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## Malaria in the Korean Peninsula: Risk Factors, Latent Infections, and the Possible Role of Tafenoquine, a New Antimalarial Weapon

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For decades, malaria infections acquired in Korea have posed a significant threat to both Korean military and civilians and to U.S. Department of Defense (DoD) personnel. In Korea, malaria infections are caused exclusively by the species *Plasmodium vivax* (PV). Despite the use of chloroquine chemoprophylaxis during the Korean War (1950–1953), thousands of cases of PV malaria were diagnosed in Korea among U.S. military personnel.<sup>1</sup> As troops returned home, however, many more cases were diagnosed stateside, inundating military hospitals and leading to research on the use of primaquine to treat what were termed “late attacks of *Plasmodium vivax* of Korean origin.”<sup>2</sup>

Since the Korean War, the Republic of Korea (ROK) has made significant strides in controlling the disease, chiefly through an aggressive eradication program in the 1970s. So successful was the program that the World Health Organization declared the ROK malaria free in 1979.<sup>3</sup> However, in 1993, ROK experienced a PV malaria resurgence that reached a peak of 1,600 cases in 1997<sup>4</sup> before gradually tapering, with ROK experiencing only 601 cases in 2016.<sup>5</sup>

In this issue of the *MSMR*, Klein et al. report a cluster of 11 U.S. soldiers with PV.<sup>6</sup> The cases were likely acquired at Dagmar North training area located near the southern border of the demilitarized zone (DMZ). As was true during the Korean War, more cases (n=9, 82%) in the cluster were diagnosed long after redeployment to the U.S., an estimated 8–11 months after presumed exposure to the mosquitoes that transmitted the infections. Due to recent historically low numbers of PV malaria cases among DoD personnel in the ROK, and no mortality due to PV, chemoprophylaxis is not routinely administered to service members in the ROK, except among

Marine Corps personnel when training near the DMZ (Surgeon Office, U.S. Marine Corps Forces, Pacific; personal communication 25 October 2018).

The most relevant contemporary report of malaria risk in the ROK was published in 2016.<sup>7</sup> In this study, mosquitoes were collected at ROK installations near the DMZ, speciated, assessed for PV infection, and correlated with human PV cases. The report concluded the following: 1) that the mosquito species *Anopheles kleini* was likely the main culprit vector responsible for PV transmission in the ROK; 2) population densities of PV-infected mosquitoes were highest in ROK installations closer to the DMZ; and 3) PV mosquito infection rates correlated highly with the number of PV cases in ROK Army soldiers.

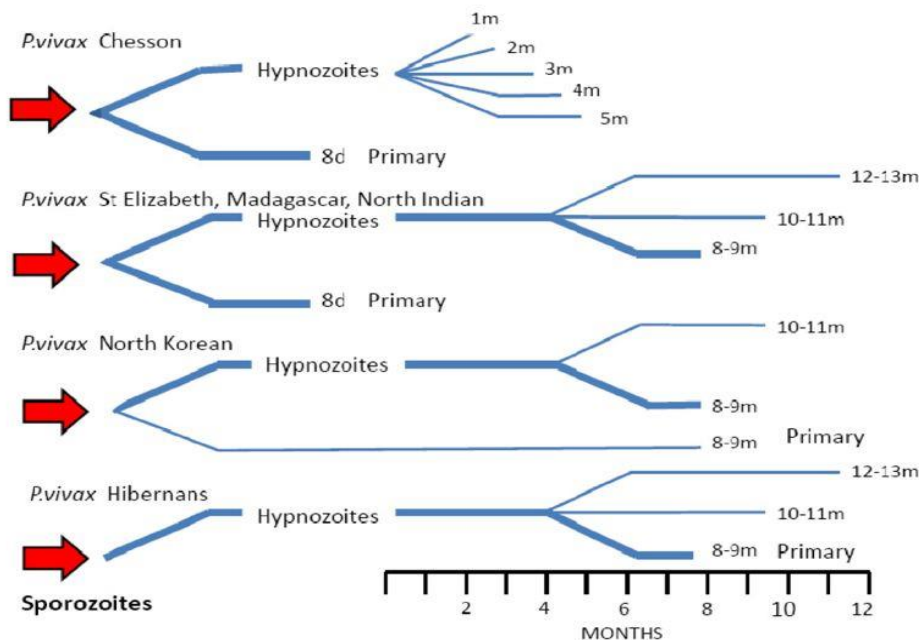
From a chemoprophylaxis perspective, it is instructive to consider the peculiar biology of Korean PV malaria. Korean PV strains are classified as “temperate zone” and are unique in that as many as 40–50% of infected individuals may not manifest the symptoms of their primary illness until 6–11 months after infection.<sup>4,8</sup> The **Figure** shows that the time between primary infection and clinical illness among different PV strains ranges between 8 days and 8–13 months.<sup>8</sup> Temperate zone PV biology reflects a possible evolutionary adaptation that enables these strains to remain latent as hypnozoites (i.e., “sleeping” parasites) through the cool or cold months that are inhospitable to mosquito vectors in temperate climates.<sup>8</sup> As in the post-Korean War period, late attacks of *Plasmodium vivax* of Korean origin continue to be observed. A 2007 review of malaria outbreaks in U.S. military personnel described 74 ROK-acquired PV malaria cases and estimated that 45% were diagnosed more than 240 days after the mid-points of their

last ROK exposure period.<sup>9</sup> Because U.S. military personnel rotate frequently in and out of the ROK, PV biology virtually ensures that a significant number of DoD personnel with ROK-acquired infections will not become symptomatic until their next duty station—whether in the U.S. or at another location outside of the contiguous U.S.

PV latency and entomological studies indicate that the following should be considered in anticipation of further exposure of DoD personnel in Korea. First, scientific reports unquestionably point to proximity to the DMZ as the highest PV risk factor, while few cases are diagnosed south of Seoul.<sup>6</sup> It is impossible to determine how much of this risk is due to a specific ecology within the DMZ or to the presence of a high PV case burden in the nearby Democratic People’s Republic of Korea. Thus, continued emphasis on surveillance of *Anopheles* spp. is warranted to identify the geographical and seasonal impact on malaria transmission in the ROK. Secondly, command emphasis on personal protective measures such as use of insecticide treated uniforms and impregnated bednets and on education about malaria risk and prevention is highly warranted. Lastly, because latent cases likely constitute the majority of cases acquired in the ROK, chemoprophylaxis practice should take into account both recent data on acute infections diagnosed shortly after exposure as well as latent infections presenting months thereafter. In this regard, analysis and dissemination of centralized DoD malaria data, such as in the annual *MSMR* issue,<sup>10</sup> are critically important to inform DoD Force Health Protection malaria practice.

The possibility of latent PV infection and frequent deployment tempo warrant consideration of the role of

**FIGURE.** Time between primary infection and clinical illness among different *P. vivax* strains<sup>a</sup>



<sup>a</sup>Taken from White<sup>8</sup> (after: Bray RS, Garnham PC. The life-cycle of primate malaria parasites. *Br Med Bull.* 1982;38:117–122)

Note: The thickness of the blue lines gives a rough approximation of proportions.

chemoprophylaxis, particularly with respect to “terminal prophylaxis”—a term referring to the pre-emptive treatment of hypnozoites to prevent latent or relapsing malaria. A major challenge for terminal prophylaxis is compliance with up to 14 days of daily dosing with primaquine, until recently the only drug capable of killing hypnozoites. For example, a survey of U.S. Army Rangers returning from Afghanistan found that self-reported compliance rates were 52% for weekly chemoprophylaxis, 41% for terminal (post-deployment) chemoprophylaxis, and 31% for both weekly and terminal chemoprophylaxis.<sup>11</sup>

In August 2018, tafenoquine, an oral long-acting primaquine analogue was approved by the U.S. Food and Drug Administration for prophylaxis against all malaria species for up to 6 months’ duration. Tafenoquine, (Arakoda™), was originally discovered by scientists at the Walter Reed Army Institute of Research (WRAIR) and further developed for a prophylaxis indication at the U.S. Army Medical Materiel

Development Activity. Critically, tafenoquine/Arakoda™ confers a major advantage over primaquine because of its requirement for only weekly “maintenance” dosing during exposure in malaria endemic areas in contrast to the daily dosing requirement for doxycycline or Malarone®. Significantly, tafenoquine also includes an indication for terminal prophylaxis consisting of a single dose given 7 days after the last maintenance dose upon leaving the malaria endemic area.<sup>12</sup> These dosing options provide commanders with the option to more feasibly monitor dosing by directly observed therapy. The implications of the “real world” effectiveness brought by this soldier/commander-friendly dosing option, whether employed to prevent latent *P. vivax* cases—or infections with other species—are a welcome advance in the fight against malaria.

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*Disclaimer:* Material has been reviewed by the Walter Reed Army Institute of Research and there is no objection to its publication. The opinions or assertions contained herein are the views of the authors and do not necessarily reflect the official policy or position of the Army, the Department of Defense, or the U.S. Government.

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# Cluster of Vivax Malaria in U.S. Soldiers Training Near the Demilitarized Zone, Republic of Korea During 2015

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## CE/CME

This article provides continuing education (CE) and continuing medical education (CME) credit. Please see information at the end of the article.

This report describes a cluster of 11 soldiers with vivax malaria among U.S. military personnel who trained at Dagmar North training area, near the demilitarized zone (DMZ), in the Republic of Korea (ROK) in 2015. Two cases were diagnosed in the ROK in 2015, one of whom subsequently experienced a relapse, and nine other cases were diagnosed in 2016, 8–11 months after the soldiers had returned to the U.S. Vivax malaria poses a health threat to U.S. Forces Korea operating near the DMZ in the ROK. Continuing and enhanced focus on force health protection measures in endemic zones is warranted.

