Armed Forces, 2001–2016

	Total 2002–2016		Inpatient		Outpatient		2001–2008		2009–2016	
	No.	%	No.	%	No.	%	No.	%	No.	%
Unintentional										
Miscellaneous	11,146	9.4	369	5.1	10,777	9.7	4,138	7.2	7,008	11.5
Slips, trips, falls	9,139	7.7	593	8.2	8,546	7.7	3,650	6.4	5,489	9.0
Land transport	7,111	6.0	641	8.8	6,470	5.8	3,046	5.3	4,065	6.7
Athletics	1,820	1.5	169	2.3	1,651	1.5	509	0.9	1,311	2.1
Parachuting-related	1,200	1.0	79	1.1	1,121	1.0	627	1.1	573	0.9
Machinery, tools	259	0.2	76	1.0	183	0.2	126	0.2	133	0.2
Air transport	247	0.2	23	0.3	224	0.2	142	0.2	105	0.2
Guns, explosives (except war)	157	0.1	80	1.1	77	0.1	67	0.1	90	0.1
Environmental factors	90	0.1	14	0.2	76	0.1	41	0.1	49	0.1
Water transport	52	0.0	6	0.1	46	0.0	17	0.0	35	0.1
Poisons, fire	23	0.0	10	0.1	13	0.0	10	0.0	13	0.0
Intentional										
Violence	3,500	3.0	142	2.0	3,358	3.0	1,754	3.1	1,746	2.9
War	92	0.1	12	0.2	80	0.1	30	0.1	62	0.1
Self-inflicted	65	0.1	22	0.3	43	0.0	25	0.0	40	0.1
Undocumented cause	83,688	70.6	5,031	69.2	78,657	70.7	43,287	75.3	40,399	66.1

TABLE 3. Number and percentage of cause codes on traumatic brain injury case-defining medical encounters among service members in group 3, by clinical setting of treatment and time period, active component, U.S. Armed Forces, 2001–2016

	Total		Inpatient		Outpatient		2001–2008		2009–2016	
	No.	%	No.	%	No.	%	No.	%	No.	%
Unintentional										
Miscellaneous	5,963	4.9	182	3.4	5,781	5.0	1,893	5.3	4,070	4.7
Land transport	5,715	4.7	399	7.5	5,316	4.6	2,061	5.8	3,654	4.2
Slips, trips, falls	5,009	4.1	251	4.7	4,758	4.1	1,532	4.3	3,477	4.0
Parachuting-related	1,115	0.9	64	1.2	1,051	0.9	484	1.4	631	0.7
Athletics	1,025	0.8	76	1.4	949	0.8	254	0.7	771	0.9
Air transport	256	0.2	11	0.2	245	0.2	120	0.3	136	0.2
Guns, explosives (except war)	249	0.2	63	1.2	186	0.2	143	0.4	106	0.1
Machinery, tools	148	0.1	30	0.6	118	0.1	54	0.2	94	0.1
Environmental factors	58	0.0	6	0.1	52	0.0	17	0.0	41	0.0
Water transport	41	0.0	4	0.1	37	0.0	20	0.1	21	0.0
Poisons, fire	26	0.0	14	0.3	12	0.0	8	0.0	18	0.0
Intentional										
Violence	2,179	1.8	73	1.4	2,106	1.8	969	2.7	1,210	1.4
War	1,133	0.9	38	0.7	1,095	0.9	551	1.5	582	0.7
Self-inflicted	34	0.0	17	0.3	17	0.0	9	0.0	25	0.0
Undocumented cause	98,972	81.2	4,085	76.9	94,887	81.4	27,632	77.3	71,340	82.8

EDITORIAL COMMENT

Results of this analysis showed that the crude overall incidence rate of TBI among deployed service members (group 2) was 1.5 times that of service members in group 1 and 1.2 times that of service members in group 3. Given the hazards of military operations in settings of armed conflict, it is not surprising that TBI incidence rates were higher in service members during or immediately following deployments. With respect to service members in group 3, it should be noted that all had previously deployed, but any subsequent diagnoses of TBI were documented more than 30 days after they returned from deployment.

Several factors may explain why the TBI incidence rates among members of group 3 were higher than those among service members in group 1. For example, in many cases, clinical diagnoses of TBI may be significantly delayed from the times of causal head injuries. This delay may occur if there are severe injuries to parts of the body other than the head. Such injuries can mask the acute signs and symptoms of mild and even moderate TBI and could delay diagnoses until affected service members are fit to complete clinical assessments. In addition, because some symptoms of post-traumatic stress disorder (PTSD) and mild TBI overlap, diagnoses of TBI may be delayed when the focus of clinical attention is on symptoms attributable to PTSD.

Furthermore, in general, service members who have recently returned from deployments may have riskier behaviors than their counterparts in group 1. These behaviors may lead to increased occurrences of TBIs.[12] Many service members returning from deployment face challenges in transitioning to their home environments. These challenges may lead to behaviors that are known risk factors for TBI. Such behaviors include driving automobiles and motorcycles recklessly and/or while intoxicated, driving motorcycles without helmets, using alcohol to excess, and fighting.[14-16]

In addition, service members leaving military service may seek medical care to document their eligibility for veterans disability compensation or follow-up medical care after separation. Potential TBIs may be identified during this process, thus contributing to the identification of TBIs that were sustained during, but diagnosed long after returning from, deployments. One manifestation of delayed diagnosis of TBI may be the observation that, among service members in group 3, a total of 1,133 cases of TBI were associated with the code for "war." All three of the aforementioned factors may have contributed to the finding that annual incidence rates of TBI among service members in group 3 were higher than among deployed service members (group 2) during 2014–2016.

Finally, the relatively high rates of TBI diagnoses among service members well after returning from deployments undoubtedly reflects markedly increased awareness of the potential long-term effects of TBIs among military and civilian healthcare providers, policy makers, senior and junior leaders, and service members and their families. Such increased awareness inevitably resulted in increased clinical ascertainment and documentation of previously undiagnosed cases.

The annual incidence rates of TBI during the early part of the surveillance period (2001–2006) among service members in group 1 could be interpreted as representing the background risk and case ascertainment capabilities for TBI that existed before the implementation of extensive mandatory concussion screening programs in 2007.[2,17] The implementation of these programs was followed by an increase in the frequency of diagnoses of TBI, although not necessarily in the actual incidence. The annual rates of TBI among service members in group 1 from 2007 onward could be seen to represent the background risk of TBI plus the impact of enhanced case ascertainment capabilities that were put in place throughout the DoD during this period. The annual incidence rates of TBI among service members in groups 3 and 2 reflect a combination of the background risk of TBI, enhanced ascertainment capabilities, and the increased risk of service in an active war zone.[17] As such, the portion of the surveillance period during which the annual incidence rates of TBI in these two groups exceeded the rates in group 1 likely represents, at least in part, the increased risk of service in an active combat zone. For deployed service members, this period extended from 2007 through 2013. For service members in group 3, this period lasted from 2007 through 2016.

The vast majority of TBIs among service members are first diagnosed in the non-deployed garrison setting or the home station environment. The leading causes of TBIs among military members in this environment are similar to those of TBIs in same-aged civilians and include accidents (e.g., motor vehicle crashes, falls, strikes by/against objects), intentional assaults (e.g., fights, brawls), and sports and other recreational activities.[2,18-20] Examination of the TBI case-defining encounters with recorded injury causes in this analysis yielded similar leading causes (land transport and slips, trips, and falls). Regardless of their causes, TBIs can have significant acute and long-term clinical effects—with consequences for both the Military Health System (MHS) and the Veterans Health Administration.

The findings of this report should be interpreted with consideration of the limitations of the analyses. For example, the analysis defined TBI diagnoses based on indicator diagnosis codes (per ICD-9 and ICD-10) reported on administrative records of medical encounters in theater (TMDS) and in fixed U.S. military and civilian (i.e., purchased care) medical facilities if reimbursed through the MHS. Records of care received outside of such medical facilities were not available for this analysis. As a result, the numbers and rates reported here may underestimate the actual numbers and rates of incident diagnoses.

Other limitations of the results presented in this report are related to external cause coding. Interestingly, 92 cases in group 1 were associated with the external cause code for "war," which could be the result of medical provider miscoding, missing deployment records, or some other misclassification event. Another limitation is the high proportion of TBI case-defining medical encounters with undocumented causes. This lack of recorded cause of injury codes prevented more in-depth analyses by deployment status group and by clinical setting. It also highlights the need for more complete and accurate reporting of the causes of TBI-related injuries to inform TBI prevention efforts, practices, and the direction of future research.

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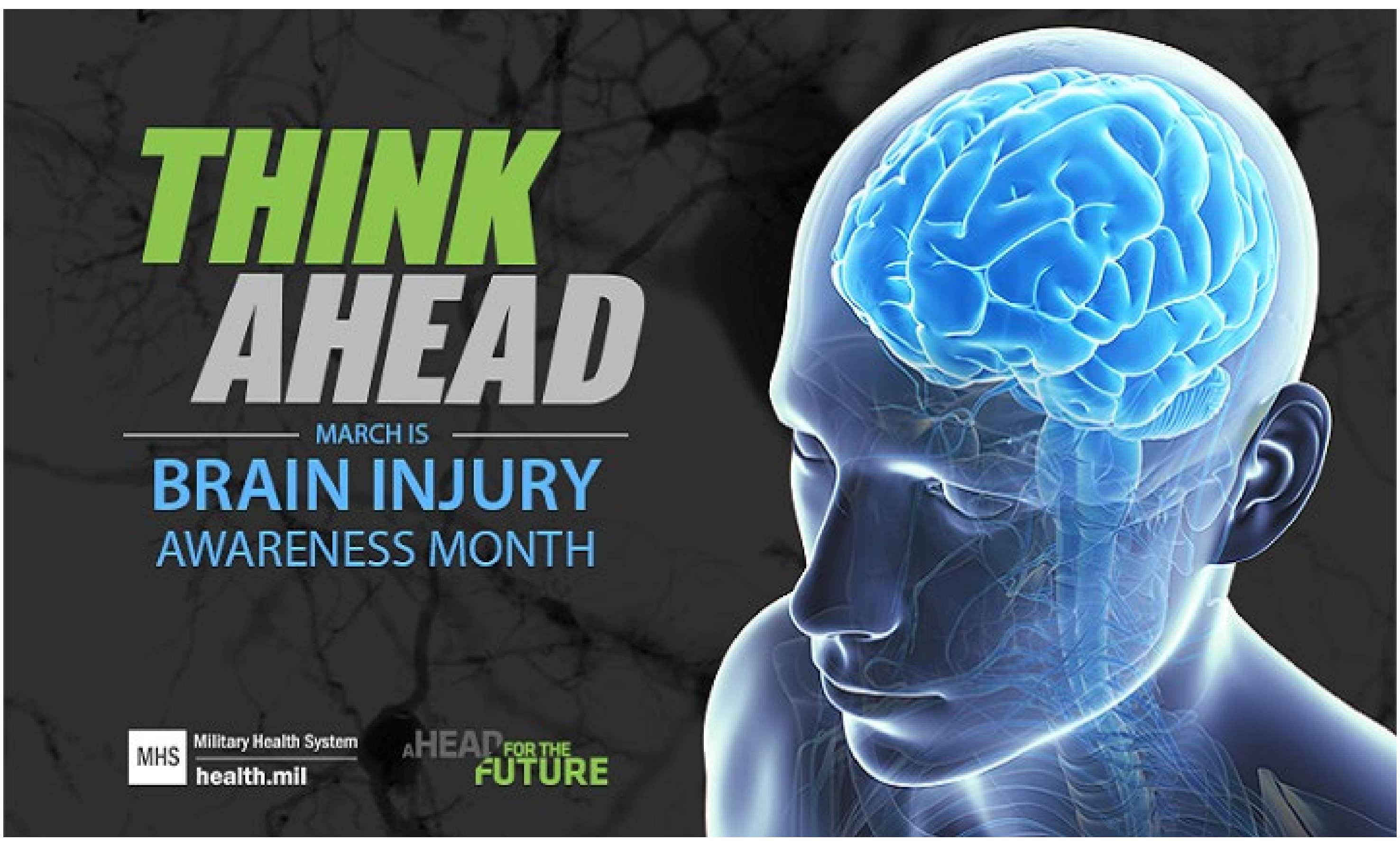

