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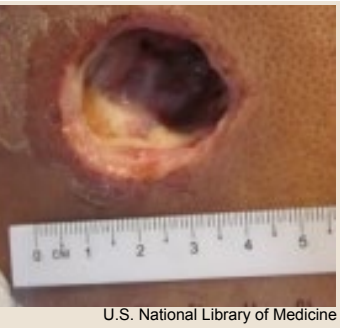

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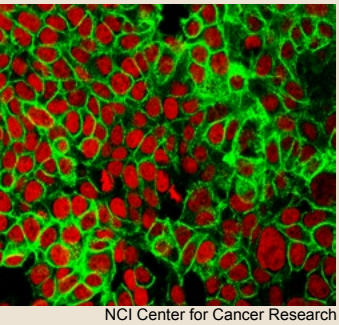

NCI Center for Cancer Research

Skin and Soft Tissue Infections, Active Component, U.S. Armed Forces, 2013–2016

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During the 4-year surveillance period, there were 282,571 incident cases of skin and soft tissue infection (SSTI) among active component U.S. military members diagnosed in inpatient or outpatient settings, corresponding to an overall incidence of 558.2 per 10,000 person-years (p-yrs). An additional 10,904 cases occurred in theater of operations (460.0 per 10,000 p-yrs). Approximately half (49.4%) were classified as "other SSTI" (e.g., folliculitis, impetigo); 45.9% were cellulitis/abscess; 4.6% were carbuncles/furuncles; and 0.1% were erysipelas. Annual incidence rates declined by 46.6% over the surveillance period. In general, higher rates of SSTIs were associated with younger age, recruit trainee status, and junior enlisted rank. During the surveillance period, 238,924 service members were treated for SSTIs in outpatient or inpatient settings, which accounted for 395,361 medical encounters and 19,213 hospital bed days. The history of operational significance of skin infections in the military, the high healthcare costs associated with evaluating and treating skin infections, and the risk of infections by antibiotic-resistant organisms highlight the importance of prevention, early diagnosis, and definitive treatment of skin infections, particularly in high-risk settings such as new recruit/basic training populations.

Skin and soft tissue infections (SSTIs) are common in both military and nonmilitary populations. Among all military personnel, SSTI rates are highest among trainees because of the preponderance of risk factors associated with SSTIs in the military training environment, including crowding, infrequent hand washing/bathing, skin abrasions and trauma, and environmental contamination. These factors favor the acquisition and transmission of *Staphylococcus* spp. and *Streptococcus* spp., the major causative agents of SSTIs, and lead to outbreaks of disease.[1-3]

The clinical manifestations of SSTIs are diverse. Cellulitis and abscess are the most common types of infections, occurring as an area of swelling and redness involving deeper skin tissue (cellulitis) or a collection of pus (abscess). Minor infections, such as impetigo and folliculitis, cause pustules or vesicles on skin surfaces or in hair follicles. Furuncles and carbuncles ("boils") occur when folliculitis progresses deeper into skin tissue and causes one (furuncle) or many (carbuncle) tender, swollen pustules. Among otherwise healthy persons, SSTIs are generally mild and resolve after a short course of antibiotics and/or drainage.

Although SSTIs are rarely associated with severe clinical outcomes among military personnel, they are a major cause of infectious disease morbidity and thus impose a significant operational and healthcare burden on the military. The epidemiology of SSTIs in the U.S. Military Health System (MHS) has been described previously.[4,5] A review of Defense Medical Surveillance System (DMSS) data from 2000–2012 demonstrated an increase in outpatient medical encounters for SSTIs.[4] Landrum et al. reported a decrease in the proportion of community-onset SSTIs due to methicillin-resistant *Staphylococcus aureus* (MRSA).[5]

Herein the frequencies, rates, and trends of incident diagnoses of SSTIs are summarized, overall and by type, among members of the active component of the U.S. Armed Forces during 2013–2016. In particular, installation-specific SSTI rates for each service's recruit/trainee population, the military group at highest risk for infection, are reported.

METHODS

The surveillance period was 1 January 2013 through 31 December 2016. The surveillance population included all members of the U.S. Army, Navy, Air Force, and Marine Corps who served in the active component at any time during the surveillance period. The data used in this analysis were derived from the DMSS, which 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. Diagnoses recorded in theaters of operations were derived from records of medical encounters of deployed service members that were documented in the Theater Medical Data Store (TMDS).