Vivax malaria was a major health threat to both Korean and United Nations Forces during the Korean War,<sup>1,2</sup> with more than 15,000 and more than 6,000 malaria cases reported among Republic of Korea (ROK) and U.S. military personnel, respectively.<sup>3–7</sup> Due to latent liver stages, an additional 12,000 or more U.S. military personnel were diagnosed with malaria after returning to the U.S. during the first year of the war.<sup>8,9</sup> With the development of primaquine phosphate, which eliminates liver stage hypnozoites, in 1952, the numbers of returning service members who developed malaria were greatly reduced.<sup>9</sup>

With the establishment of the ROK National Malaria Eradication Service in 1959<sup>10</sup> and greatly improved living conditions and medical services, the number of malaria cases rapidly declined. By 1979 the World Health Organization declared the ROK malaria free.<sup>7,11,12</sup> However, in 1993, vivax malaria reemerged in the ROK<sup>13</sup>; the Korean Centers for Disease Control reported a total of 32,576 autochthonous vivax malaria cases among ROK civilian,

veteran, and military populations from 1993–2015, with as many as 4,000 cases in a single year (2000). The ecology in and around the demilitarized zone (DMZ) is particularly prone to *Plasmodium vivax* transmission because of fishermen from malarial regions fishing along the Imjin river (which also borders the Dagmar North training area) during evening hours, an abundance of larval habitat in low-lying flooded areas and rice paddies, potential continued cross-border introduction of malaria by anopheline mosquitoes, and a high proportion of primary vivax malaria vectors belonging to the *Anopheles* Hyrcanus Group that has resulted in hundreds of cases of vivax malaria annually since 1996. Thus, malaria poses a significant health threat to ROK/U.S. military and civilian personnel residing and operating near the DMZ.<sup>13–15</sup>

This paper summarizes a cluster of vivax malaria infections acquired during August 2015 among U.S. soldiers who trained at Dagmar North training area (DNTA) near the DMZ separating South and North Korea.

## WHAT ARE THE NEW FINDINGS?

A small outbreak of 11 cases of malaria occurred in 2015–2016 from exposures in Korea localized to the demilitarized zone (DMZ). Nine (82%) of the cases developed their first symptoms of infection 9 or more months after exposure and after their departure from Korea.

## WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Although rates have declined in recent years, vivax malaria poses a focal health threat to ROK/U.S. military personnel operating near the demilitarized zone (DMZ). Lack of command-directed adherence to force health protection measures for malaria in the absence of routine chemoprophylaxis can result in clusters of malaria infection which can adversely impact military readiness.

## METHODS

### Population and setting

Members of an Armored Brigade Combat Team (ABCT) stationed in the U.S. arrived at Osan Air Base, ROK, during 5–12 June 2015 and went directly to Joint Camps Casey/Hovey. Camps Casey/Hovey are collocated and are bordered by the city of Dongducheon in northeastern Gyeonggi Province (**Figure**). Soldiers resided and conducted training at Camps Casey/Hovey training sites, except when selected units proceeded to Rodriguez Combined Arms Collective Training Facility (CACTF) near Pocheon in northeastern Gyeonggi province where they conducted a

**FIGURE.** Map showing Camps Casey/Hovey and the DNTA in northeastern Gyeonggi Province, ROK, near the demilitarized zone where the *Plasmodium vivax* infections occurred



DNTA, Dagmar North training area; ROK, Republic of Korea; DPRK, Democratic People's Republic of Korea; MPRC, multipurpose range complex

major field exercise on 15 July–16 August 2015. Selected units then moved to DNTA on 17 August where they conducted live fire training during the daytime at Story CACTF and returned to DNTA where they conducted nighttime exercises and bivouacked before returning to Camps Casey/Hovey on 22 August. After 22 August 2015 and until the ABCT units departed during 2–17 February 2016 for their home base in the U.S., the soldiers resided and trained only at Camps Casey/Hovey.

### Vivax malaria diagnosis

Blood was drawn from patients suspected of having malaria when reporting to a hospital or clinic with febrile illness. Patients were tested for *Plasmodium* sp. infections using BinaxNOW® (Alere Scarborough Inc., Scarborough, ME) malaria test, examination of blood films for the presence of malaria parasites, and/or by polymerase chain reaction (PCR). The BinaxNOW malaria test distinguishes among *P. falciparum*, non-falciparum *Plasmodium* species (*P. vivax*, *P. ovale*, and *P. malariae*), and mixed infections. Based on the manufacturer's documentation, the assay has a sensitivity of 93.5% and a specificity of 99.8% for *P. vivax*. All military patients diagnosed with vivax malaria

were reported through the Department of Defense Disease Reportable Systems internet (DRSi).

### Epidemiologic investigations

The Public Health Nurse (PHN), Force Health Protection & Preventive Medicine (FHP&PM), 65th Medical Brigade, ROK, was notified through DRSi of malaria cases among U.S. service members. The PHN contacted the PHN at the reporting installation outside of Korea to determine whether the malaria infections were attributed to exposure in the ROK or other malaria endemic countries. Malaria patients suspected of acquiring malaria in the ROK were contacted, and epidemiologic investigations were conducted by FHP&PM and the reporting installation. Epidemiologic investigations involved gathering information related to each patient's training activities, exposures (including training dates, field training conditions, mosquito bite prevention measures, and estimates of the relative numbers of mosquitoes observed and bites received), symptoms, date of symptom onset, and medical care received (treatment type, days and number of medical visits from onset of symptoms to diagnosis, and method of diagnosis). These data were collected from interviews with

patients and from a review of their medical records. During interviews a standardized set of questions was asked of all patients whenever possible. Written epidemiologic reports were submitted to the Commanders, 65th Medical Brigade and Brian Allgood Army Community Hospital, ROK; the Surgeons of the U.S. Forces Korea, the Eighth Army, and the 2nd Infantry Division; the Chief, FHP&PM; and others as appropriate.

## RESULTS

A total of 11 soldiers with malaria were reported among U.S. soldiers assigned to the ABCT who deployed to the ROK from 5–12 June 2015 through 2–17 February 2016 (Table 1). Two patients were diagnosed with vivax malaria in Korea during 2015, demonstrating symptoms 1–14 and 9–14 days following the training exercise at DNTA, and nine different patients with presumptive exposure at DNTA demonstrated symptoms 8–11 months later (2 May–22 July 2016), after they had returned to the U.S. (Table 2). Patients were diagnosed with malaria using the BinaxNOW® malaria kit (three cases), BinaxNOW® + blood film (four cases), BinaxNOW® + blood film+PCR (one case), or blood film only (three cases) (Table 2). Based on epidemiologic reports, transmission was most likely due to exposure at DNTA during 17–22 August, because the soldiers with malaria reported few or no mosquito bites at Camps Casey/Hovey or Rodriguez CACTF but reported numerous bites at DNTA. In addition, there were no cases of malaria among soldiers belonging to the ABCT rotational unit who had not trained at DNTA during 17–22 August.

With few exceptions, the malaria patients had documented fever (up to 104°F) and reported chills, sweats, headache, body aches, and malaise. Some patients also reported having nausea, vomiting, and diarrhea. The two patients diagnosed in the ROK in 2015 were initially treated with hydroxychloroquine (Patient #7-2015) or atovaquone/proguanil (Malarone®; #8-2015). Both patients also received primaquine phosphate;

**TABLE 1.** Vivax malaria patient exposure, military occupational specialty (MOS) codes, use of preventive medicine measures, and perception of mosquito abundance and bites

Patient no.	MOS <sup>b</sup>	Sleeping <sup>c</sup>	Permethrin-treated uniforms <sup>d</sup>	Skin repellent usage <sup>e</sup>	Mosquitoes present <sup>f</sup>	Mosquito bites <sup>g</sup>
7-2015/6-2016R <sup>a</sup>	91L	Tent	ACU-Unknown	Yes	4	2
8-2015	19K	Tracked Vehicle	Nomex®-Unknown	No	5	5
1-2016	19K	Tracked Vehicle	Nomex-Unknown	Yes	5	5
2-2016	19K	Tracked Vehicle	Nomex-Unknown	Yes	5	5
3-2016	19K	Tracked Vehicle	Nomex-Unknown	Yes	5	5
4-2016	19K	Tracked Vehicle	Nomex-Unknown	Yes	5	3
7-2016	19B	Tent	ACU-Unknown	No	3	2
8-2016	19K	Tent	ACU-Yes	No	5	5
9-2016	91E	Tent	ACU-Yes	Yes	4	3
12-2016	19K	Tracked Vehicle	Nomex-Yes	Yes	5	5
14-2016	19K	Tracked Vehicle	ACU-No	No	5	3

<sup>a</sup>Patient #7-2015 was treated with only 26.3 mg primaquine and relapsed with malaria the following year.

<sup>b</sup>MOS codes: 91L = Construction Equipment Repairer; 91E = Allied Trade Specialist; 19K = Armor Crewman; 19B = M1 Armor Officer

<sup>c</sup>Patients slept in all climate uniforms (ACUs) and Nomex® (flame-resistant meta-aramid material) uniforms on/in tracked vehicles, or permethrin-treated uniforms in multiple man ill-kempt screened tents (openings in the screens and screens unsecured that allowed mosquitoes to enter), or two-man screened tents. Patients reported being bitten while in tents and in/on tracked vehicles during the evening hours.

<sup>d</sup>Only two patients were aware that they had permethrin-treated ACUs. However, the ACU of one patient was >1 year old and outside the lifetime of usage and unknown repellent effect.

<sup>e</sup>Patients were not issued insect repellents, but some (64%) reporting using personally purchased repellents of various, often unknown active repellents.

<sup>f</sup>Patients trained at Dagmar North Training Area during 17–22 August 2015. On a scale of 0 (none) to 5 (too many to count), for presence of mosquitoes, most patients (73%) noted "5" (too many mosquitoes present to count), and, for the number of mosquitoes bites, the majority (55%) reported "5" (too many bites to count).

however, one was given only 26.3 mg per day for 14 days and subsequently experienced a relapse 9 months later after returning to the U.S. The other patient (#8-2015) received 52.6 mg primaquine phosphate daily for 14 days (**Table 3**). All patients diagnosed with malaria after returning to the U.S., including the one relapse case, were treated with chloroquine phosphate (n=9) or chloroquine+Lariam® (n=1) for blood stage parasites (**Table 3**), followed by primaquine phosphate (52.6 mg per day for 14 days) for latent liver stage parasites. Some soldiers reported being initially diagnosed with an influenza-like illness and receiving symptomatic treatment for headache and fever. From the time of onset of symptoms to diagnosis, the malaria patients reported being seen in clinic one to four times over 3–31 days (**Tables 2, 3**).

None of the malaria patients remembered receiving a medical threat brief prior to their departure to the ROK,

during in-processing, or prior to conducting field training at Rodriguez CACTF and DNTA, and none had been forewarned of the presence of large numbers of mosquitoes at DNTA or that malaria was endemic near the DMZ. Soldiers were not placed on malaria chemoprophylaxis, because it was not routinely recommended for soldiers in the ROK due to low numbers of malaria cases in previous years and very low mortality (no deaths from 1993 to present). Pop-up permethrin-treated bed nets were not available for military units training in field environments. While at Camps Casey/Hovey, patients stated that they saw few mosquitoes present during the evening hours, and none reported being bitten by mosquitoes. From 15 July through 17 August 2016, selected units of the ABCT trained at Rodriguez CACTF. There they slept in air-conditioned barracks during the evening hours and saw

few mosquitoes during the evening hours; none reported being bitten by mosquitoes. Several units then moved from Rodriguez CACTF to DNTA on 17 August where they bivouacked and conducted nighttime exercises until 22 August when they returned to Camps Casey/Hovey (**Table 1**). All except one of the malaria patients trained at Rodriguez CACTF before moving to DNTA.