Update: Heat Illness, Active Component, U.S. Armed Forces, 2016

In 2016, there were 2,536 incident diagnoses of heat illness among active component service members (incidence rate: 1.96 cases per 1,000 person-years [p-yrs]). The overall crude incidence rates of heat stroke and "other heat illness" were 0.31 and 1.65 per 1,000 p-yrs, respectively. In 2016, subgroup-specific incidence rates of heat stroke were highest among males and service members aged 19 years or younger, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and those in combat-specific and "other" occupations. Subgroup-specific incidence rates of "other heat illnesses" in 2016 were highest among females, service members aged 19 years or younger, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations. During 2012–2016, a total of 572 diagnoses of heat injuries were documented among service members serving in Iraq/Afghanistan; 7.9% (n=45) of those diagnoses were for heat stroke. Commanders, small unit leaders, training cadre, and supporting medical personnel must ensure that military members whom they supervise and support are informed regarding risks, preventive countermeasures, early signs and symptoms, and first-responder actions related to heat illnesses.

The term "heat illness" refers to a spectrum of disorders that occur when the body is unable to dissipate heat absorbed from the external environment and the heat generated by internal metabolic processes.[1,2] As heat illness progresses, failure of one or more body systems can occur.[3] Timely medical intervention can prevent milder cases of heat illness, such as heat exhaustion, from becoming severe (e.g., heat stroke) and potentially life threatening. However, even with medical intervention, severe heat illness (heat stroke) may have lasting effects, including damage to the nervous system and other vital organs and decreased heat tolerance, making an individual more susceptible to subsequent episodes of heat illness.[4-6]

Strenuous physical activity for extended durations in occupational settings as well as during military operational and training exercises expose service members to considerable heat stress due to high environmental heat and/or a high rate of metabolic heat production.[7] In some military settings, wearing needed protective clothing or equipment may make it biophysically difficult to dissipate body heat. The resulting body heat burden and associated cardiovascular strain limit exercise performance and increase the risk of heat-related illness.[7,8]

Over many decades, lessons learned during military training and operations in hot environments as well as the findings of numerous research studies have resulted in doctrine, equipment, and preventive measures that can significantly reduce the adverse health effects of military activities in hot weather.[9-15] Although numerous effective countermeasures are available, heat-related illness remains a significant threat to the health and operational effectiveness of military members and their units and accounts for considerable morbidity, particularly during recruit training in the U.S. military.[7,16]

In the U.S. Military Health System (MHS), the most serious heat-related illnesses are considered notifiable medical events. Since 31 July 2009, a notifiable case of heat stroke (ICD-9: 992.0) has been defined as a severe heat stress illness, "specifically including injury to the central nervous system, characterized by central nervous system dysfunction and often accompanied by heat injury to other organs and tissue."[17,18] Notifiable cases of heat illness other than heat stroke include moderate to severe heat illnesses "associated with strenuous exercise and environmental heat stress…that require medical intervention or result in lost duty time." All cases of heat illness that require medical intervention or result in lost duty are reportable. Cases that do not require medical intervention or result in lost duty time are not reportable.[17,18]

This report summarizes not only reportable medical events of heat illnesses but also heat illness–related hospitalizations and ambulatory visits among active component members during 2016 and compares them to the previous 4 years. Episodes of heat stroke and "other heat illnesses" are summarized separately; for this analysis, "other heat illnesses" includes heat exhaustion and "unspecified effects of heat."

METHODS

The surveillance period was 1 January 2012 through 31 December 2016. The surveillance population included all individuals who served in the active components of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. The Defense Medical Surveillance System (DMSS) maintains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted/purchased care through the MHS) medical facilities worldwide; the DMSS also maintains records of medical encounters of service members deployed to Southwest Asia/Middle East (as documented in the Theater Medical Data Store [TMDS]). Because heat illnesses represent a threat to the health of individual service members and to military training and operations, the Armed Forces require expeditious reporting of these reportable medical events through one of the service-specific electronic reporting systems; these reports are routinely transmitted and incorporated into the DMSS.

For this analysis, DMSS was searched to identify all records of medical encounters and notifiable medical event reports that included primary (first-listed) or secondary (second-listed) diagnoses of heat stroke (ICD-9: 992.0; ICD-10: T67.0) or "other heat illness" (heat exhaustion [ICD-9: 992.3–992.5; ICD-10: T67.3–T67.5] and "unspecified effects of heat" [ICD-9: 992.8, 992.9; ICD-10: T67.3–T67.5, T67.8, T67.9]). Encounters for each individual within each calendar year were prioritized in terms of record source—hospitalizations > reportable events > ambulatory visits.

This report summarizes numbers of incident cases of heat illnesses during each calendar year. To estimate numbers of incident cases per year, each individual who was affected by a heat illness event (one or more) during a year accounted for one incident case during the respective year. To classify the severity of incident cases per year, those that were associated with any heat stroke diagnosis were classified as heat stroke cases; all others were classified as "other heat illness" cases.

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

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

RESULTS

In 2016, there were 401 incident cases of heat stroke and 2,135 incident cases of "other heat illness" among active component service members **(Table 1)**. The overall crude incidence rates of heat stroke and "other heat illness" were 0.31 and 1.65 per 1,000 person-years (p-yrs), respectively.

The annual incidence rate (unadjusted) of cases of heat stroke in 2016 was slightly lower than the rate in 2015 **(Figure 1)**. There were fewer heat stroke–related ambulatory visits and more reportable events in 2016 than in 2015 but relatively comparable numbers of hospitalizations. The annual crude incidence rate of cases of "other heat illness" was slightly higher in 2016 than in 2015 due largely to an increase in reportable events and ambulatory visits **(Figure 2)**.

In 2016, subgroup-specific incidence rates of heat stroke were highest among males and service members aged 19 years or younger, Asian/Pacific Islanders, Marine Corps and Army members, recruit trainees, and those in combat-specific and "other" occupations **(Table 1)**. The heat stroke rate in the Marine Corps was 88.9% higher than in the Army; the Army rate was more than 4-fold that in the Navy and 8-fold that in the Air Force; the rate among females was more than 44% lower than the rate among males. There were only 20 cases of heat stroke among recruit trainees, but their incidence rate was more than twice that of other enlisted members and officers.

In contrast to the heat stroke findings, the crude incidence rate of "other heat illnesses" was higher among females than males **(Table 1)**. In 2016, subgroup-specific incidence rates of "other heat illnesses" were notably higher among service members aged 19 years or younger, Marine Corps and Army members, recruit trainees, and service members in combat-specific occupations.

Heat illnesses by location

During the 5-year surveillance period, 11,967 heat-related illnesses were diagnosed at more than 250 military installations and geographic locations worldwide. Three Army installations accounted for close to one-third (31.5%) of all heat illnesses during the period (Fort Benning, GA [n=1,451]; Fort Bragg, NC [n=1,409]; and Fort Jackson, SC [n=911]); five other installations accounted for an additional 21.7% of heat illness events (Marine Corps Base Camp Lejeune/Cherry Point, NC [n=661]; Fort Campbell, KY [n=579]; Marine Corps Recruit Depot Parris Island/Beaufort, SC [n=498]; Fort Polk, LA [n=468]; and Marine Corps Base Camp Pendleton, CA [n=393]). Of the 10 installations with the most heat illness events, seven are located in the southeastern U.S. **(Table 2)**. The 22 installations with 100 or more cases of heat illness accounted for 75.1% of all active component cases during 2012–2016.

Heat illnesses in Iraq and Afghanistan

During the 5-year surveillance period, 572 heat illnesses were diagnosed and treated in Iraq and Afghanistan **(Figure 3)**. Of these, 7.9% (n=45) were diagnosed as heat stroke. The numbers of heat illnesses in Iraq and Afghanistan decreased 9.8% in 2016 relative to 2015 **(Figure 3)**. Deployed service members who were affected by heat illnesses were most frequently male (n=472; 82.5%); white, non-Hispanic (n=327: 57.2%); aged 20–24 years (n=278; 48.6%); in the Army (n=291; 50.9%); enlisted (n=547; 95.6%); and in repair/engineering (n=195; 34.1%) or combat-specific (n=154; 26.9%) occupations **(data not shown)**. During the surveillance period, five service members were medically evacuated for heat illnesses from Iraq or Afghanistan; all of the evacuations took place in the summer months (June–September).