For surveillance purposes, cases of SSTI were identified from records of hospitalizations, ambulatory visits, and in-theater medical encounters that included diagnostic codes (ICD-9 and ICD-10) specific for SSTI **(Table 1)**. Incident cases of SSTI were defined by hospitalization records with case-defining diagnostic codes in the primary or secondary diagnostic position or by ambulatory records with case-defining diagnostic codes in the first diagnostic position. An individual could account for multiple incident cases (i.e., recurrent SSTI) if there were more than 30 days between the dates of consecutive incident case-defining encounters.

TABLE 1. ICD-9/ICD-10 diagnostic codes for skin and soft tissue infections

	Cellulitis/abscess	Carbuncle/furuncle	Erysipelas	Other infections of skin and subcutaneous tissue[a]
All ICD-9	681**–682*	680*	035	684, 686.0, 686.00, 686.09, 686.8, 686.9, 704.8
All ICD-10	L02.01, L02.11, L02.21*, L02.31, L02.41*, L02.51*, L02.61*, L02.81*, L02.91, L03***	L02.02, L02.03, L02.12, L02.13, L02.22*, L02.23*, L02.32, L02.33, L02.42*, L02.43*, L02.52*, L02.53*, L02.62*, L02.63*, L02.82*, L02.83*, L02.92, L02.93	A46	L01**, L08.0, L08.81, L08.82, L08.89, L08.9, L73.8, L73.9
Upper extremity				
Arm	ICD-9: 682.3 ICD-10: L03111–L03114, L03121–L03124, L02411–L02414	ICD-9: 680.3 ICD-10: L02.421–L02.424, L02.431–L02.434	–	–
Hand	ICD-9: 682.4 ICD-10: L02.51*	ICD-9: 680.4 ICD-10: L0252*, L0253*		
Finger	ICD-9: 681.0* ICD-10: L03.01*, L03.02*	–	–	–
Unspecified digit	ICD-9: 681.9	–	–	–
Lower extremity				
Leg	ICD-9: 682.6 ICD-10: L03.115, L03.116, L03.125, L03.126, L02.415, L02.416	ICD-9: 680.6 ICD-10: L02.425, L02.426, L02.435, L02.436	–	–
Foot	ICD-9: 682.7 ICD-10: L02.61*	ICD-9: 680.7 ICD-10: L02.62*, L02.63*		
Toe	ICD-9: 681.1* ICD-10: L03.03*, L03.04*	–	–	–
Head/face/neck				
Neck	ICD-9: 682.1 ICD-10: L03.22*, L02.11	ICD-9: 680.1 ICD-10: L02.12, L02.13	–	–
Face	ICD-9: 682.0 ICD-10: L03.21*, L02.01	ICD-9: 680.0 ICD-10: L02.02, L02.03	–	–
Head/scalp	ICD-9: 682.8 ICD-10: L03.811, L03.891, L02.811	ICD-9: 680.8 ICD-10: L02.821, L02.831	–	–
Trunk				
Buttock	ICD-9: 682.5 ICD-10: L03.317, L03.327, L02.31	ICD-9: 680.5 ICD-10: L02.32, L02.33	–	–
Trunk	ICD-9: 682.2 ICD-10: L02.21*, L03.311–L03.316, L03.319, L03.321–L03.326, L03.329	ICD-9: 680.2 ICD-10: L02.22*, L02.23*	–	–
Other/ unspecified	ICD-9: 682.9 ICD-10: L03.119, L03.129, L03.818, L03.898, L03.9*, L02.419, L02.818, L02.91	ICD-9: 680.9 ICD-10: L02.429, L02.439, L02.828, L02.838, L02.92, L02.93		

[a]Impetigo, pyoderma, pyogenic granuloma skin/subcutaneous, folliculitis, other specified/unspecified skin infections
*Any digit/character, up to and including the last position

SSTIs occurring during deployments were analyzed separately using the same incidence rules. To qualify as an incident case during deployment, an individual needed to have a medical encounter with a case-defining diagnosis of SSTI documented in the TMDS. Further, this medical encounter had to occur during a period of deployment as indicated by the Defense Manpower Data Center Contingency Tracking System in the DMSS.