The units that trained at DNTA consisted mainly of tracked vehicle (e.g., Abrams tank) operators and crew members who wore Nomex® (fire retardant) uniforms, while mechanics wore coveralls and command staff wore all climate uniforms (ACU). Most of the patients were unaware if their uniforms had been factory-treated with permethrin. Tank operators and crewmen slept in or on their tracked vehicles during the evening hours in sleeping bags in Nomex® uniforms or ACUs to protect themselves from biting mosquitoes, while others (mechanics and administrative and command groups) slept in physical training uniforms in screened tents (**Table 1**). Vivax malaria patients who slept in or on their vehicles were unprotected from biting mosquitoes and reported numerous mosquitoes biting during the evening. On a scale of 0 (none) to 5 (too many to count) for presence of mosquitoes, most patients (73%) noted "5" (too many mosquitoes present to count), and, for the number of mosquitoes bites, the majority (55%) reported "5" (too many bites to count) (**Table 1**). Two patients slept in a two-man screened tent and reported keeping the screen tightly closed to keep mosquitoes from entering the tent, while two others slept in a large ill-kempt general purpose tent where the screened entrance was left unsecured and they reported the presence of numerous mosquitoes and having been frequently bitten while inside the tent.

Soldiers were not issued arthropod repellents to protect themselves from mosquitoes and other biting arthropods while training. However, seven of 11 patients (64%) reported that they brought personal repellents, mostly consisting of spray-on DEET formulations or unknown creams and liquids (**Table 1**).

After the departure of the ABCT from Korea to the U.S. during 2–17 February 2016 and until the time that the malaria

**TABLE 2.** Vivax malaria patient characteristics, dates of training, time from exposure to the onset of symptoms, medical clinics, number of visits, method of diagnosis, and number of days from the onset of symptoms to diagnosis

Patient no.	Race/ethnicity	Training date	Date of symptom onset	Exposure to symptom onset	Final hospital/ clinic <sup>a,b</sup>	Total medical visits	Diagnosis <sup>c</sup>	Date of diagnosis	Days to diagnosis
7-2015	White	7–20 Aug 2015	21-Aug-15	1–14 days	St. Mary's Hospital, Korea	4	blood film+	31-Aug-15	10
8-2015	Pacific Islander	17–22 Aug 2015	31-Aug-15	9–14 days	Brian Allgood ACH	2	Ag+ and blood film+	9-Sep-15	9
1-2016	White	17–22 Aug 2015	2-May-16	8 mo, 11–16 days	Darnall AMC	3	Ag+ and blood film+	16-May-16	14
2-2016	White	17–22 Aug 2015	14-May-16	8 mo, 23–28 days	Darnall AMC	2	Ag+, blood film+, PCR+	20-May-16	6
3-2016	White	17–22 Aug 2015	6-May-16	8 mo, 15–20 days	Claxton-Hepburn Medical Center (civilian)	2	Ag+	19-May-16	13
4-2016	White	17–22 Aug 2015	15-May-16	8 mo, 24–29 days	Darnall AMC	3	Ag+	15-Jun-16	31
6-2016-R	White	7–20 Aug 2015	16-Jun-16	9 mo, 25–30 days	Darnall AMC	2	blood film+	21-Jun-16	5
7-2016	Hispanic	17–22 Aug 2015	17-Jun-16	9 mo, 26–31 days	Darnall AMC	2	blood film+	24-Jun-16	7
8-2016	White	17–22 Aug 2015	9-Jun-16	9 mo, 18–23 days	Darnall AMC	2	Ag+ and blood film+	15-Jun-16	6
9-2016	White	17–22 Aug 2015	15-Jun-16	9 mo, 23–29 days	Genesys Hospital (civilian)	1	blood film+	25-Jun-16	10
12-2016	Black	17–22 Aug 2015	21-Jul-16	9 mo, 31–36 days	Martin ACH	2	Ag+ and blood film+	24-Jul-16	3
14-2016	White	17–22 Aug 2015	22-Jul-16	10 mo, 31–36 days	Martin ACH	2	Ag+ and blood film+	25-Jul-16	3

<sup>a</sup>Soldiers were treated often first at Aid Stations by medics, diagnosed with flu-like symptoms, and provided medications for headache and temperature as they often reported to sick call following a paroxysm when temperatures were near normal. Two patients were treated at civilian hospitals (leave). Most soldiers were administered chloroquine 1,000 mg at 0 hr (initial dose), followed by 500 mg at 6, 24, and 48 hr. Patients were given 52.6 mg primaquine phosphate x 14 days concurrently or after chloroquine therapy as an outpatient. Patient #7-2015, admitted to a Korean hospital, was given hydroxychloroquine (800 mg at 0 hr, followed by 400 mg at 6 and 12 hr later) and only given 26.3 mg primaquine phosphate x 14 days.

<sup>b</sup>Final diagnosis was at Army Medical Centers (AMC), Army Community Hospitals (ACH) in the U.S., the Brian Allgood Army Community Hospital in ROK, local ROK civilian hospitals (Saint Mary's Hospital), or U.S. civilian hospitals (Claxton-Hepburn Medical Center, NY, and Genesys Hospital, MI).

<sup>c</sup>The malaria Ag kit was not specific for *Plasmodium vivax* but was differential for non-falciparum malaria.

patients demonstrated symptoms, none reported any recent travel outside the U.S. Although several patients stated that they heard rumors that several members of their units had contracted malaria due to exposure in the ROK, the patients stated that the command did not inform them that members in their units were diagnosed with malaria, nor were they informed about the symptoms of vivax malaria.

## EDITORIAL COMMENT

Because of the low numbers of malaria cases in previous years (10 cases or fewer annually between 2008 and 2014; less than 0.2 per 1,000 population at-risk) and the extremely low mortality rate,<sup>14,16</sup> U.S. military personnel in the ROK, with the

exception of Marines, are not routinely placed on malaria chemoprophylaxis. Ree reported that during 1998, none of the “properly administered” ROK soldiers training near the DMZ developed malaria, whereas 11% of inadequately monitored ROK soldiers on chemoprophylaxis developed malaria and 89% of untreated soldiers developed malaria.<sup>17</sup> U.S. soldiers in the ROK are recommended to use appropriate wear (e.g., permethrin-treated uniforms with the sleeves rolled down, pants tucked into the boots) and effective arthropod repellents (e.g., DEET >20% or picaridin). Factory permethrin-treated ACUs replaced the non-permethrin ACUs for sale in military clothing sales stores in October 2012 and factory permethrin-treated ACUs replaced non-permethrin-treated ACUs as an Army clothing bag item in February 2013. Previous to the implementation

of factory treatment, U.S. soldiers treated their uniforms with permethrin using 6 oz. spray cans or individual dynamic absorption (IDA) kits. Although U.S. soldiers are currently issued permethrin-treated uniforms, uniforms purchased before the era of factory permethrin-treated uniforms were often treated by other methods. In addition, most soldiers were unaware whether or not they were wearing permethrin-treated uniforms, and that factory permethrin-treated uniforms are not authorized to be retreated by other methods. In addition, several soldiers who utilized factory permethrin-treated uniforms during the field exercise noted that the uniforms were beyond the lifetime of repellent effectiveness. The consequences of wearing “outdated” permethrin-treated uniforms are unclear, but their use may result in diminished protection from insect bites.

**TABLE 3.** Medical history, including treatment and symptoms, of patients diagnosed with vivax malaria attributed to exposure at Dagmar North Training Area during 17–22 August 2015

Patient no.	Medication, blood stage <sup>a,b</sup>	Symptoms								
		Chills	Fever <sup>c</sup>	Intense sweats	Headache	Nausea	Vomiting	Diarrhea	Body aches	Malaise
7-2015	Hydroxy-chloroquine	Yes	N/D	Yes	Yes	Yes	Yes	N/D	Yes	Yes
8-2015	Malarone®	Yes	>103°F	Yes	Yes	No	No	Yes	Yes	Yes
1-2016	Chloroquine	Yes	>103°F	Yes	Yes	N/D	N/D	Yes	Yes	Yes
2-2016	Chloroquine	N/D	102.4°F	N/D	N/D	N/D	N/D	N/D	N/D	N/D
3-2016	Chloroquine	Yes	>102°F	Yes	Yes	N/D	N/D	N/D	Yes	Yes
4-2016	Chloroquine	Yes	>102°F	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6-2016-R	Chloroquine	Yes	103.4°F	Yes	Yes	Yes	Yes	N/D	Yes	Yes
7-2016	Chloroquine	Yes	104°F	Yes	N/D	N/D	N/D	N/D	Yes	Yes
8-2016	Chloroquine	Yes	>103°F	Yes	Yes	N/D	N/D	N/D	Yes	Yes
9-2016	Chloroquine	Yes	>100.8°F	Yes	Yes	Yes	Yes	Yes	Yes	Yes
12-2016	Chloroquine + Lariam®	Yes	103.1°F	Yes	Yes	N/D	N/D	N/D	Yes	Yes
14-2016	Chloroquine	Yes	104.9°F	Yes	Yes	Yes	Yes	Yes	Yes	Yes

N/D, not determined/data not available

<sup>a</sup>All patients were administered chloroquine for blood stage parasites, except patient no. 7-2015 who was given hydroxychloroquine (treated at Korean hospital), patient no. 8-2015 who was given Malarone®, and patient no. 12-2016, who was initially given chloroquine and then the medication was changed to mefloquine (Lariam®, Roache Laboratories Inc., Nutley, NJ).

<sup>b</sup>All patients given 52.6 mg primaquine phosphate × 14 days, except patient no. 7-2015, who was given 26.3 mg primaquine phosphate × 14 days.

<sup>c</sup>Temperatures were taken at various times during or after the paroxysm.

Distribution of insect repellents is a unit supply function and should be based on recommendations to the Commander by the field sanitation team (FST), and repellents must be procured prior to training exercises through the Defense Logistics Agency or purchased locally. The unit that trained at DNTA did not procure repellents for their soldiers to reduce mosquito bites and protect them from vector-borne diseases. Some soldiers reported purchasing repellents locally, but their ingredients and efficacy were unknown. Soldiers with and without repellents reported receiving numerous bites, and some reported to sick call with “numerous red bumps,” suggesting a lack of protection. Additionally, insecticide application to the exterior and interior of tents should be considered as it may reduce biting populations inside tents while soldiers are resting or sleeping.