TABLE 1. Incident cases[a] and incidence rates[b] of heat illness, active component, U.S. Armed Forces, 2016

	Heat stroke		Other heat illnesses		Total heat illness diagnoses	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	401	0.31	2,135	1.65	2,536	1.96
Sex						
Male	363	0.33	1,749	1.61	2,112	1.94
Female	38	0.19	386	1.90	424	2.08
Age group						
<20	62	0.68	562	6.20	624	6.88
20–24	189	0.46	946	2.30	1,135	2.76
25–29	90	0.30	342	1.14	432	1.44
30–34	31	0.15	160	0.76	191	0.91
35–39	23	0.16	69	0.47	92	0.63
40+	6	0.05	56	0.43	62	0.47
Race/ethnicity						
White, non-Hispanic	209	0.28	1,203	1.62	1,412	1.90
Black, non-Hispanic	64	0.30	389	1.84	453	2.14
Hispanic	63	0.33	320	1.67	383	2.00
Asian/Pacific Islander	32	0.62	117	2.26	149	2.88
Other/unknown	33	0.36	106	1.14	139	1.50
Service						
Army	205	0.43	1,236	2.62	1,441	3.05
Navy	29	0.09	127	0.39	156	0.48
Air Force	16	0.05	189	0.61	205	0.66
Marine Corps	151	0.82	583	3.17	734	3.99
Military status						
Enlisted	315	0.30	1,661	1.60	1,976	1.91
Officer	66	0.29	133	0.58	199	0.87
Recruit	20	0.76	341	12.88	361	13.63
Military occupation						
Combat-specific	146	0.84	683	3.95	829	4.79
Armor/motor transport	12	0.27	72	1.61	84	1.88
Pilot/air crew	5	0.10	14	0.29	19	0.39
Repair/engineering	41	0.11	321	0.83	362	0.94
Communications/intelligence	56	0.20	292	1.03	348	1.23
Health care	21	0.18	119	1.03	140	1.22
Other	120	0.50	634	2.62	754	3.12
Home of record[c]						
Midwest	73	0.32	390	1.71	463	2.03
Northeast	52	0.32	261	1.60	313	1.92
South	159	0.30	981	1.83	1,140	2.13
West	89	0.30	443	1.49	532	1.79
Other/unknown	28	0.42	60	0.90	88	1.31

[a]One case per person per year

[b]Number of cases per 1,000 person-years

[c]As self-reported at time of entry into service

EDITORIAL COMMENT

This annual update of heat illnesses among service members in the active component documented that the annual crude incidence rate of cases of heat stroke was slightly lower in 2016 than in 2015. The annual crude rate of cases of "other heat illness" increased slightly from 2015 to 2016. The separate analysis of heat illnesses diagnosed and treated in Iraq and Afghanistan during the surveillance period showed a 9.8% decrease in the number of heat illnesses in 2016 relative to 2015. The overall decrease in the annual numbers of incident cases of heat illnesses in Iraq and Afghanistan during the entire surveillance period is consistent with the declining numbers of U.S. forces in those two countries in the past 6 years.

The results of this update should be interpreted with consideration of its limitations. Similar heat-related clinical illnesses are likely managed differently and reported with different diagnostic codes at different locations and in different clinical settings. Such differences undermine the validity of direct comparisons of rates of nominal heat stroke and "other heat illness" events across locations and settings. Also, heat illnesses during training exercises and deployments that are treated in field medical facilities are not completely ascertained as cases for this report. It should also be noted that the guidelines for mandatory reporting of heat illnesses (previously referred to as "heat injury") were modified in the 2012 revision of the guidelines for reportable medical events.[17,18] It is possible that the numbers of reports of heat illnesses might have been affected by the change in guidelines. To compensate for such possible variation in reporting, the analysis for this update, as in previous years, included cases identified in DMSS records of ambulatory care and hospitalizations utilizing a consistent set of ICD-9/ICD-10 codes for the entire surveillance period. As was noted in earlier *MSMR* heat illness updates, results indicate that a sizable proportion of cases identified through DMSS records did not prompt mandatory reports through the reporting system.

In spite of its limitations, this report documents that heat illnesses are still a significant threat to both the health of U.S. military members and the effectiveness of military operations. Of all military members, the youngest and most inexperienced Marines and soldiers (particularly those training at installations in the southeastern U.S.) are at highest risk of heat

FIGURE 1. Incident cases and incidence rates of heat stroke, by source of report and year of diagnosis, active component, U.S. Armed Forces, 2012–2016

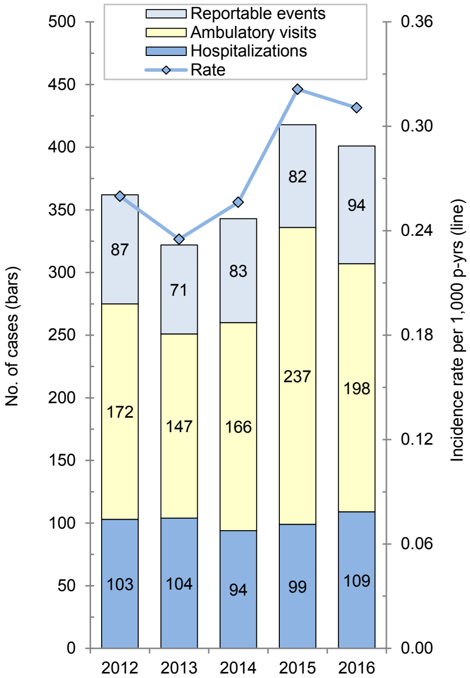

FIGURE 2. Incident cases and incidence rates of "other heat illness," by source of report and year of diagnosis, active component, U.S. Armed Forces, 2012–2016

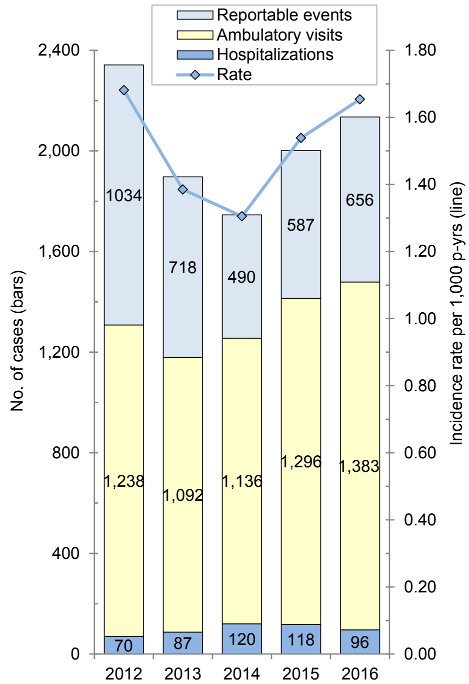

FIGURE 3. Numbers of heat illnesses diagnosed in Iraq/Afghanistan, active component, U.S. Armed Forces, 2012–2016

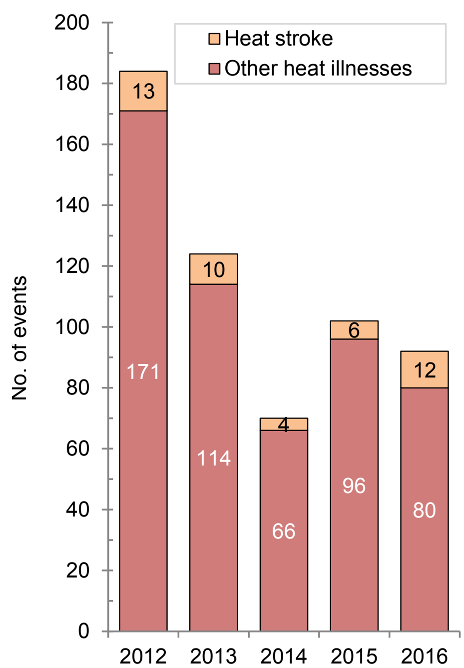

TABLE 2. Heat illness events,[a] by location of diagnosis/report, active component, U.S. Armed Forces, 2012–2016

Location of diagnosis	No.	% total
Fort Benning, GA	1,451	12.1
Fort Bragg, NC	1,409	11.8
Fort Jackson, SC	911	7.6
MCB Camp Lejeune/Cherry Point, NC	661	5.5
Fort Campbell, KY	579	4.8
MCRD Parris Island/ Beaufort, SC	498	4.2
Fort Polk, LA	468	3.9
MCB Camp Pendleton, CA	393	3.3
Fort Hood, TX	308	2.6
NMC San Diego, CA	276	2.3
Okinawa, Japan	259	2.2
MCB Quantico, VA	254	2.1
Fort Stewart, GA	211	1.8
JBSA-Lackland AFB, TX	202	1.7
Fort Leonard Wood, MO	198	1.7
Fort Shafter, HI	166	1.4
NH Twentynine Palms, CA	165	1.4
Fort Irwin, CA	132	1.1
Fort Riley, KS	117	1.0
Eglin AFB, FL	112	0.9
Fort Sill, OK	109	0.9
Fort Bliss, TX	103	0.9
All other locations	2,985	24.9
Total	11,967	100.0

[a]One heat illness per person per year

MCB, Marine Corps Base; MCRD, Marine Corps Recruit Depot; NMC, Naval Medical Center; JBSA, Joint Base San Antonio; AFB, Air Force Base; NH, Naval Hospital

illnesses—including heat stroke, exertional hyponatremia, and exertional rhabdomyolysis (see the other articles in this issue of the *MSMR*).

Commanders, small unit leaders, training cadre, and supporting medical personnel—particularly at recruit training centers and installations with large combat troop populations—must ensure that military members whom they supervise and support are informed regarding risks, preventive countermeasures (e.g., water consumption), early signs and symptoms, and first-responder actions related to heat illnesses.[9-15] Leaders should be aware of the dangers of insufficient hydration on the one hand and excessive water intake on the other; they must have detailed knowledge of, and rigidly enforce countermeasures against, all types of heat illnesses.

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

https://phc.amedd.army.mil/topics/discond/hipss/Pages/HeatinjuryPrevention.aspx

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

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Update: Exertional Rhabdomyolysis, Active Component, U.S. Armed Forces, 2012–2016

Among active component service members in 2016, there were 525 incident diagnoses of rhabdomyolysis likely due to physical exertion and/or heat stress ("exertional rhabdomyolysis"). The crude incidence rate in 2016 was 40.7 cases per 100,000 person-years. Annual rates of incident diagnoses of exertional rhabdomyolysis increased 46.2% between 2013 and 2016, with the greatest percentage change occurring between 2014 and 2015. In 2016, relative to their respective counterparts, the highest incidence rates of exertional rhabdomyolysis affected service members who were male; younger than 20 years of age; and black, non-Hispanic. During the surveillance period, annual incidence rates were highest among service members of the Marine Corps, intermediate among those in the Army, and lowest among those in the Air Force and Navy. Most cases of exertional rhabdomyolysis were diagnosed at installations that support basic combat/recruit training or major ground combat units of the Army or the Marine Corps. Medical care providers should consider exertional rhabdomyolysis in the differential diagnosis when service members (particularly recruits) present with muscular pain or swelling, limited range of motion, or the excretion of dark urine (possibly due to myoglobinuria) after strenuous physical activity, particularly in hot, humid weather.

Rhabdomyolysis is characterized by the rapid breakdown of skeletal muscle cells and the release of intracellular muscle contents into the circulation. This process is most often recognized by the appearance of red to brown urine (due to myoglobinuria) and elevated serum muscle enzymes.[1] In exertional rhabdomyolysis, damage to skeletal muscle is caused by excessive physical activity in otherwise healthy individuals. This condition occurs when the energy supply to local muscle is insufficient to meet demands and muscle cells are unable to maintain cellular integrity.[2] Illness severity ranges from elevated serum muscle enzyme levels without clinical symptoms to life-threatening disease associated with extreme enzyme elevations, electrolyte imbalances, and kidney failure.[1-5]

Risk factors for exertional rhabdomyolysis include younger age, male sex, lower level of physical fitness, a prior heat injury, lower educational level, and exertion during the warmer months of the year.[6,7] Acute kidney injury is the most dangerous potential complication of exertional rhabdomyolysis and is thought to be due to an excessive concentration of free myoglobin in the urine accompanied by volume depletion, resulting in renal tubular obstruction, direct tubular cell injury, and vasoconstriction.[4,8]

In U.S. military members, rhabdomyolysis is a significant threat during physical exertion, particularly under heat stress. Each year, the *MSMR* summarizes numbers, rates, trends, risk factors, and locations of occurrences of exertional heat injuries, including exertional rhabdomyolysis. This report summarizes the results of analyses of data for 2012–2016. Additional information about the definition, causes, and prevention of exertional rhabdomyolysis can be found in previous issues of the *MSMR*.[9,10]

METHODS

The surveillance period was 1 January 2012 through 31 December 2016. The surveillance population included all individuals who served in an active component of the U.S. Armed Forces at any time during the surveillance period. The Defense Medical Surveillance System (DMSS) maintains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted or purchased care through the Military Health System) medical facilities worldwide. The DMSS also maintains records of medical encounters of service members deployed to Southwest Asia/Middle East (as documented in the Theater Medical Data Store).

For this analysis, the DMSS was searched for records of healthcare encounters (inpatient or outpatient) associated with diagnoses related to the occurrence of exertional rhabdomyolysis. For surveillance purposes, a case of "exertional rhabdomyolysis" was defined as a hospitalization or ambulatory visit with a discharge diagnosis in any position of either "rhabdomyolysis" (ICD-9: 728.88; ICD-10: M62.82) or "myoglobinuria" (ICD-9: 791.3; ICD-10: R82.1) plus a diagnosis in any position of one of the following: "volume depletion (dehydration)" (ICD-9: 276.5x; ICD-10: E86.0, E86.1, E86.9), "effects of heat" (ICD-9: 992.0–992.9; ICD-10: T67.0–T67.9), "effects of thirst (deprivation of water)" (ICD-9: 994.3; ICD-10: T73.1), "exhaustion due to exposure" (ICD-9: 994.4; ICD-10: T73.2), or "exhaustion due to excessive exertion (overexertion)" (ICD-9: 994.5; ICD-10: T73.3). Each individual could be included as a case only once per calendar year.

To exclude cases of rhabdomyolysis that were secondary to traumatic injuries, intoxications, or adverse drug reactions, medical encounters with diagnoses in any position of "injury, poisoning, toxic effects"

(ICD-9: 800–999; ICD-10: S00–T88)—except the codes specific for "sprains and strains of joints and adjacent muscles," and "effects of heat, thirst, and exhaustion"—were not considered indicative of "exertional rhabdomyolysis."[11]

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

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

RESULTS

In 2016, there were 525 incident diagnoses of rhabdomyolysis likely associated with physical exertion and/or heat stress ("exertional rhabdomyolysis") **(Table 1)**. The crude incidence rate was 40.7 cases per 100,000 person-years (p-yrs).

In 2016, relative to their respective counterparts, the highest incidence rates of exertional rhabdomyolysis affected service members who were male (43.0 cases per 100,000 p-yrs); younger than 20 years of age (86.1 cases per 100,000 p-yrs); and black, non-Hispanic (60.0 cases per 100,000 p-yrs) **(Table 1)**. Subgroup-specific incidence rates were highest among service members in the Marine Corps and Army (88.0 cases per 100,000 p-yrs and 51.7 cases per 100,000 p-yrs, respectively), and those in combat-specific or "other" occupations

TABLE 1. Incident cases[a] and incidence rates[b] of exertional rhabdomyolysis, active component, U.S. Armed Forces, 2016

	Hospitalizations		Ambulatory visits		Total	
	No.	Rate[b]	No.	Rate[b]	No.	Rate[b]
Total	211	16.3	314	24.3	525	40.7
Sex						
Male	195	17.9	272	25.0	467	43.0
Female	16	7.9	42	20.6	58	28.5
Age group						
<20	26	23.6	69	62.5	95	86.1
20–24	86	20.6	121	29.0	207	49.7
25–29	55	18.7	66	22.4	121	41.1
30–34	24	11.7	35	17.1	59	28.8
35–39	11	7.8	13	9.2	24	16.9
40+	9	7.3	10	8.1	19	15.5
Race/ethnicity						
White, non-Hispanic	107	14.4	163	21.9	270	36.3
Black, non-Hispanic	57	26.9	70	33.1	127	60.0
Hispanic	32	16.7	37	19.3	69	36.1
Asian/Pacific Islander	7	13.5	18	34.8	25	48.3
Other/unknown	8	8.6	26	28.0	34	36.6
Service						
Army	108	22.9	136	28.8	244	51.7
Navy	24	7.4	28	8.7	52	16.1
Air Force	36	11.6	31	10.0	67	21.5
Marine Corps	43	23.4	119	64.7	162	88.0
Military status						
Enlisted	167	16.1	213	20.6	380	36.7
Officer	26	11.4	46	20.1	72	31.5
Recruit	18	68.0	55	207.7	73	275.7
Military occupation						
Combat-specific	57	33.0	76	43.9	133	76.9
Armor/motor transport	6	13.4	10	22.4	16	35.9
Pilot/air crew	5	10.2	1	2.0	6	12.3
Repair/engineering	34	8.8	39	10.1	73	19.0
Communications/intelligence	37	13.1	36	12.7	73	25.8
Health care	23	20.0	19	16.5	42	36.5
Other	49	20.3	133	55.0	182	75.2
Home of record[c]						
Midwest	42	18.4	46	20.1	88	38.5
Northeast	23	14.1	44	26.9	67	41.0
South	92	17.2	162	30.3	254	47.4
West	49	16.5	58	19.5	107	36.1
Territory	1	20.8	0	0.0	1	20.8
Unknown	4	6.4	4	6.4	8	12.9

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

(76.9 cases per 100,000 p-yrs and 75.2 cases per 100,000 p-yrs, respectively). Of note, incidence rates among recruit trainees were more than seven times those among other enlisted members and officers, even though cases among this group accounted for only 13.9% of all cases in 2016.

During the 5-year period, annual rates of incident diagnoses of exertional rhabdomyolysis increased 46.2% between 2013 and 2016, with the greatest change occurring between 2014 and 2015 (17.5%) **(Figure 1)**. Compared to service members of other race/ethnicity groups, the overall incidence rate of exertional rhabdomyolysis among black, non-Hispanics was highest during the surveillance period and in every year except 2013 when the highest rate occurred in Asian/Pacific Islanders **(data not shown)**. Annual incidence rates were highest among service members in the Marine Corps, intermediate among those in the Army, and lowest among those in the Air Force and Navy **(Figure 2)**. The annual incidence rates in the Marine Corps and the Army increased during 2013–2016 (37.0% and 46.4%, respectively), but rates in the Air Force and Navy remained relatively stable. During the surveillance period, most cases (69.7%) occurred during May–September **(Figure 3)**.

FIGURE 2. Annual incidence rates of exertional rhabdomyolysis, by service, active component, U.S. Armed Forces, 2012–2016

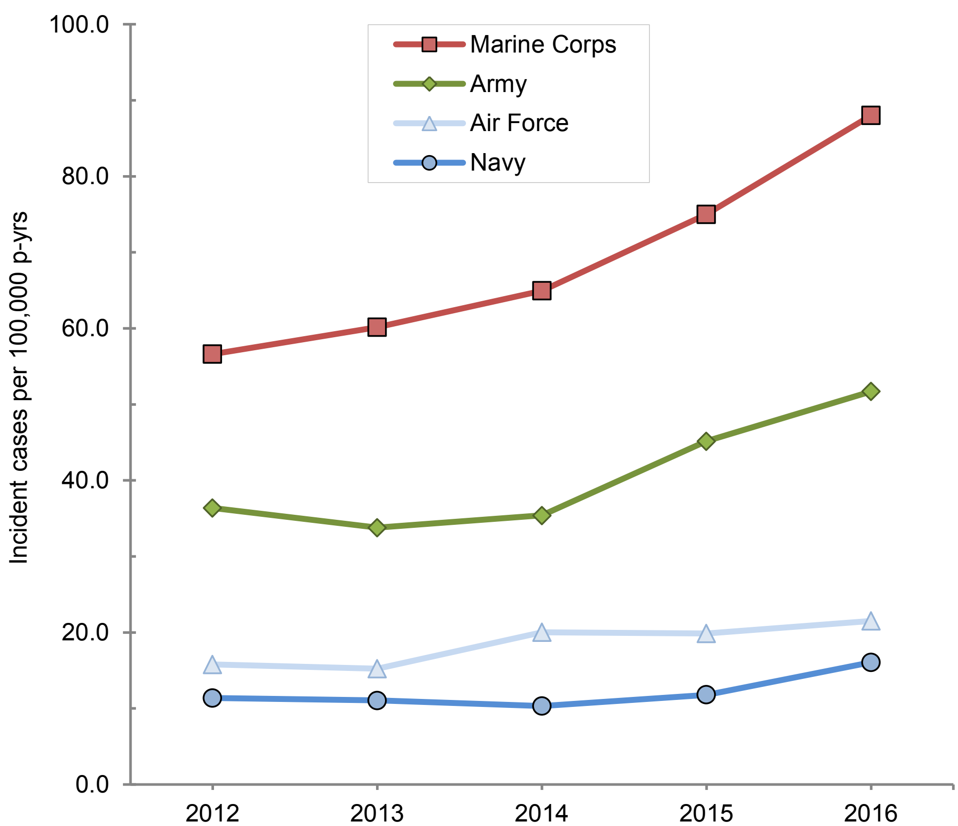
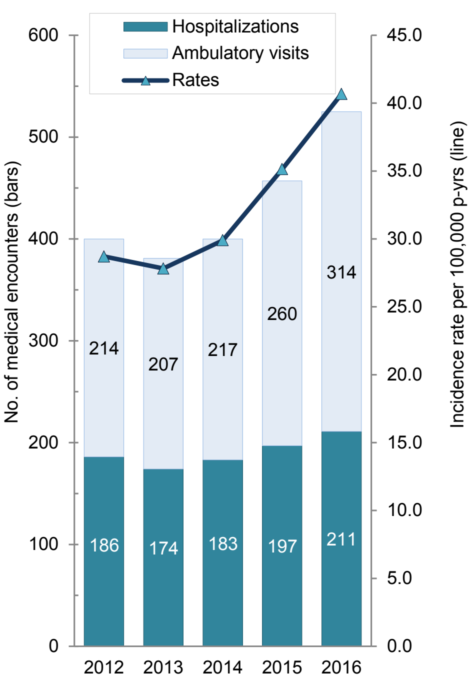


FIGURE 1. Annual incident cases and incidence rates of exertional rhabdomyolysis, by clinical setting, active component, U.S. Armed Forces, 2012–2016



Rhabdomyolysis by location

During the 5-year surveillance period, the medical treatment facilities at nine installations diagnosed at least 50 cases each and, together, approximately half (49.9%) of all diagnosed cases **(Table 2)**. Of these nine installations, three provide support to recruit/basic combat training centers (Marine Corps Recruit Depot Parris Island/Beaufort, SC; Fort Benning, GA; and Joint Base San Antonio–Lackland, TX). In addition, six installations support large combat troop populations (Fort Bragg, NC; Marine Corps Base [MCB] Camp Pendleton, CA; MCB Camp Lejeune/Cherry Point, NC; Fort Shafter, HI; Fort Hood, TX; and Fort Campbell, KY). The most cases overall, together accounting for almost one-quarter (23.1%) of all cases, were diagnosed at Fort Bragg, NC (n=281) and MCRD Parris Island/Beaufort, SC (n=219).