From 2008 through 2013, the number of malaria cases decreased sharply among U.S. Forces Korea, in part due to the replacement of ill-kempt tents at Warrior Base with air conditioned barracks<sup>14</sup>.

However, at DNTA, a combination of factors may have led to increased numbers of malaria cases among U.S. personnel in 2014–2015,<sup>16</sup> including local transmission among ROK soldiers and civilians, an abundance of larval habitat, low-lying flooded areas and rice paddies that border DNTA, and potential for continued introduction of malaria by anopheline mosquitoes from North Korea.<sup>17</sup> Thus, a combination of factors that included *Plasmodium*-infected mosquitoes and concurrent training activities that exposed soldiers to biting mosquitoes (e.g., non-use of repellents, non-use of permethrin impregnated uniforms and mosquito nets, and sleeping unprotected in/on vehicles or ill-kempt tents) increased the potential for malaria transmission.

In healthy nonimmune young adults, *P. vivax* infections in the ROK cause a debilitating, but non-life-threatening, acute febrile illness that reduces military effectiveness. Informing commanders, soldiers, and medical personnel at all levels is imperative to increase their knowledge of potential malaria risks and to rapidly diagnose

infections to minimize morbidity, disruption of military operations, and risk of continued autochthonous transmission both in the ROK and the U.S. Soldiers described in this report who developed malaria were unaware of the risks of malaria transmission or the presence of other vector-borne and zoonotic disease risks in the ROK. Soldiers were not informed of malaria risks in the ROK, so they may have delayed reporting to a medical clinic in the U.S. after they developed symptoms of malaria. In addition, the possibility that medics were often unaware of the signs and symptoms of malaria may have delayed diagnosis and increased the risk for autochthonous transmission to civilian communities in the U.S. Providers at all levels should be cognizant of the signs and symptoms of malaria and should review the travel histories of febrile patients to determine if they had deployed or trained in malaria endemic areas.

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*Disclaimer: The views expressed herein are those of the authors and do not necessarily reflect the official policy or position of the Army, the Department of Defense, or the United States Government.*

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### Key points

- Vivax malaria is endemic in South and North Korea.
- It is the military command's responsibility to provide repellents to soldiers while training in field conditions where vector-borne diseases are present.
- Soldiers deployed to the Republic of Korea (ROK) should receive a “health threat brief” to ensure that they are aware of malaria risks near the demilitarized zone and the signs and symptoms of vivax malaria.

### Learning objectives

1. The reader will interpret the likely causes of the re-emergence of vivax malaria in the ROK.
2. The reader will summarize the principal signs and symptoms of vivax malaria.
3. The reader will critique personal protection activities in a malaria endemic area such as the ROK.

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# Update: Cold Weather Injuries, Active and Reserve Components, U.S. Armed Forces, July 2013–June 2018

From July 2017 through June 2018, a total of 478 members of the active (n=402) and reserve (n=76) components had at least one medical encounter with a primary diagnosis of cold injury. The crude overall incidence rate of cold injury for all active component service members in 2017–2018 was 19.6% higher than the rate for the 2016–2017 cold season and was the highest rate since the 2013–2014 season. Frostbite was the most common type of cold injury among active component service members in 2017–2018. Among active component members during the 2013–2018 cold seasons, overall rates of cold injuries were generally highest among males, non-Hispanic black service members, the youngest (less than 20 years old), and those who were enlisted. As noted in prior *MSMR* updates, the rate of all cold injuries among active component Army members was considerably higher in females than in males due to a much higher rate of frostbite among female soldiers. The numbers of cold injuries associated with overseas deployments have fallen precipitously in the past three cold seasons and included 17 cases in the most recent year.

Since 2004, the *MSMR* has published annual updates on the incidence of cold weather injuries that affected U.S. military members during the five most recent cold seasons.<sup>1</sup> The content of this 2018 report addresses the occurrence of such injuries during the cold seasons from July 2013 through June 2018. The timing of the annual updates is intended to call attention to the recurring risks of such injuries as winter approaches in the Northern Hemisphere, where most members of the U.S. Armed Forces are assigned.

For many years, the U.S. Armed Forces have developed and improved robust training, doctrine, procedures, and protective equipment and clothing to counter the threat from cold environments.<sup>2–4</sup> Although these measures are highly effective, cold injuries have continued to affect hundreds of service members each year because of exposure to cold and wet environments.<sup>5</sup> Such environmental conditions pose the threat of hypothermia, frostbite, and non-freezing cold injury such as immersion injury. The human physiologic response

to cold exposure is to retard heat loss and preserve core body temperature, but this response may not be sufficient to prevent hypothermia if heat loss is prolonged.<sup>6</sup> Moreover, the response includes constriction of the peripheral (superficial) vascular system, which may result in non-freezing injuries or hasten the onset of actual freezing of tissues (frostbite).<sup>6</sup> Traditional measures to counter the dangers associated with cold environments include minimizing loss of body heat and protecting superficial tissues through such means as protective clothing, shelter, physical activity, and nutrition. However, military training or mission requirements in cold and wet weather may place service members in situations where they may be unable to be physically active, find warm shelter, or change wet or damp clothing.<sup>2,3</sup>

Military history has well documented the toll of cold weather injuries. Continuous surveillance of these injuries is essential to inform steps to reduce their impact as well as to remind leaders of the predictable threat of cold injuries. This update

## WHAT ARE THE NEW FINDINGS?

Cold weather injuries increased by 20% in 2017–2018 from the previous year. Rates were highest among exposed Army and Marine Corps personnel. Frostbite remained the most common cold weather injury.

## WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Prevention of cold injuries is the responsibility of commanders at all levels and cold weather injuries such as hypothermia, frostbite, and trench foot can be avoided during cold weather exercises. Preparation for cold weather operations involves advance planning by leaders, individual compliance, and supervisory follow-through.

summarizes the frequencies, incidence rates, and correlates of risk of cold injuries among members of both active and reserve components of the U.S. Armed Forces during the past 5 years.

## METHODS

The surveillance period was 1 July 2013 through 30 June 2018. The surveillance population included all individuals who served in the active or reserve component of the U.S. Armed Forces at any time during the surveillance period. For analysis purposes, “cold years” or “cold seasons” were defined as 1 July through 30 June intervals so that complete cold weather seasons could be represented in year-to-year summaries and comparisons.

Because cold weather injuries 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 (RMEs) via one of the service-specific electronic reporting systems; these reports are routinely incorporated into the Defense Medical Surveillance

System (DMSS). For this analysis, the DMSS and the Theater Medical Data Store (which maintains electronic records of medical encounters of deployed service members) were searched for records of RMEs and inpatient and outpatient care for the diagnoses of interest (frostbite, immersion injury, and hypothermia). A case was defined by the presence of an RME or of any qualifying ICD-9 or ICD-10 code in the first diagnostic position of a record of a healthcare encounter (**Table 1**). The DoD guidelines for RMEs require the reporting of cases of hypothermia, frostbite, and immersion injuries but not “other specified/unspecified effects of reduced temperature.”<sup>7</sup> Cases of chilblains are not included in this report because the condition is common, infrequently diagnosed, usually mild in severity, and thought to have minimal medical, public health, or military impacts.

To estimate the number of unique individuals who suffered a cold injury each cold season, and to avoid counting follow-up healthcare encounters after single episodes of cold injury, only one cold injury per individual per cold season was included. A slightly different approach was taken for summaries of the incidence of the different

**TABLE 1.** ICD-9/ICD-10 diagnostic codes for cold weather injuries

	ICD-9	ICD-10 <sup>a</sup>
Frostbite	991.0, 991.1, 991.2, 991.3	T33.*, T34.*
Immersion hand and foot	991.4	T69.0*
Hypothermia	991.6	T68.*

<sup>a</sup>An asterisk (\*) indicates any digit/character in this position and includes all subsequent digits/characters.

types of cold injury diagnoses. In counting types of diagnoses, one of each type of cold injury per individual per cold season was included. For example, if an individual was diagnosed with immersion foot at one point during a cold season and then with frostbite later during the same cold season, each of those different types of injury would be counted in the tally of injuries. If a service member had multiple medical encounters for cold injuries on the same day, only one encounter was used for analysis (hospitalizations were prioritized over ambulatory visits which were prioritized over RMEs). Annual incidence rates of cold injuries among active component service members were calculated as incident cold injury diagnoses per 100,000 person-years

(p-yrs) of service. Annual rates of cold injuries among reservists were calculated as cases per 100,000 persons using the total number of reserve component service members for each year of the surveillance period. Counts of persons were used as the denominator in these calculations because information on the start and end dates of active duty service periods of reserve component members was not available.

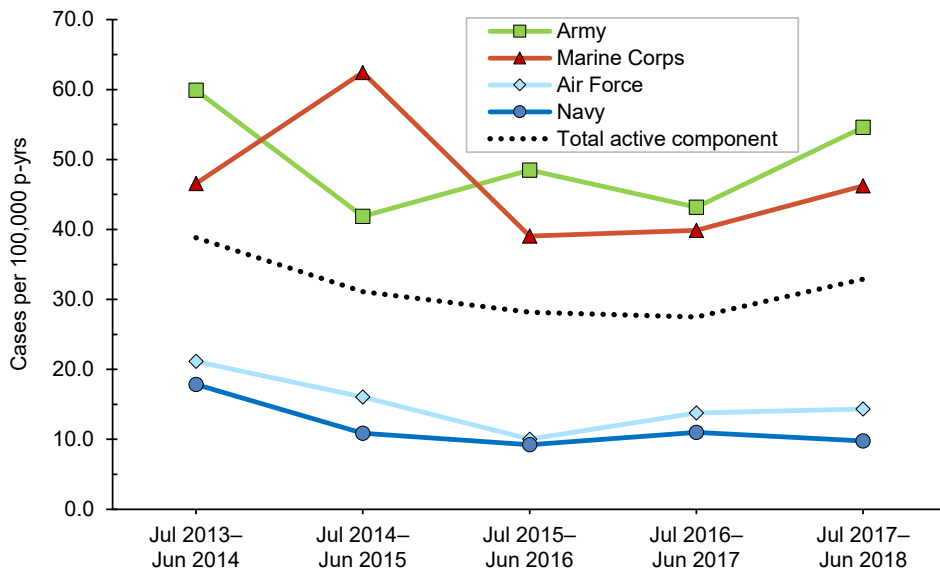
The numbers of cold injuries were summarized by the locations at which service members were treated for these injuries as identified by the Defense Medical Information System Identifier (DMIS ID) recorded in the medical records of the cold injuries. Because such injuries may be sustained during field training exercises,