Rhabdomyolysis in Iraq and Afghanistan

There were nine incident cases of exertional rhabdomyolysis diagnosed and treated in Iraq/Afghanistan **(data not shown)** during the 5-year surveillance period. Deployed service members who were affected by exertional rhabdomyolysis were white; or black, non-Hispanic (n=5; 55.6% and n=4; 44.4%, respectively); most frequently male (n=8; 88.9%); between 25 and 29 years of age (n=4; 44.4%); in the Army (n=7; 77.8%); enlisted (n=8; 88.9%); and in combat-specific occupations (n=6; 66.7%). One active component service member was medically evacuated from Iraq/Afghanistan for exertional rhabdomyolysis; this medical evacuation occurred in September 2015 **(data not shown)**.

FIGURE 3. Incident cases of exertional rhabdomyolysis, by month, active component, U.S. Armed Forces, 2012–2016

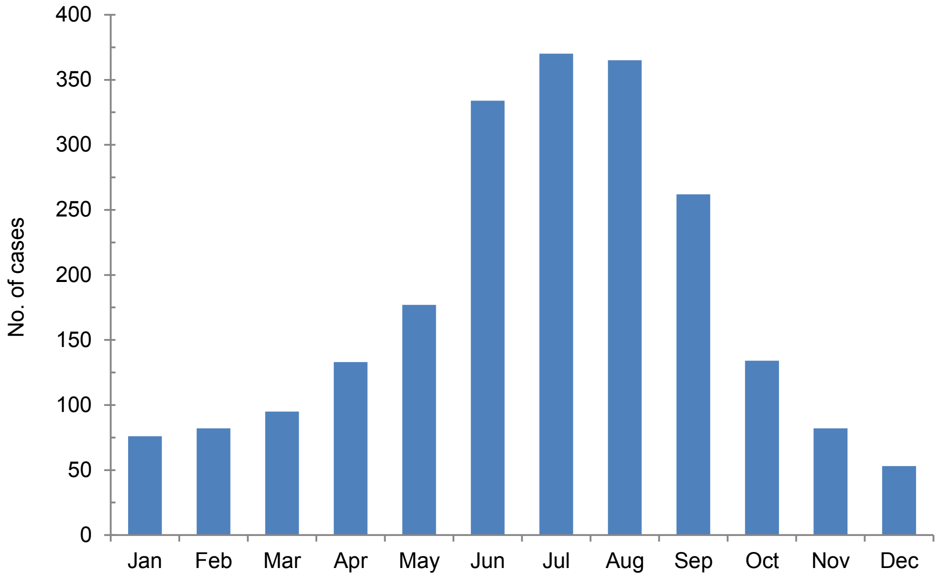


TABLE 2. Incident cases of exertional rhabdomyolysis, by installation (with at least 30 cases during the period), active component, U.S. Armed Forces, 2012–2016

Location of diagnosis	No.	% total
Fort Bragg, NC	281	13.0
MCRD Parris Island/ Beaufort, SC	219	10.1
MCB Camp Pendleton, CA	107	4.9
MCB Camp Lejeune/Cherry Point, NC	101	4.7
Fort Shafter, HI	91	4.2
Fort Benning, GA	89	4.1
Fort Hood, TX	77	3.6
JBSA-Lackland, TX	63	2.9
Fort Campbell, KY	52	2.4
Fort Jackson, SC	47	2.2
Fort Leonard Wood, MO	41	1.9
Fort Belvoir, VA	37	1.7
Walter Reed NMMC, MD[a]	59	2.7
Fort Bliss, TX	35	1.6
Fort Carson, CO	35	1.6
NMC San Diego, CA	34	1.6
NMC Portsmouth, VA	33	1.5
Fort Stewart, GA	33	1.5
Other locations	729	33.7
Total	2,163	100.0

[a]Walter Reed National Military Medical Center (NMMC) provides inpatient and outpatient care in support of numerous installations in the National Capital Region.

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

EDITORIAL COMMENT

This report documents an increase in the annual rates of diagnoses of exertional rhabdomyolysis among active component U.S. military members in 2016, compared to the first 4 years of the surveillance period. Exertional rhabdomyolysis continued to occur most frequently from late spring through early fall at installations that support basic combat/recruit training or major Army or Marine Corps combat units.

The risks of heat injuries, including exertional rhabdomyolysis, are increased among individuals who suddenly increase overall levels of physical activity, recruits who are not physically fit when they begin training, and recruits from relatively cool and dry climates who may not be acclimated to the high heat and humidity at training camps in the summer.[2,3] Soldiers and Marines in combat units often conduct rigorous unit physical training, personal fitness training, and field training exercises regardless of weather conditions. Thus, it is not surprising that recruit camps and installations with large ground combat units account for most of the cases of exertional rhabdomyolysis.

The annual incidence rates in black, non-Hispanic service members were higher than the rates among members of other race/ethnicity subgroups in 2016 and in 3 of the 4 previous years. This observation has been attributed, at least in part, to an increased risk of exertional rhabdomyolysis among individuals with sickle cell trait.[12-15] However, in 2013, the rate among Asian/Pacific Islanders was the highest of all race/ethnicity groups. Although the annual incidence rates for this group have been on the increase since 2009, the reasons for such a trend are unknown. Supervisors at all levels should ensure that guidelines to prevent heat injuries are consistently implemented and should be vigilant for early signs of exertional heat injuries, including rhabdomyolysis, among all service members.

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

The measures that are effective at preventing exertional heat injuries in general apply to the prevention of exertional rhabdomyolysis. In the military training setting, risk of exertional rhabdomyolysis can be reduced by stressing graded, individual preconditioning before starting a more strenuous exercise program and adhering to recommended work/rest and hydration schedules, especially in hot weather. The physical activities of overweight and/or previously sedentary new recruits should be closely monitored. Strenuous activities during relatively cool mornings following days of high heat stress should be particularly closely monitored; in the past, such situations have been associated with increased risk of exertional heat injuries (including rhabdomyolysis).[7]

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

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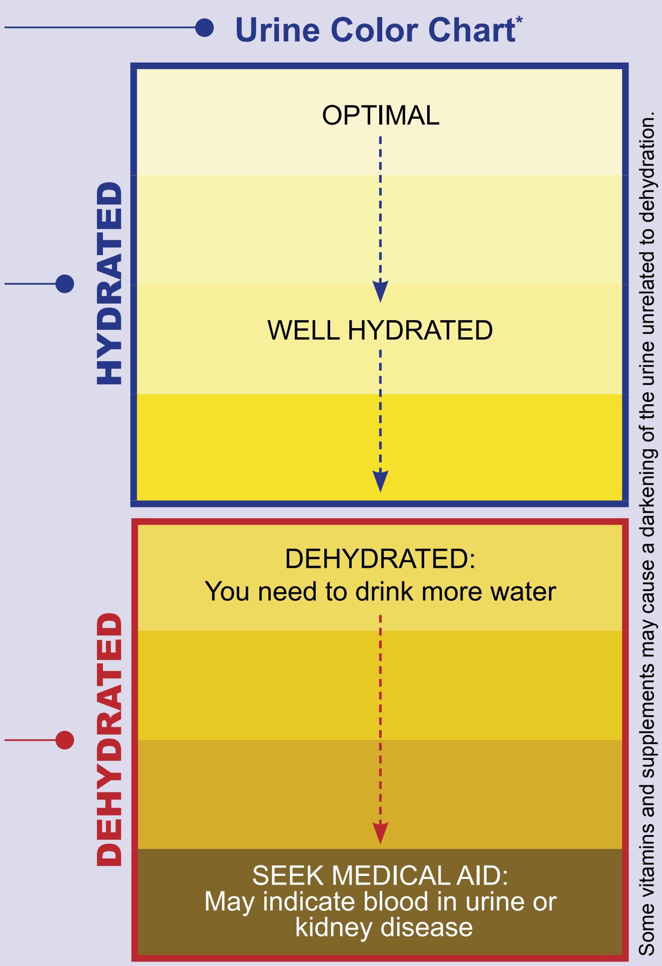
Are You Hydrated? Take the Urine Color Test



*This color chart is not for clinical use.

Source: U.S. Army Public Health Center

Update: Exertional Hyponatremia, Active Component, U.S. Armed Forces, 2001–2016

From 2001 through 2016, there were 1,519 incident diagnoses of exertional hyponatremia among active component service members (incidence rate: 6.9 cases per 100,000 person-years [p-yrs]). The incidence rate in 2016 (6.6 cases per 100,000 p-yrs) represented a decrease of 23.3% from 2015. Compared to their respective counterparts, overall incidence rates of exertional hyponatremia were higher among females, those aged 19 years or younger, and recruit trainees. The overall incidence rate during the surveillance period was highest in the Marine Corps, intermediate in the Army and Air Force, and lowest in the Navy. Overall incidence rates were lowest among black, non-Hispanic service members and highest among white, non-Hispanic and Asian/Pacific Islander service members. Service members (particularly recruit trainees) and their supervisors must be vigilant for early signs of heat-related illnesses and must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, recreational activities) in hot, humid weather.

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

Serum sodium concentration is determined mainly by the total content of exchangeable body sodium and potassium relative to total body water. Thus, exertional hyponatremia can result from loss of sodium and/or potassium, a relative excess of body water, or a combination of both.[5,6] However, in most clinical cases, a relative excess of body water is the driving factor for the development of the condition.[7] Other important factors include the persistent secretion of antidiuretic hormone (arginine vasopressin), excessive sodium losses in sweat, and inadequate sodium intake during prolonged physical exertion, particularly during heat stress.[2-4,8] The importance of sodium losses through sweat in the development of exertional hyponatremia is influenced by the fitness level of the individual. Less fit individuals generally have a higher sweat sodium concentration, a higher rate of sweat production, and an earlier onset of sweating during exercise.[9-11]

This report uses a surveillance case definition for "exertional hyponatremia" to estimate the frequencies, rates, trends, geographic locations, and demographic and military characteristics of exertional hyponatremia cases among U.S. military members from 2001 through 2016.

METHODS

The surveillance period was 1 January 2001 through 31 December 2016. The surveillance population included all individuals who served in an active component of the U.S. Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. Diagnoses were ascertained from administrative records of medical encounters archived in the Defense Medical Surveillance System (DMSS), which contains electronic records of all actively serving U.S. military members' hospitalizations and ambulatory visits in U.S. military and civilian (contracted/purchased care through the Military Health System) medical facilities worldwide as well as records of medical encounters of service members deployed to Southwest Asia/Middle East (as documented in the Theater Medical Data Store [TMDS]).

For surveillance purposes, a case of exertional hyponatremia was defined as a hospitalization or ambulatory visit with a primary (first-listed) diagnosis of "hypo-osmolality and/or hyponatremia" (ICD-9: 276.1; ICD-10: E87.1) and no other illness or injury-specific diagnoses (ICD-9: 001–999) in any diagnostic position; or both a diagnosis of "hypo-osmolality and/or hyponatremia" and at least one of the following within the first three diagnostic positions (dx1–dx3): "fluid overload" (ICD-9: 276.6; ICD-10: E87.7, E87.9), "alteration of consciousness" (ICD-9: 780.0x; ICD-10: R40.0–R40.2), "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).

Medical encounters were not considered case-defining events if the associated records included the following diagnoses in any diagnostic position: alcohol/illicit drug abuse; psychosis, depression, or other major mental disorders; endocrine (e.g., pituitary, adrenal) disorders; kidney diseases; intestinal infectious diseases; cancers; major traumatic injuries; or complications of medical care.[12] Each individual could be included as a case only once per calendar year.

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

Records of medical evacuations from the U.S. Central Command (CENTCOM) area of responsibility (AOR) (e.g., Iraq, Afghanistan) to a medical treatment facility outside the CENTCOM AOR were analyzed separately. Evacuations were considered case-defining if the affected service members met the above criteria in a permanent military medical facility in the U.S. or Europe from 5 days before to 10 days after their evacuation dates.

RESULTS

During 2001–2016, permanent medical facilities recorded 1,519 incident diagnoses of exertional hyponatremia among active component service members (incidence rate: 6.9 cases per 100,000 person-years [p-yrs]) **(Table 1)**. In 2016, there were 85 incident diagnoses of exertional hyponatremia (incidence rate: 6.6 per 100,000 p-yrs) among active component members. During the year, 77.6% of exertional hyponatremia cases (n=66) affected males, but the annual rate was higher among females (9.4 per 100,000 p-yrs) than males (6.1 per 100,000 p-yrs) **(Table 1)**. The highest age group–specific incidence rates affected the oldest (40 years and older) service members. Although the Army had the most cases during the year (n=31), the highest incidence rate was among members of the Marine Corps (9.3

TABLE 1. Incident cases[a] and incidence rates[b] of exertional hyponatremia, active component, U.S. Armed Forces, 2001–2016

	2016		Total 2001–2016	
	No.	Rate[b]	No.	Rate[b]
Total	85	6.6	1,519	6.9
Sex				
Male	66	6.1	1,254	6.7
Female	19	9.4	265	8.2
Age group				
<20	8	8.8	208	13.6
20–24	21	5.1	474	6.6
25–29	23	7.7	272	5.5
30–34	8	3.8	165	5.0
35–39	10	6.8	174	6.5
40+	15	11.4	226	9.8
Race/ethnicity				
White, non-Hispanic	51	6.9	1,029	7.6
Black, non-Hispanic	19	9.0	194	5.2
Hispanic	4	2.1	149	5.9
Asian/Pacific Islander	3	5.8	61	7.4
Other/unknown	8	8.6	86	6.1
Service				
Army	31	6.6	538	6.6
Navy	15	4.7	233	4.3
Air Force	22	7.1	304	5.6
Marine Corps	17	9.3	444	14.9
Military status				
Enlisted	52	5.0	1,083	6.1
Officer	29	12.7	302	8.3
Recruit	4	16.0	134	30.0
Military occupation				
Combat-specific	16	9.3	234	8.1
Armor/motor transport	1	2.3	46	5.4
Pilot/air crew	4	8.2	44	5.3
Repair/engineering	9	2.3	269	4.2
Communications/intelligence	14	5.0	258	5.2
Health care	11	9.6	120	6.4
Other	30	12.4	548	13.3
Home of record[c]				
Midwest	13	5.7	257	7.0
Northeast	17	10.4	207	7.9
South	28	5.2	597	7.1
West	22	7.4	249	5.6
Territory	0	0.0	6	5.6
Unknown	5	8.1	203	7.6

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

per 100,000 p-yrs). Rates in 2016 were highest among recruit trainees **(Table 1)**.

During the 16-year surveillance period, incidence rates of exertional hyponatremia were lowest in 2002 (4.0 per 100,000 p-yrs), peaked in 2010 (12.4 per 100,000 p-yrs), and then decreased to 5.2 cases per 100,000 p-yrs in 2013 before increasing in 2014 and 2015. The incidence rate in 2016 (6.6 per 100,000 p-yrs) represented a decrease of 23.3% from 2015 **(Figure 1)**. Compared to males, females had higher overall incidence rates during the surveillance period. The overall crude incidence rate during the surveillance period was highest in the Marine Corps (14.9 per 100,000 p-yrs), intermediate in the Army and Air Force (6.6 and 5.6 per 100,000 p-yrs, respectively), and lowest in the Navy (4.3 per 100,000 p-yrs) **(Table 1)**. From 2015 to 2016, incidence rates decreased sharply among members of the Army and the Marine Corps but increased slightly among members of the Navy and Air Force **(Figure 2)**. Overall rates during the surveillance period were lowest among black, non-Hispanic and highest among white, non-Hispanic and Asian/Pacific Islander service members than other racial/ethnic groups of service members. Although recruit trainees accounted for only 9% of all cases, the overall crude incidence rate among recruit trainees was more than three times the rates among other enlisted members and officers **(Table 1)**. During the 16-year period, 86.8% (n=1,320) of all cases were diagnosed and treated without having to be hospitalized **(data not shown)**.

Exertional hyponatremia by location

During the 16-year surveillance period, exertional hyponatremia cases were diagnosed at U.S. military medical facilities at more than 200 locations; however, 14 locations contributed 20 or more cases each and accounted for nearly one-half (49.7%) of all cases **(Table 2)**. The location with the most cases overall was the Marine Corps Recruit Depot (MCRD) Parris Island/Beaufort, SC (n=214).

Exertional hyponatremia in Iraq and Afghanistan

From 2008 through 2016, a total of 89 cases of exertional hyponatremia were diagnosed and treated in Iraq and Afghanistan.

FIGURE 1. Annual incident cases and incidence rates of exertional hyponatremia, active component, U.S. Armed Forces, 2001–2016

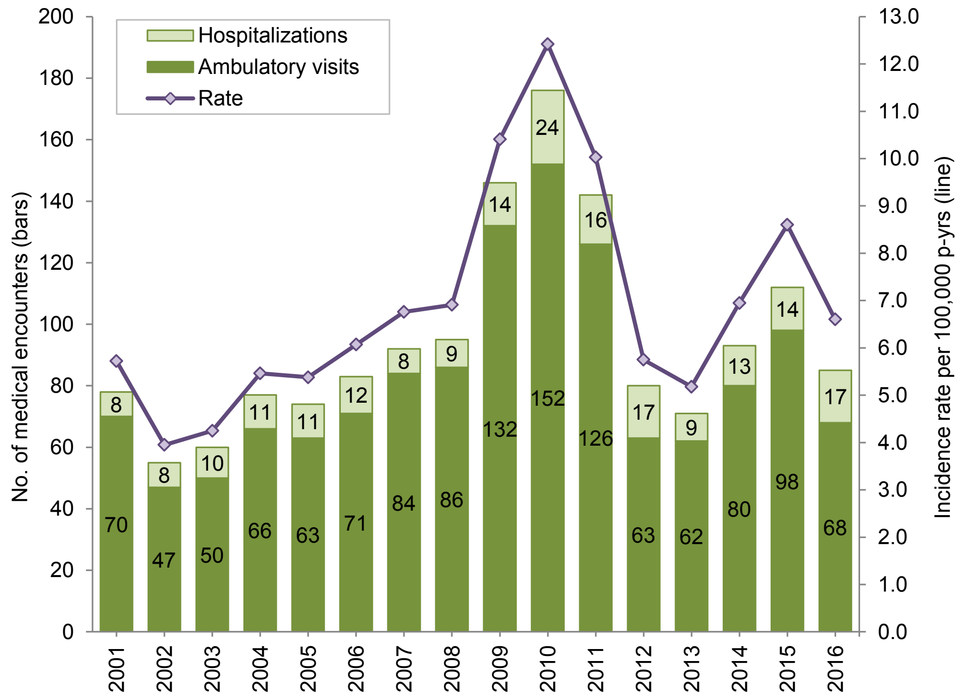
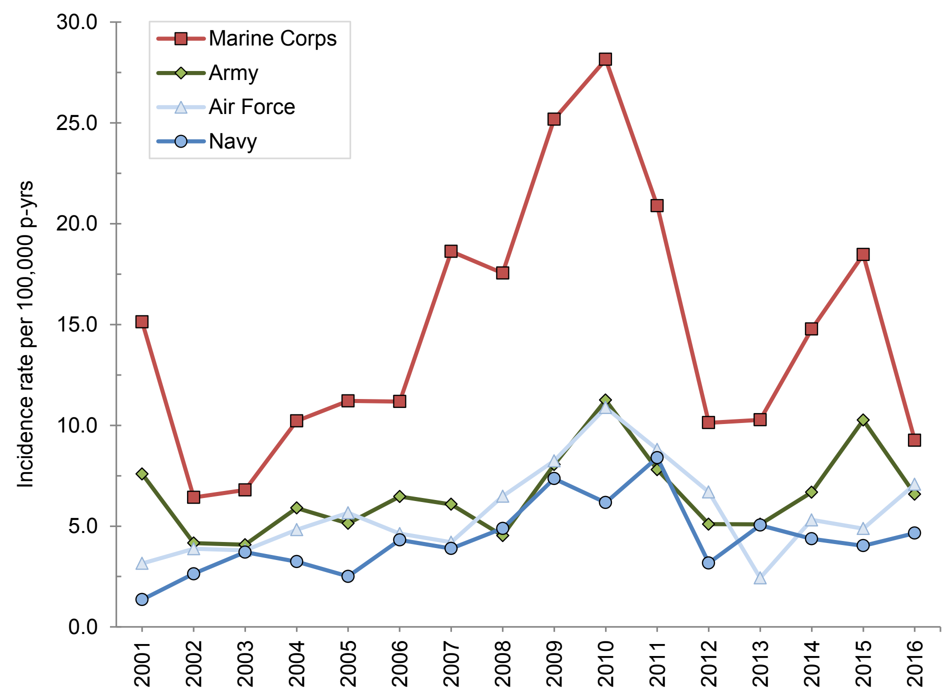