**TABLE 2.** Any cold injury (one per person per year), by service and component, U.S. Armed Forces, July 2013–June 2018

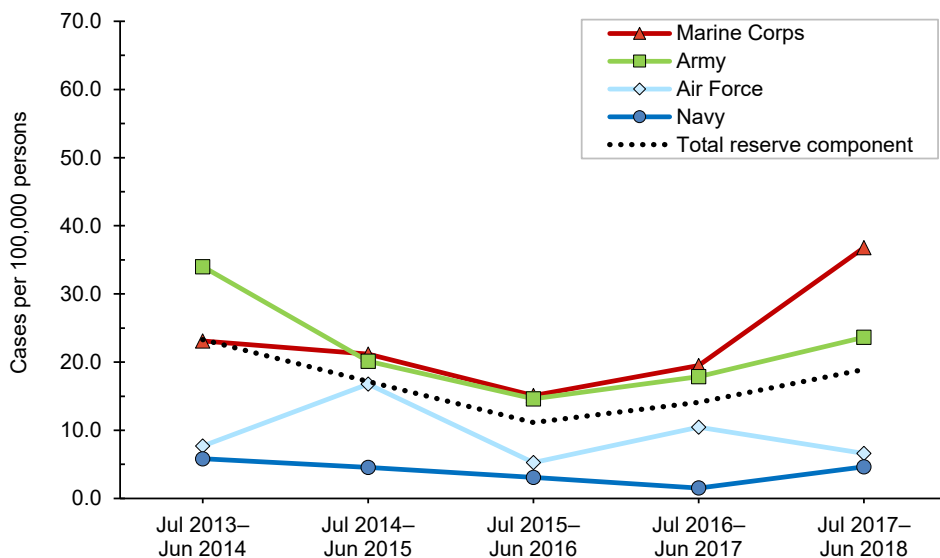
	Army		Navy		Air Force		Marine Corps		All services	
	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>
Active component										
All years (2013–2018)	1,198	49.7	184	11.8	238	15.1	436	46.9	2,056	31.8
Jul 2013–Jun 2014	312	59.9	57	17.8	69	21.1	90	46.6	528	38.8
Jul 2014–Jun 2015	208	41.9	35	10.9	50	16.1	116	62.4	409	31.1
Jul 2015–Jun 2016	233	48.5	30	9.2	31	10.0	72	39.1	366	28.2
Jul 2016–Jun 2017	200	43.2	35	11.0	43	13.8	73	39.9	351	27.5
Jul 2017–Jun 2018	245	54.6	27	9.8	45	14.3	85	46.2	402	32.9
Reserve component										
All years (2013–2018)	246		13		36		54		349	
Jul 2013–Jun 2014	77	34.0	4	5.8	6	7.7	11	23.1	98	23.3
Jul 2014–Jun 2015	45	20.1	3	4.6	13	16.8	10	21.2	71	17.1
Jul 2015–Jun 2016	33	14.6	2	3.1	4	5.3	7	15.1	46	11.1
Jul 2016–Jun 2017	40	17.9	1	1.5	8	10.5	9	19.5	58	14.1
Jul 2017–Jun 2018	51	23.7	3	4.6	5	6.6	17	36.8	76	18.9
Overall, active and reserve										
All years (2013–2018)	1,444		197		274		490		2,405	
Jul 2013–Jun 2014	389		61		75		101		626	
Jul 2014–Jun 2015	253		38		63		126		480	
Jul 2015–Jun 2016	266		32		35		79		412	
Jul 2016–Jun 2017	240		36		51		82		409	
Jul 2017–Jun 2018	296		30		50		102		478	

<sup>a</sup>For active component, rate is per 100,000 person-years. For reserve component, rate is per 100,000 persons.

**FIGURE 1.** Annual incidence rates of cold injuries (one per person per year), by service, active component, U.S. Armed Forces, July 2013–June 2018



**FIGURE 2.** Annual incidence rates of cold injuries (one per person per year), by service, reserve component, U.S. Armed Forces, July 2013–June 2018



temporary duty, or other instances for which a service member may not be located at his/her usual duty station, DMIS ID was used as a proxy for the location where the cold injury occurred.

The new electronic health record for the Military Health System, MHS GENESIS, was implemented at several military treatment facilities during 2017. Medical

data from sites using MHS GENESIS are not available in the DMSS. These sites include Naval Hospital Oak Harbor, Naval Hospital Bremerton, Air Force Medical Services Fairchild, and Madigan Army Medical Center. Therefore, medical encounter and person-time data for individuals seeking care at one of these facilities during 2017 were not included in this analysis.

## RESULTS

### 2017–2018 cold season

From July 2017 through June 2018, a total of 478 members of the active ( $n=402$ ) and reserve ( $n=76$ ) components had at least one medical encounter with a primary diagnosis of cold injury (Table 2). The crude overall incidence rate of cold injury for all active component service members in 2017–2018 (32.9 per 100,000 p-yrs) was 19.6% higher than the rate for the 2016–2017 cold season (27.5 per 100,000 p-yrs) and was the highest rate since the 2013–2014 season (Table 2, Figure 1). Throughout the surveillance period, the cold injury rates were consistently higher among active component members of the Army or the Marine Corps than among those in the Air Force or Navy. In 2017–2018, the service-specific incidence rate for active component Army members (54.6 per 100,000 p-yrs) was 26.5% higher than the 2016–2017 Army rate (43.2 per 100,000 p-yrs). The Army contributed slightly more than three-fifths (60.9%;  $n=245$ ) of all cold injury diagnoses in the active component during the 2017–2018 cold season. For the Marine Corps, the active component rate for 2017–2018 was 15.9% higher than the rate for the previous season. The 85 members of the Marine Corps diagnosed with a cold injury in 2017–2018 represented 21.1% of all affected active component service members. Navy service members ( $n=27$ ) had the lowest service-specific rate of cold injuries during the 2017–2018 cold season (9.8 per 100,000 p-yrs) (Table 2, Figure 1).

This update for 2017–2018 represents the second year that annual rates of cold injuries for members of the reserve component were estimated. Army personnel ( $n=51$ ) accounted for 67.1% of all reserve component service members ( $n=76$ ) affected by cold injuries during 2017–2018 (Table 2). As was true for the active component, service-specific rates among reserve component members were higher among those in the Army or Marine Corps than among those in the Air Force or Navy (Figure 2). For the 2017–2018 cold season, the overall rate of cold injuries for the reserve

**TABLE 3a.** Counts and incidence rates of cold injuries (one per type per person per year), active component, U.S. Army, July 2013–June 2018

	Frostbite		Immersion foot		Hypothermia		All cold injuries	
	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>
Total	762	31.6	217	9.0	233	9.7	1,212	50.3
<b>Sex</b>								
Male	599	29.0	201	9.7	201	9.7	1,001	48.5
Female	163	47.3	16	4.6	32	9.3	211	61.3
<b>Race/ethnicity</b>								
Non-Hispanic white	279	20.1	103	7.4	136	9.8	518	37.3
Non-Hispanic black	359	70.4	74	14.5	47	9.2	480	94.1
Other	124	24.2	40	7.8	50	9.7	214	41.7
<b>Age group</b>								
<20	65	40.6	23	14.4	33	20.6	121	75.7
20–24	331	46.8	98	13.9	109	15.4	538	76.0
25–29	156	28.3	57	10.4	58	10.5	271	49.2
30–34	105	26.3	25	6.3	20	5.0	150	37.6
35–39	58	20.1	10	3.5	8	2.8	76	26.3
40–44	28	15.4	2	1.1	3	1.7	33	18.2
45+	19	15.6	2	1.6	2	1.6	23	18.8
<b>Rank</b>								
Enlisted	681	35.1	177	9.1	200	10.3	1,058	54.5
Officer	81	17.3	40	8.5	33	7.0	154	32.8
<b>Occupation</b>								
Combat-specific <sup>b</sup>	252	41.6	103	17.0	114	18.8	469	77.3
Motor transport	41	55.8	6	8.2	8	10.9	55	74.8
Repair/engineering	129	26.3	37	7.5	27	5.5	193	39.3
Communications/intelligence	184	30.8	39	6.5	53	8.9	276	46.3
Health care	41	16.4	7	2.8	9	3.6	57	22.8
Other/unknown	115	29.3	25	6.4	22	5.6	162	41.2
<b>Cold year (July–June)</b>								
2013–2014	209	40.1	50	9.6	55	10.6	314	60.3
2014–2015	136	27.4	19	3.8	55	11.1	210	42.3
2015–2016	126	26.2	73	15.2	42	8.7	241	50.2
2016–2017	131	28.3	33	7.1	37	8.0	201	43.4
2017–2018	160	35.7	42	9.4	44	9.8	246	54.8

<sup>a</sup>Rate per 100,000 person-years

<sup>b</sup>Infantry/artillery/combat engineering/armor

component and the rates for each of the services except the Air Force were higher than in the 2016–2017 season. Among reserve component members, the most pronounced increase in service-specific rates between the 2016–2017 and 2017–2018 seasons was seen in the Marine Corps.

When all injuries were considered, not just the numbers of individuals affected,

frostbite was the most common type of cold injury (n=247; 60.8% of all cold injuries) among active component service members in 2017–2018 (Tables 3a–3d). In the Air Force and Army respectively, 84.4% and 65.0% of all cold injuries were frostbite, whereas the proportions in the Navy (55.6%) and Marine Corps (38.6%) were much lower. For the Army and Marine

Corps, the 2017–2018 numbers and rates of frostbite injuries among active component service members were the highest of the past 4 years. For all active component service members during 2017–2018, the proportions of all cold weather injuries that were hypothermia and immersion injuries were 18.7% and 20.4%, respectively (data not shown). Among active component Navy members, the numbers and rates of hypothermia cases and immersion injuries in 2017–2018 were the lowest of the 5-year surveillance period and of the past 4 years, respectively (Table 3b). The number and rate of immersion injury cases in 2017–2018 in the Air Force were the lowest of the surveillance period (Table 3c).

### Five cold seasons: July 2013–June 2018

During the 5-year surveillance period, the rates of cold injuries among members of the active components of the Navy, Air Force, and Marine Corps were higher among males than females. Among active component Army members, there was a striking difference between the rates for females (61.3 per 100,000 p-yrs) and males (48.5 per 100,000 p-yrs). In all of the services during 2013–2018, females had lower rates of immersion injury and hypothermia than did males but higher rates of frostbite (except in the Air Force) (Tables 3a–3d). For active component service members in all four services combined, the overall rate of cold injury was slightly higher among males (32.6 per 100,000 p-yrs) than among females (29.4 per 100,000 p-yrs) (data not shown).