FIGURE 2. Annual incidence rates of exertional hyponatremia, by service, active component, U.S. Armed Forces, 2001–2016



Deployed service members who were affected by exertional hyponatremia were most frequently male (n=62; 69.7%); white, non-Hispanic (n=59; 66.3%); aged 20–24 years (n=33; 37.1%); in the Army (n=47; 52.8%); enlisted (n=73; 82.0%); and in repair/engineering (n=22; 24.7%) or communications/intelligence (n=21; 23.6%)

TABLE 2. Incident cases of exertional hyponatremia by installation (with at least 20 cases during the period), active component, U.S. Armed Forces, 2001–2016

Location of diagnosis	No.	%
MCRD Parris Island/ Beaufort, SC	214	14.1
Fort Benning, GA	102	6.7
JBSA-Lackland AFB, TX	55	3.6
Walter Reed NMMC, MD[a]	49	3.2
Fort Bragg, NC	47	3.1
MCB Camp Lejeune/ Cherry Point, NC	47	3.1
MCB Quantico, VA	38	2.5
MCB Camp Pendleton, CA	36	2.4
NMC San Diego, CA	35	2.3
NMC Portsmouth, VA	34	2.2
Fort Jackson, SC	30	2.0
Fort Leonard Wood, MO	25	1.6
Fort Shafter, HI	22	1.4
Fort Campbell, KY	21	1.4
Other locations	764	50.3
Total	1,519	100.0

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

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

occupations **(data not shown)**. During the entire surveillance period, six service members were medically evacuated from Iraq or Afghanistan for exertional hyponatremia **(data not shown)**.

EDITORIAL COMMENT

This report documents that, after a 2-year period (2014–2015) of increasing numbers and rates of exertional hyponatremia among active component U.S. military members, numbers and rates of diagnoses decreased slightly in 2016. Patterns of overall incidence rates of exertional hyponatremia in specific subgroups (e.g., sex, age, race/ethnicity, service, and military status) were similar to those noted in previous *MSMR* updates.

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

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

In summer 1997, Army training centers reported five hospitalizations of soldiers for hyponatremia secondary to excessive water consumption during military training in hot weather—one case was fatal and several others required intensive medical care.[13] In April 1998, the U.S. Army Research Institute of Environmental Medicine, Natick, MA, revised the guidelines for fluid replacement during military training in hot weather. The new guidelines were designed to protect service members from not only heat injury, but also hyponatremia due to excessive water consumption. The guidelines limited fluid intake regardless of heat category or work level to no more than 1.5 quarts hourly and 12 quarts daily.[14] There were fewer hospitalizations of soldiers for hyponatremia due to excessive water consumption during the year after compared to before implementation of the new guidelines.[15]

In many circumstances (e.g., recruit training, Ranger School), military trainees rigorously adhere to standardized training schedules—regardless of weather conditions. In hot and humid weather, commanders, supervisors, instructors, and medical support staff must be aware of and enforce guidelines for work-rest cycles and water consumption. The finding in this report that most cases of hyponatremia were treated in outpatient settings suggests that monitoring by supervisors and medical staff identified most cases during the early and less severe manifestations of hyponatremia. In general, service members and their supervisors must be knowledgeable of the dangers of excessive water consumption and the prescribed limits for water intake during prolonged physical activity (e.g., field training exercises, personal fitness training, recreational activities) in hot, humid weather. The current U.S. Military Fluid Replacement Guidelines can be found at: https://usaphcapps.amedd.army.mil/HIOShoppingCart/viewItem.aspx?id=705.

Women had relatively high rates of hyponatremia during the entire surveillance period; women may be at greater risk because of lower fluid requirements and longer periods of exposure to risk during some training exercises (e.g., land navigation courses, load-bearing marches).[8] Service members (particularly recruit trainees and women) and their supervisors must be vigilant for early signs of heat-related illnesses and intervene immediately and appropriately (but not excessively) in such cases.

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MSMR's Invitation to Readers

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

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

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

Work/Rest Times and Fluid Replacement Guide

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

NL = No limit to work time per hour.

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

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

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

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

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

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

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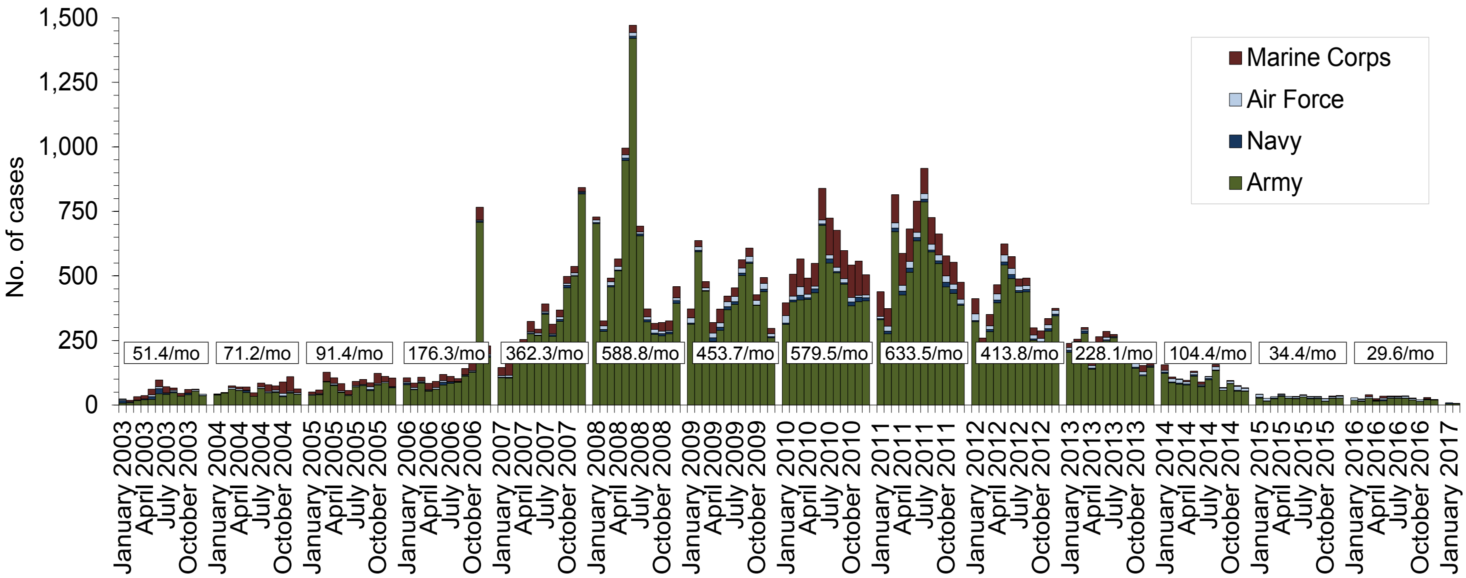
Deployment-related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003–February 2017 (data as of 21 March 2017)

Traumatic brain injury (TBI)[a,b]

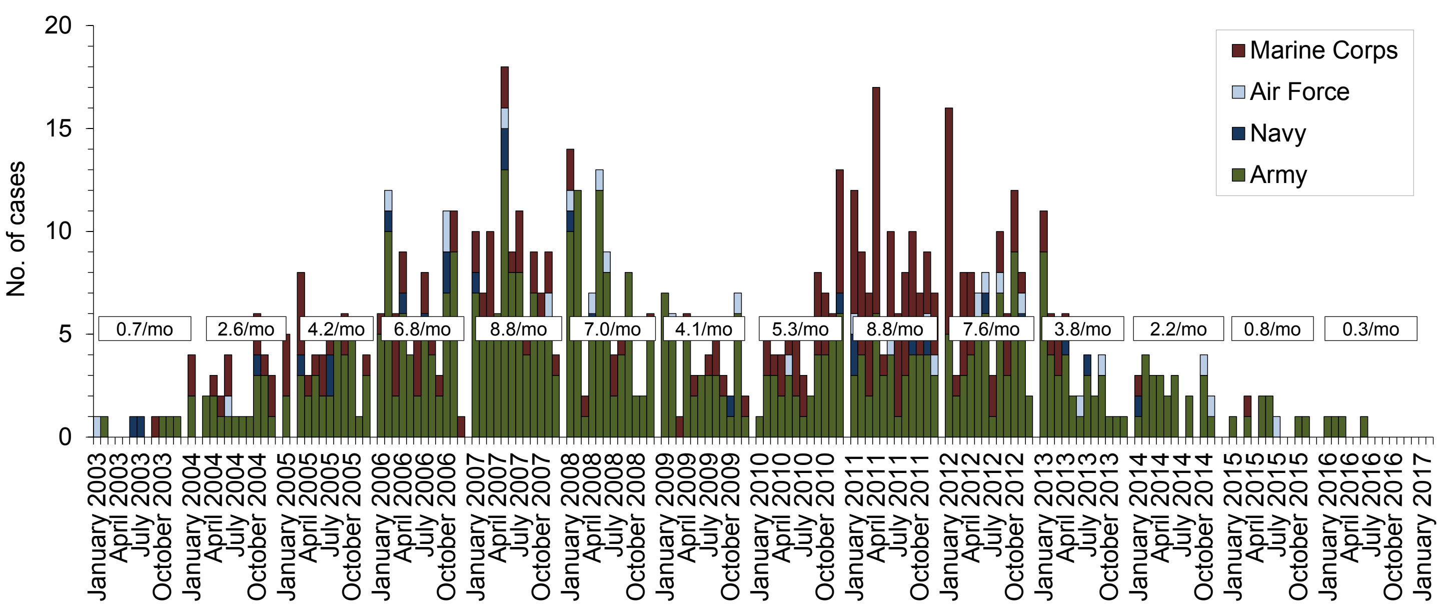


Reference: Armed Forces Health Surveillance Center. Deriving case counts from medical encounter data: considerations when interpreting health surveillance reports. *MSMR*. 2009;16(12):2–8.