In all of the services, overall rates of cold injuries were higher among non-Hispanic black service members than among those of the other race/ethnicity groups. In particular, within the Marine Corps and Army, and for all services combined, rates of cold injuries were more than twice as high among non-Hispanic black service members than among either non-Hispanic white service members or those in the “other/unknown” race/ethnicity group (Tables 3a–3d). The major underlying factor in these differences is that rates of frostbite among non-Hispanic black members of all services were 1.5 or more times higher than those of the other race/ethnicity groups

**TABLE 3b.** Counts and incidence rates of cold injuries (one per type per person per year), active component, U.S. Navy, July 2013–June 2018

	Frostbite		Immersion foot		Hypothermia		All cold injuries	
	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>
Total	80	5.1	53	3.4	51	3.3	184	11.8
<b>Sex</b>								
Male	63	4.9	49	3.8	48	3.8	160	12.6
Female	17	5.9	4	1.4	3	1.0	24	8.3
<b>Race/ethnicity</b>								
Non-Hispanic white	38	4.8	22	2.8	33	4.1	93	11.6
Non-Hispanic black	17	7.1	9	3.8	10	4.2	36	15.1
Other	25	4.8	22	4.2	8	1.5	55	10.5
<b>Age group</b>								
<20	22	25.3	7	8.1	6	6.9	35	40.3
20–24	13	2.7	25	5.2	19	4.0	57	11.9
25–29	22	5.6	13	3.3	17	4.3	52	13.1
30–34	10	3.9	5	1.9	3	1.2	18	7.0
35–39	8	4.4	2	1.1	5	2.8	15	8.3
40–44	2	2.0	1	1.0	0	0.0	3	3.0
45+	3	4.8	0	0.0	1	1.6	4	6.3
<b>Rank</b>								
Enlisted	69	5.3	51	3.9	46	3.6	166	12.8
Officer	11	4.1	2	0.8	5	1.9	18	6.8
<b>Occupation</b>								
Combat-specific <sup>b</sup>	10	10.4	0	0.0	4	4.2	14	14.5
Motor transport	6	9.6	7	11.2	9	14.3	22	35.1
Repair/engineering	22	3.2	26	3.8	12	1.8	60	8.8
Communications/intelligence	11	4.5	4	1.6	4	1.6	19	7.7
Health care	9	5.0	4	2.2	6	3.3	19	10.6
Other/unknown	22	7.4	12	4.0	16	5.4	50	16.9
<b>Cold year (July–June)</b>								
2013–2014	34	10.6	6	1.9	17	5.3	57	17.8
2014–2015	16	5.0	13	4.0	7	2.2	36	11.2
2015–2016	8	2.5	11	3.4	10	3.1	29	8.9
2016–2017	7	2.2	15	4.7	13	4.1	35	11.0
2017–2018	15	5.4	8	2.9	4	1.4	27	9.8

<sup>a</sup>Rate per 100,000 person-years

<sup>b</sup>Infantry/artillery/combat engineering/armor

with the biggest differences apparent in the Marine Corps and the Army. Additionally, across the active components of all services during 2013–2018, non-Hispanic black service members had incidence rates of cold injuries greater than the rates of other race/ethnicity groups in nearly every military occupational category (**data not shown**).

Rates of cold injuries were generally highest among the youngest service members (less than 20 years old) and tended to be lower with each succeeding older age group. Enlisted members of the Army, Air Force, and Navy had higher rates than officers, but the opposite was true of Marine Corps members (**Tables 3a–3d**). In the

Army and Air Force, rates of all cold injuries combined were highest among service members in combat-specific occupations (infantry/artillery/combat engineering/armor) (**Tables 3a, 3c**).

During the 5-year surveillance period, the 2,405 service members who were affected by any cold injury included 2,056 from the active component and 349 from the reserve component. Of all affected reserve component members, 70.5% (n=246) were members of the Army (**Table 2**). Overall, soldiers accounted for the majority (60.0%) of all cold injuries affecting active and reserve component service members (**Table 2, Figure 3**).

Of all active component service members who were diagnosed with a cold injury (n=2,056), 195 (9.5% of the total) were affected during basic training. The Army (n=79) and Marine Corps (n=107) accounted for 95.4% of all basic trainees who suffered a cold injury (**data not shown**). Additionally, during the surveillance period, 73 service members who were diagnosed with cold injuries (3.6% of the total) were hospitalized, and most (91.8%) of the hospitalized cases were members of either the Army (n=40) or Marine Corps (n=27) (**data not shown**).

### Cold injuries during deployments

During the 5-year surveillance period, a total of 77 cold injuries were diagnosed and treated in service members deployed outside of the U.S. Of these, 38 (49.4%) were immersion injuries; 26 (33.8%) were frostbite; and 13 (16.9%) were hypothermia. Of all 77 cold injuries during the surveillance period, nearly one-third (32.5%) occurred in the first cold season. There were 25 cold injuries during cold season 2013–2014 but only 13 during 2014–2015, 11 during 2015–2016, 11 during 2016–2017, and 17 during 2017–2018 (**data not shown**).

### Cold injuries by location

During the 5-year surveillance period, 21 military locations had at least 30 incident cold injuries (one per person per year) among active and reserve component service members (**data not shown**). Among these locations, those with the

**TABLE 3c.** Counts and incidence rates of cold injuries (one per type per person per year), active component, U.S. Air Force, July 2013–June 2018

	Frostbite		Immersion foot		Hypothermia		All cold injuries	
	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>
Total	183	11.6	25	1.6	32	2.0	240	15.3
<b>Sex</b>								
Male	151	11.9	23	1.8	29	2.3	203	16.0
Female	32	10.6	2	0.7	3	1.0	37	12.2
<b>Race/ethnicity</b>								
Non-Hispanic white	106	10.6	20	2.0	21	2.1	147	14.7
Non-Hispanic black	41	19.5	3	1.4	4	1.9	48	22.9
Other	36	10.0	2	0.6	7	1.9	45	12.4
<b>Age group</b>								
<20	13	18.1	5	7.0	3	4.2	21	29.2
20–24	78	18.2	6	1.4	8	1.9	92	21.4
25–29	49	12.0	7	1.7	10	2.5	66	16.2
30–34	19	6.4	5	1.7	3	1.0	27	9.1
35–39	14	6.8	2	1.0	5	2.4	21	10.1
40–44	7	6.5	0	0.0	1	0.9	8	7.5
45+	3	5.9	0	0.0	2	3.9	5	9.8
<b>Rank</b>								
Enlisted	158	12.5	24	1.9	29	2.3	211	16.7
Officer	25	8.1	1	0.3	3	1.0	29	9.4
<b>Occupation</b>								
Combat-specific <sup>b</sup>	6	55.4	0	0.0	0	0.0	6	55.4
Motor transport	5	45.6	0	0.0	0	0.0	5	45.6
Repair/engineering	64	12.8	7	1.4	4	0.8	75	15.1
Communications/intelligence	32	8.9	3	0.8	6	1.7	41	11.4
Health care	12	7.9	1	0.7	3	2.0	16	10.6
Other/unknown	64	11.8	14	2.6	19	3.5	97	17.9
<b>Cold year (July–June)</b>								
2013–2014	52	15.9	9	2.8	8	2.5	69	21.1
2014–2015	42	13.5	4	1.3	4	1.3	50	16.1
2015–2016	19	6.2	4	1.3	8	2.6	31	10.0
2016–2017	32	10.3	6	1.9	7	2.2	45	14.4
2017–2018	38	12.1	2	0.6	5	1.6	45	14.3

<sup>a</sup>Rate per 100,000 person-years

<sup>b</sup>Infantry/artillery/combat engineering/armor

highest 5-year counts of incident injuries were Fort Wainwright, AK (n=155); Bavaria (Vilseck/Grafenwoehr), Germany (117); Marine Corps Recruit Depot Parris Island/Beaufort, SC (100); Fort Benning, GA (86); San Diego, CA (78); Fort Carson, CO (67); and Fort Campbell, KY (65). During the 2017–2018 cold season, the numbers of incident cases of cold injuries were

higher than the counts for the previous 2016–2017 cold season at 13 of the 21 locations (**data not shown**). The most noteworthy increases were found at the Army's Fort Benning and Fort Campbell, where there were 16 total cases diagnosed at each location in 2017–2018, compared to just five and six, respectively, the year before (**data not shown**). **Figure 4** shows the numbers of

cold injuries during 2017–2018 and the median numbers of cases for the previous 4 years for those locations that had at least 30 cases during the surveillance period. For nine of the 21 installations, the numbers of cases in 2017–2018 were below the median counts for the previous 4 years.

## EDITORIAL COMMENT

Overall incidence rates of cold injuries among U.S. service members increased in 2017–2018 compared with the previous winter. Across all services, the number of cold injury cases in 2017–2018 was the highest count of the past 3 years.

In 2017–2018, frostbite was the most common type of cold injury among active component service members in all the services except for the Marine Corps, in which immersion injury was the most common. Compared to their respective counterparts, overall rates of cold injuries were generally higher among males, non-Hispanic black service members, the youngest (less than 20 years old), and those who were enlisted. Increased rates of cold injuries affected nearly all enlisted and officer occupations among non-Hispanic black service members. Of note, rates of frostbite were markedly higher among non-Hispanic blacks compared to non-Hispanic whites and those in the other/unknown race/ethnicity group. These differences have been noted in prior *MSMR* updates and the results of several studies suggest that other factors (e.g., physiologic differences and/or previous cold weather experience) are possible explanations for increased susceptibility.<sup>4,8–10</sup>

The numbers of cold injuries associated with deployment have fallen precipitously in the past four cold seasons. This reduction in the number of cases is almost certainly a result of the dramatic decline in the numbers of service members deployed to Iraq and Afghanistan and of changes in the nature of military operations there.