[a]For the complete list of ICD-10 codes used here for TBI, see p. 23 of the May 2016 issue of the *MSMR*.

[b]Indicator diagnosis (one per individual) during a hospitalization or ambulatory visit while deployed to/within 30 days of returning from deployment (includes in-theater medical encounters from the Theater Medical Data Store [TMDS] and excludes 4,773 deployers who had at least one TBI-related medical encounter any time prior to deployment).

Heterotopic ossification[a,b]



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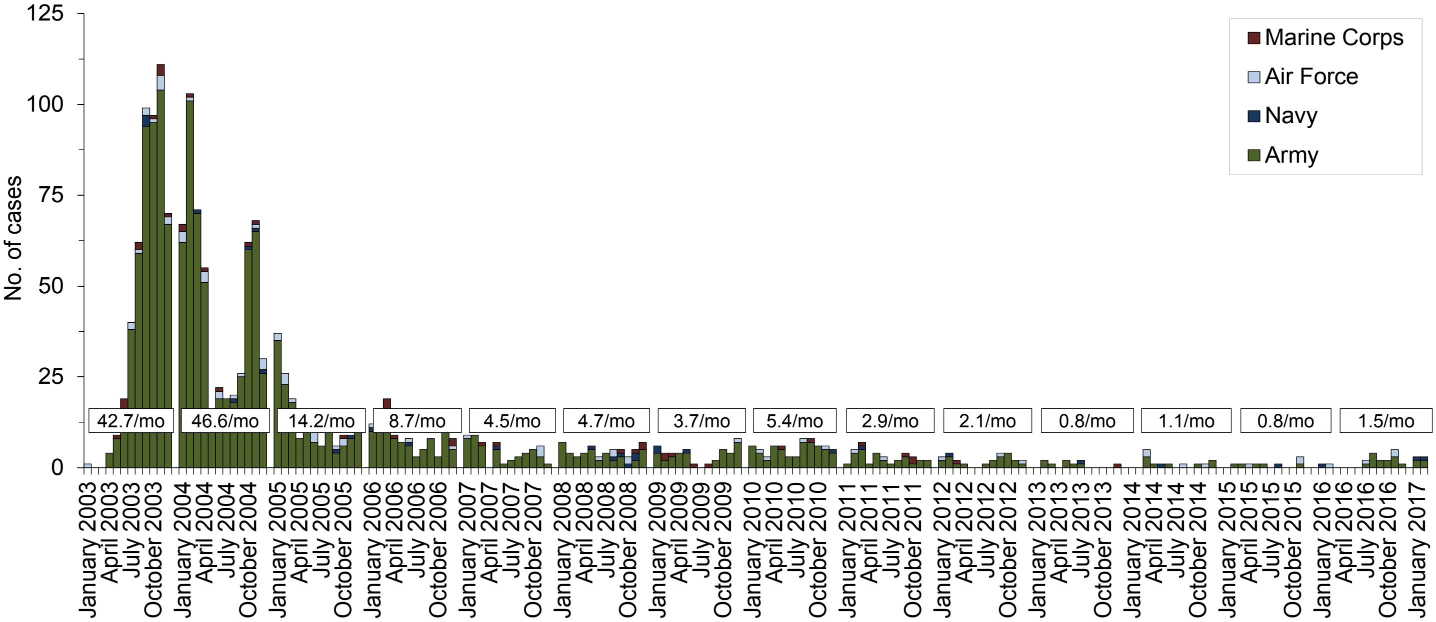
[a]Heterotopic ossification (ICD-10: M610, M614, M615)
[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 365 days of returning from deployment.

Deployment-related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003–February 2017 (data as of 21 March 2017)

Leishmaniasis[a,b]

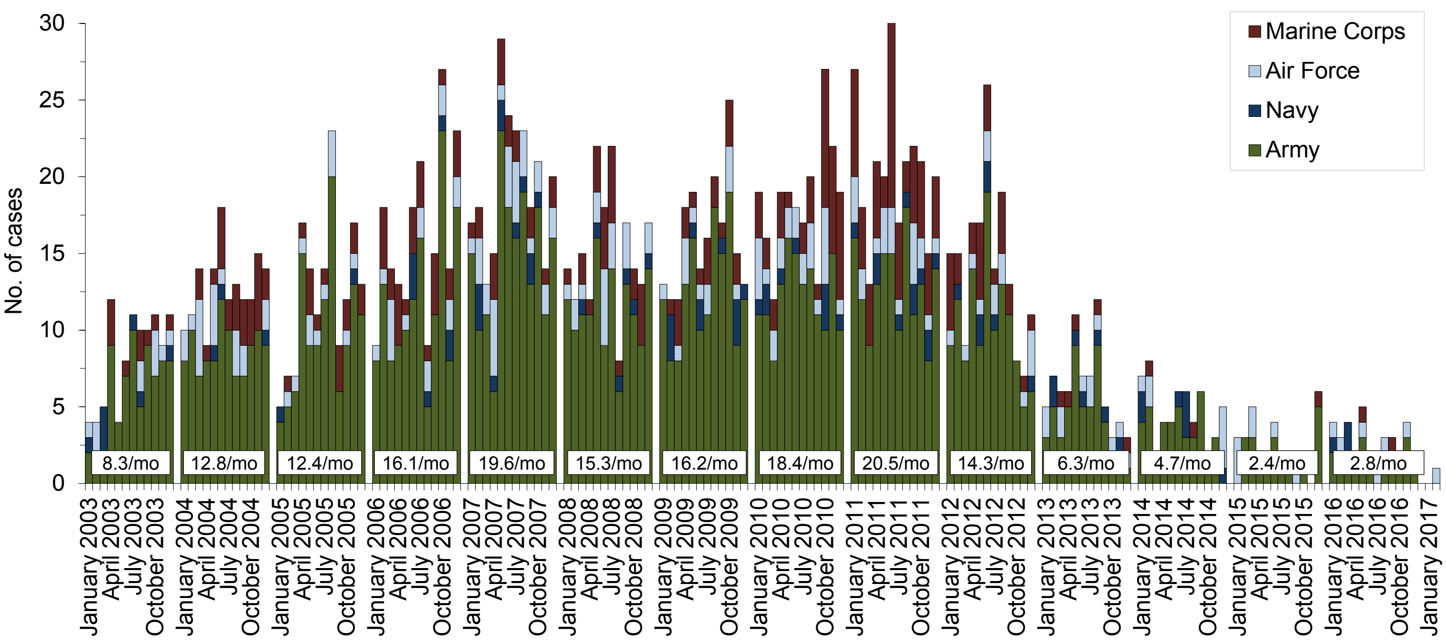


Reference: Army Medical Surveillance Activity. Deployment-related condition of special surveillance interest: leishmaniasis. Leishmaniasis among U.S. Armed Forces, January 2003–November 2004. *MSMR*. 2004;10(6):2–4.

[a]Leishmaniasis (ICD-10: B55, B550, B551, B552, B559)

[b]Indicator diagnosis (one per individual) during a hospitalization, ambulatory visit, and/or from a notifiable medical event during or after service in OEF/OIF/OND.

Deep vein thrombophlebitis/pulmonary embolus[a,b]



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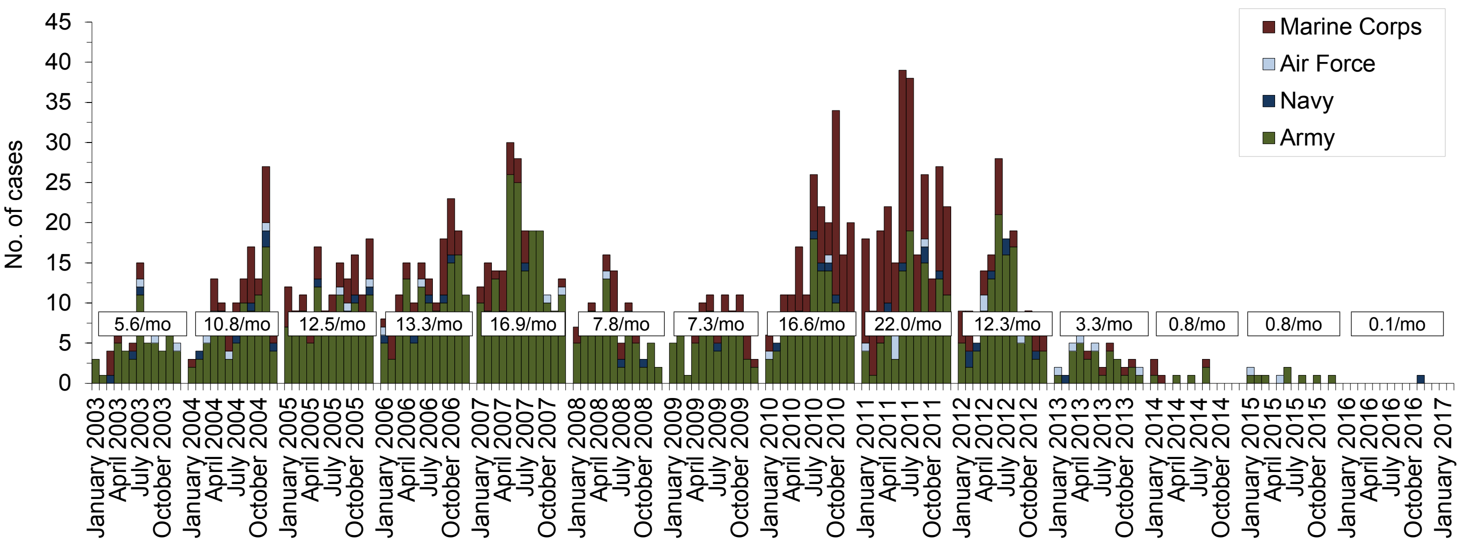
[a]Deep vein thrombophlebitis/pulmonary embolus (ICD-10: I2601, I2609, I2690, I2699, I801–I803, I808, I809, I822–I824, I826, I82A1, I82B1, I82C1, I8281, I82890, I8290)

[b]One diagnosis during a hospitalization or two or more ambulatory visits at least 7 days apart (one case per individual) while deployed to/within 90 days of returning from deployment.

Deployment-related Conditions of Special Surveillance Interest, U.S. Armed Forces, by Month and Service, January 2003–February 2017 (data as of 21 March 2017)

Amputations[a,b]



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[a]Amputations (ICD-10: S48, S58, S684, S687, S78, S88, S980, S983, S989, Z440, Z441, Z4781, Z891, Z892, Z8943, Z8944, Z895, Z896, Z899)

[b]Indicator diagnosis (one per individual) during a hospitalization while deployed to/within 365 days of returning from deployment.

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