Policies and procedures are in place to protect service members against cold weather injuries. Modern cold weather uniforms and equipment provide excellent protection against the cold when used correctly. However, in spite of these

**TABLE 3d.** Counts and incidence rates of cold injuries (one per type per person per year), active component, U.S. Marine Corps, July 2013–June 2018

	Frostbite		Immersion foot		Hypothermia		All cold injuries	
	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>	No.	Rate <sup>a</sup>
Total	158	17.0	171	18.4	115	12.4	444	47.7
<b>Sex</b>								
Male	140	16.3	170	19.8	110	12.8	420	49.0
Female	18	24.6	1	1.4	5	6.8	24	32.8
<b>Race/ethnicity</b>								
Non-Hispanic white	66	11.4	126	21.8	61	10.5	253	43.7
Non-Hispanic black	63	67.3	12	12.8	24	25.7	99	105.8
Other	29	11.2	33	12.8	30	11.6	92	35.6
<b>Age group</b>								
<20	28	22.2	90	71.4	37	29.4	155	123.0
20–24	78	17.9	70	16.1	52	12.0	200	46.0
25–29	28	16.6	8	4.8	22	13.1	58	34.4
30–34	14	15.0	0	0.0	2	2.1	16	17.1
35–39	7	11.5	3	4.9	2	3.3	12	19.7
40–44	2	6.3	0	0.0	0	0.0	2	6.3
45+	1	6.7	0	0.0	0	0.0	1	6.7
<b>Rank</b>								
Enlisted	117	14.2	166	20.1	109	13.2	392	47.5
Officer	41	39.0	5	4.8	6	5.7	52	49.4
<b>Occupation</b>								
Combat-specific <sup>b</sup>	53	26.2	17	8.4	26	12.9	96	47.5
Motor transport	2	5.2	4	10.3	3	7.7	9	23.2
Repair/engineering	14	6.0	9	3.9	11	4.7	34	14.6
Communications/intelligence	31	15.1	4	2.0	10	4.9	45	21.9
Health care	0	0.0	0	0.0	0	0.0	0	0.0
Other/unknown	58	23.0	137	54.3	65	25.8	260	103.1
<b>Cold year (July–June)</b>								
2013–2014	53	27.4	21	10.9	20	10.3	94	48.6
2014–2015	17	9.2	76	40.9	23	12.4	116	62.4
2015–2016	22	11.9	20	10.8	30	16.3	72	39.1
2016–2017	32	17.5	23	12.6	19	10.4	74	40.4
2017–2018	34	18.5	31	16.9	23	12.5	88	47.9

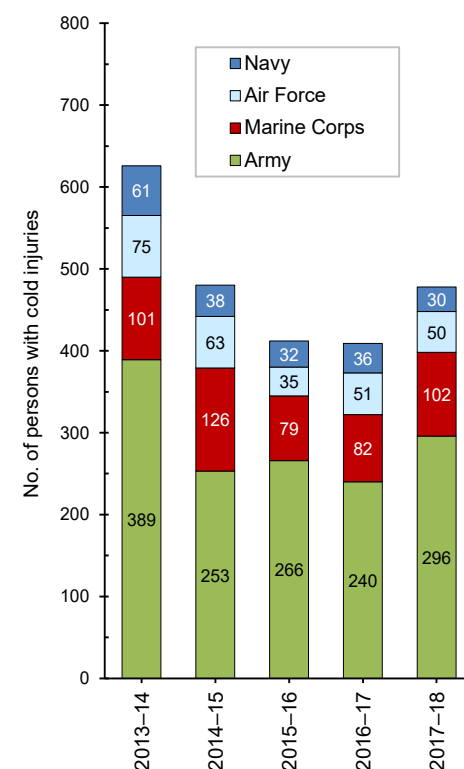
<sup>a</sup>Rate per 100,000 person-years

<sup>b</sup>Infantry/artillery/combat engineering/armor

safeguards, a significant number of individuals within all military services continue to be affected by cold weather injuries each year. It is important that awareness, policies, and procedures continue to be emphasized to reduce the toll of such injuries. In addition, enhancements in protective technologies deserve continued research. It should be noted that this analysis of cold

injuries was unable to distinguish between injuries sustained during official military duties (training or operations) and injuries associated with personal activities not related to official duties. To provide for all circumstances that pose the threat of cold weather injury, service members should know well the signs of cold injury and how to protect themselves against such injuries

**FIGURE 3.** Numbers of service members who had a cold injury (one per person per year), by service and cold season, active and reserve components, U.S. Armed Forces, July 2013–June 2018



whether they are training, operating, fighting, or recreating under wet and freezing conditions.

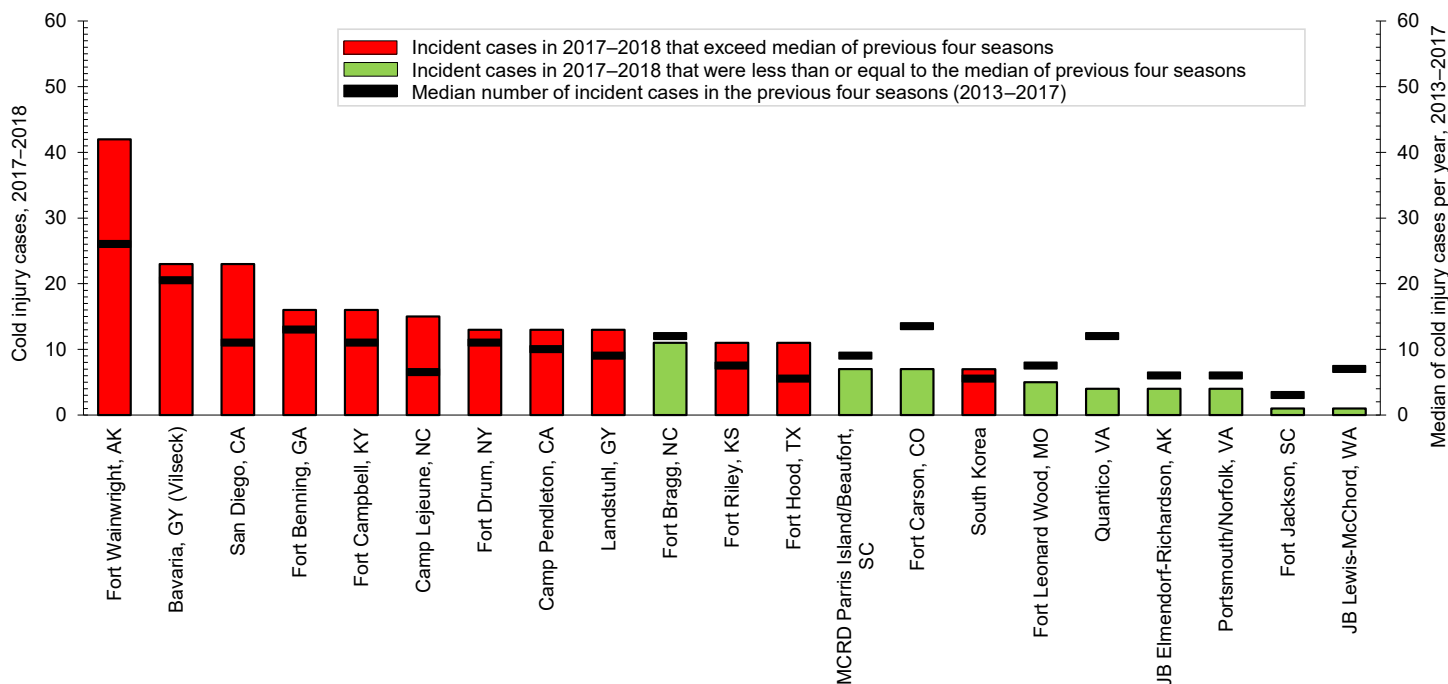
The most current cold injury prevention materials are available at:

<https://phc.amedd.army.mil/topics/discond/cip/Pages/Cold-Weather-Casualties-and-Injuries.aspx>.

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**FIGURE 4.** Annual number of cold injuries (cold season 2017–2018) and median number of cold injuries (cold seasons 2013–2017) at locations with at least 30 cold injuries during the surveillance period, active component members, U.S. Armed Forces, July 2013–June 2018



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# Increased Number of Possible Rabies Exposures Among U.S. Healthcare Beneficiaries Treated in Military Clinics in Southern Germany in 2016

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Following the death of a soldier from rabies in 2011, linked to exposure to rabies in Afghanistan,<sup>1</sup> the U.S. military implemented enhanced active surveillance of animal exposures to prevent rabies in service members and other Military Health System beneficiaries.<sup>2</sup> Because many exposures were related to deployment to Iraq or Afghanistan, the Department of Defense (DoD) added questions about animal exposure to post-deployment health assessments to improve the detection of possible rabies exposures. Exposures identified through post-deployment health assessments as well as exposures documented through local military healthcare or law enforcement reports are collected by military public health personnel.

Although Germany is rabies-free for terrestrial land mammals,<sup>3</sup> rabies exposure remains a concern for U.S. military personnel assigned there because of personal and military travel and deployments to rabies-endemic countries. Since 2011, however, the number of service members deploying to Southwest Asia has greatly declined; as a result, deployments have become much more variable both in location and duration. Deployments have increasingly focused on enhancing partnerships and peacekeeping. For example, U.S. soldiers stationed in Germany have been involved in partnering missions with European allies and UN peacekeeping operations in the Sinai region of Egypt.<sup>4</sup> In 2016, U.S. Army Medical Department Activity-Bavaria (MEDDAC-B) Preventive Medicine (PM) personnel suspected an increase in the risk of rabies exposure for soldiers deployed in support of the Sinai peacekeeping mission. This report describes efforts that were undertaken to investigate this possible increased risk of rabies exposure faced by service members.

## METHODS

For purposes of this report, the term “exposure” refers to all instances of human contact with animals, including bites, contact with animal saliva, scratches, or casual contact, which came to medical attention and were evaluated for the potential that the patient might have been exposed to rabies virus. The U.S. Army Medical Department Activity Bavaria (MEDDAC-B) provides public health support to all U.S. military and affiliated personnel stationed in southern Germany. For such personnel, all reported exposures, independent of location, are reviewed by PM and Veterinary personnel to ensure appropriate care and follow-up. Decisions about whether to initiate rabies post-exposure prophylaxis (RPEP) are made on the basis of the risk of the exposure. Such assessments consider the type of animal, the geographic location of the exposure event, and the immunization status of the animal. In general, exposures are reported per DoD Policy using DoD Form 2341, Report of Animal Bite – Potential Rabies Exposure (DD Form 2341);<sup>5</sup> however, some exposures were reported through other channels, such as email, phone call, or Military Police Report forwarded to MEDDAC-B PM. In those cases, a DD Form 2341 is completed by the treating or evaluating medical facility to which the patient is assigned and referred (if needed). The DD Form 2341 captures information on patient demographics and consists of four parts: animal bite history, management of animal bite case, management of biting animal, and case review. The biting animal is handled in accordance with the Compendium of Animal Rabies Prevention and Control; for dogs and cats (the vast majority of exposures considered

## WHAT ARE THE NEW FINDINGS?

In 2016, the U.S. Army Medical Department Activity-Bavaria recorded 108 possible rabies exposures, a 112% increase from the previous year. Of these, 49 (45%) occurred during prior deployments to Egypt and Eastern Europe in which they had not received timely rabies post-exposure prophylaxis.

## WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Military members are at risk for rabies exposure because of personal and military travel and deployments to rabies endemic areas. In order to avoid a repeat of the rabies fatalities of the past, commanders must enforce General Order #1 which calls for avoidance of contact with local animals, including mascots and pets.

here), the animal is observed for 10 days from the time of exposure for the development of signs consistent with rabies, if possible. For unwanted/stray animals, euthanasia for testing of the brain was an option, though to the best of our knowledge this was not carried out.<sup>6</sup>

In cases where prophylaxis is clearly indicated (such as exposure to bats or bite from a stray dog in a non-rabies-free area), prophylaxis is initiated by the evaluating provider and then reported to MEDDAC-B PM as part of information collected on DD Form 2341. If there is any question about whether prophylaxis is indicated, the evaluating provider can contact MEDDAC-B PM for discussion and consultation. Upon receipt of DD 2341, MEDDAC-B PM reviews the prophylaxis given, if any. If further prophylaxis (including RPEP) is indicated, MEDDAC-B PM immediately contacts the treating provider to discuss this. The exposure and prophylaxis,

as recorded on DD Form 2341, are concurrently reviewed by a local veterinarian. After any additional prophylaxis and veterinary review, the MEDDAC-B PM physician again reviews the case and is the final signatory. Under normal circumstances, potential exposures (and attendant DD Form 2341) are reviewed concurrently with periodic in-person meetings between all involved (Rabies Advisory Board) to review cases. In response to the concerns described above, in 2016 the Rabies Advisory Board increased the frequency of its meetings, and included leadership from the units of the deployed soldiers, staff from the treating clinic, and others as appropriate.

Since mid-2011, MEDDAC-B personnel have recorded details of exposures to assure appropriate and timely follow up and have documented rabies post-exposure prophylaxis when indicated. The number of individuals affected by possible rabies exposures and the number of individuals who received RPEP in 2016 were compared to data from 2011–2015 and 2017. In addition, details from the 2016 exposures were extracted, including age, sex, military status, animal type, location and exposure type. All exposures reported to MEDDAC-B PM or Veterinary Section through the means described above were included in the study. Exposures were included independent of the final determination of risk

for transmission of rabies or the status of the victim (U.S. Military or Civilian, German National, or citizen from other country); however, because most exposure reports were initiated at U.S. military health clinics, these data represent primarily individuals who had access to healthcare in such clinics in southern Germany.

### Investigation

In response to the suspected increase in rabies exposures in 2016, several actions were immediately undertaken. PM and Veterinary assets in Bavaria began closely coordinating follow-up and risk stratification of reported exposures, especially those from Egypt. Veterinary personnel coordinated directly with personnel stationed in Egypt to identify the names, appearance (through photos) and locations of all approved NATO mascot dogs in Egypt. These data were discussed with individual soldiers reporting possible exposure upon return from deployment. Prophylaxis and follow-up efforts, where indicated, were closely coordinated with the local clinic and the unit medical assets (Regimental Surgeon) of the unit to which the soldiers were assigned. All soldiers started on RPEP were followed up for prophylaxis completion, even those who moved back to the U.S. or deployed again.

**TABLE 1.** Numbers of individuals with possible rabies exposures and numbers and percentages who received rabies post-exposure prophylaxis (RPEP) among U.S. healthcare beneficiaries in southern Germany, 2011–2017

Year	No. of individuals exposed	No. of RPEP recipients	Received RPEP (%)	Country					
				Germany	Egypt	Eastern Europe	Afghanistan	Iraq	Other
2011	54	11	20.4	52	0	0	0	0	2
2012	59	11	18.6	55	0	0	4	0	0
2013	61	13	21.3	59	0	1	1	0	0
2014	58	6	10.3	55	0	1	1	0	1
2015	51	11	21.6	46	0	2	1	0	2
2016	108	63	58.3	57	37	12	0	0	2
2017	49	22	44.9	38	1	7	1	0	2
Total	440	137	31.1						

**TABLE 2.** Characteristics of individuals with possible rabies exposures, U.S. healthcare beneficiaries in southern Germany, 2016

	No.	%
Total	108	
Age group		
<18	13	12.0
18–24	40	37.0
25–29	33	30.6
30–35	14	13.0
>35	7	6.5
Unknown	1	0.9
Sex		
Male	83	76.9
Female	25	23.1
Beneficiary status <sup>a</sup>		
Junior enlisted (E1–E4)	35	32.4
Senior enlisted (E5–E7)	37	34.3
Officers (O1–O3)	11	10.2
Family member	19	17.6
Civilian employee	5	4.6
Unknown	1	0.9
Animal type		
Stray/feral	44	40.7
Mascot	4	3.7
Fox/wild animal	15	13.9
Bat	1	0.9
U.S. or German pet	44	40.7
Location		
Germany	57	52.8
Egypt	37	34.3
Eastern Europe	12	11.1
Other	2	1.9
Exposure type		
Bite	62	57.4
Intact skin <sup>b</sup>	6	5.6
Saliva	25	23.1
Scratch	14	13.0
Unknown	1	0.9

<sup>a</sup>There were no exposures among higher ranks (E8–E9 and O4–O6).

<sup>b</sup>Ultimately determined not to be true exposures; included in the analysis because they required full consideration by public health and veterinary personnel.

## RESULTS

Among service members and other persons (e.g., family members, civilian employees) located in southern Germany in 2016, 108 individuals were associated with reports of possible rabies exposure. Numbers of individuals with possible rabies exposures and the numbers and percentages who received RPEP by year (2011–2017) are presented in **Table 1**. In 2016, compared to prior years, there was a notable increase in the numbers of individuals evaluated in southern Germany for possible exposure to rabies (**Table 1**). Moreover, in 2016, compared to the previous 5 years, a larger proportion of exposed individuals were prescribed rabies post-exposure prophylaxis (RPEP). In 2017, the number of exposures reported was much closer to historical numbers in the years 2011–2015.

Characteristics of the individuals with possible rabies exposures in 2016 are presented in **Table 2**. Most exposures occurred in individuals who were active duty service members, male, those aged 18–29 years, and junior (E1–E4) or senior (E5–E7) enlisted service members. Many exposures (47.2%) occurred outside of Germany (Egypt or Eastern Europe). The animals most commonly implicated in the exposures were stray/feral cats or dogs or other wild animals and the most common exposure type was animal bite.

## EDITORIAL COMMENT

Several factors appeared to be related to the 2016 increase in possible rabies exposures. First, a large number of soldiers was assigned to United Nations (UN) peacekeeping operations in Egypt during 2016. Of the years considered, only in 2016 were a large number of troops supported by MEDDAC-B deployed to Egypt. In Egypt, UN camp policies permitted mascot dogs. Many soldiers brought onto their base camps non-approved/informal mascots (cats and dogs). Approved mascots received complete and ongoing preventive veterinary care (including rabies vaccine). Some non-approved/informal mascots were captured in a trap-neuter-release program

(spayed/neutered and provided a single dose of rabies vaccine) while other non-approved mascots received no such care. This situation led to the common misperception that interaction with any animal on the base was permissible and safe (i.e., many soldiers believed that all animals had been fully immunized against rabies). Only through retrospective discussion with veterinary staff in Egypt was it discovered that most animals on base were unprotected from rabies. This misperception among soldiers about the status of an animal (unclear if mascot or stray) was a very significant, and likely preventable, cause of the increased number of exposures seen in 2016.

Second, exposures from foxes or other (unidentified) wild animals occurred in a forested training area in Germany. Although Germany is rabies-free for terrestrial mammals, these exposures were determined to be of sufficient risk to merit prophylaxis, given the close proximity of the training areas to the border of the Czech Republic where rabies is present in bats.<sup>7</sup> These exposures from foxes/wild animals in the training area occurred at an increased level in 2016, compared to other years. Finally, some U.S. soldiers who were in Eastern Europe (i.e., outside Germany) for partnership building and training events were exposed to stray animals with unknown immunization status. Of note, there were no local policy changes, new leadership or meaningful demographic changes in the MEDDAC-B supported population in 2016 that might have resulted in increased rabies reports.

U.S. combat operations in Iraq and Afghanistan have diminished, but peacekeeping and partnership building missions continue. The characteristics of U.S. military deployments have changed, becoming generally shorter, more frequent, and to a much broader range of destinations; accordingly, the potential for rabies exposure is more variable and difficult to predict. As years pass since the last rabies case and as the nature of deployments changes, the U.S. military faces the risk of again underappreciating the threat from this highly lethal virus.<sup>8</sup> The findings presented here suggest a need for accurate risk assessment with clear risk communication<sup>9</sup> and ongoing robust surveillance with strong command engagement in preventing service member contact with possibly rabid animals.<sup>10</sup>

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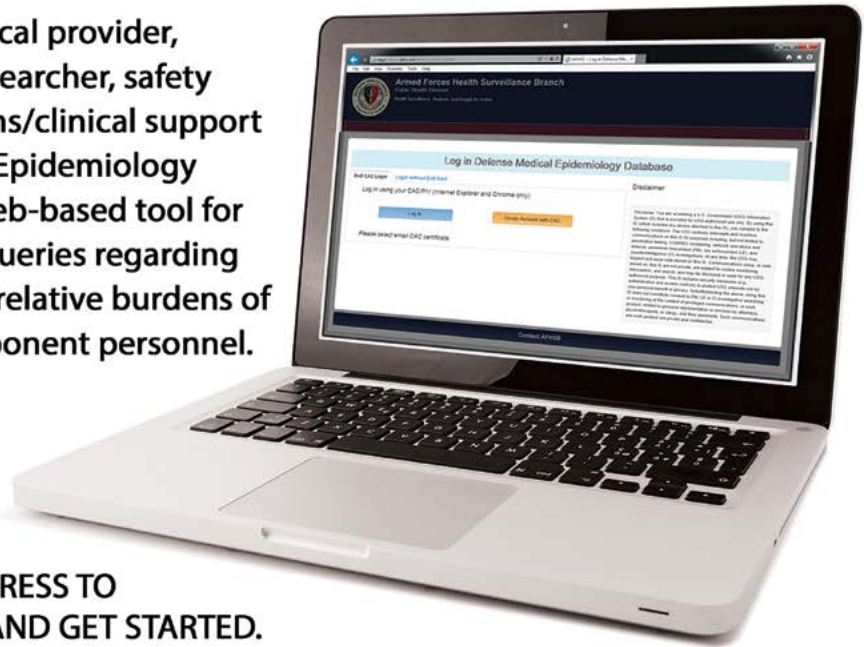
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