Because an SSTI can progress in clinical severity, case-defining diagnoses from hospitalization records were prioritized over those from outpatient records in characterizing incident cases. Thus, if a service member had two or more case-defining encounters for SSTI that occurred within 30 days of each other, an inpatient diagnosis was prioritized over an outpatient diagnosis. Also, case-defining diagnoses

TABLE 2. Incident cases and incidence rates of skin and soft tissue infection (SSTI), by encounter type, active component, U.S. Armed Forces, 2013–2016

	2013		2014		2015		2016		Total 2013–2016	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Cellulitis/abscess total										
Inpatient	1,571	12.3	1,388	10.9	1,337	10.6	1,087	8.7	5,383	10.6
Outpatient	34,818	271.5	31,738	248.6	29,922	238.2	27,869	223.4	124,347	245.6
In-theater	1,327	150.6	1,047	168.0	799	175.9	676	164.1	3,849	162.4
Erysipelas total										
Inpatient	12	0.1	6	0.0	7	0.1	3	0.0	28	0.1
Outpatient	55	0.4	82	0.6	66	0.5	62	0.5	265	0.5
In-theater	4	0.5	1	0.2	2	0.4	3	0.7	10	0.4
Carbuncle/furuncle total										
Inpatient	7	0.1	5	0.0	3	0.0	6	0.0	21	0.0
Outpatient	4,133	32.2	3,236	25.3	2,913	23.2	2,761	22.1	13,043	25.8
In-theater	249	28.3	176	28.2	160	35.2	96	23.3	681	28.7
Other SSTI total										
Inpatient	38	0.3	38	0.3	34	0.3	47	0.4	157	0.3
Outpatient	44,907	350.2	44,616	349.5	37,201	296.1	12,603	101.0	139,327	275.2
In-theater	1,981	224.8	1,658	266.0	1,544	339.9	1,181	286.7	6,364	268.5
Total										
Inpatient/outpatient	85,541	667.1	81,109	635.3	71,483	569.0	44,438	356.2	282,571	558.2
In-theater	3,561	404.2	2,882	462.4	2,505	551.5	1,956	474.8	10,904	460.0

[a]Rate per 10,000 person-years

were prioritized by their presumed severity as follows: cellulitis/abscess, erysipelas, carbuncle/furuncle, and "other" (e.g., folliculitis, impetigo, pyoderma, pyogenic granuloma). Medical evacuations for SSTI were estimated by identifying cases that were diagnosed from 5 days prior to 10 days after reported dates of medical evacuations from within to outside of the U.S. Central Command (CENTCOM). Recruit/trainees were defined as such by identifying cases during recruit/training periods specific to each service at service-specific training locations.

RESULTS

During the 4-year surveillance period, there were 282,571 incident cases of SSTI among active component U.S. military members diagnosed in inpatient or outpatient settings, corresponding to an overall incidence of 558.2 cases per 10,000 person-years (p-yrs) **(Table 2)**. Overall crude annual incidence rates ranged from 667.1 to 356.2 cases per 10,000 p-yrs in 2013 and 2016, respectively, representing a 46.6% decline in the incidence of SSTI over the surveillance period. The vast majority of cases (98.0%) were treated in outpatient facilities (rate: 547.1 cases per 10,000 p-yrs) **(Table 3)**. By contrast, the SSTI rate in inpatient facilities was 11.0 cases per 10,000 p-yrs.

Of all incident inpatient or outpatient diagnoses, 49.4% were classified as "other SSTI" (e.g., folliculitis, impetigo, pyoderma); 45.9% were cellulitis/abscess; 4.6% were carbuncles/furuncles; and 0.1% were erysipelas **(Table 3)**. Among hospitalized cases, cellulitis/abscess was the most frequent diagnosis (n=5,383; 10.6 cases per 10,000 p-yrs).

For cellulitis/abscess and carbuncle/furuncles, overall incidence rates were higher among females than males **(Table 3)**. Rates of "other SSTI" were higher among males than females. Compared to their respective counterparts, non-Hispanic white service members had higher rates of cellulitis/abscess and non-Hispanic black service members had higher rates of carbuncles/furuncles and "other SSTI."

Overall rates of cellulitis/abscess, carbuncles/furuncles, and "other SSTI" were highest among service members in the youngest (less than 20 years) age group **(Table 3)**. Compared to members of the other services, rates of cellulitis/abscess were highest among Marine Corps and Army members. Rates of carbuncles/furuncles were highest among Army members, and rates of "other SSTI" were highest among Air Force and Navy members **(Table 3)**.

For cellulitis/abscess, carbuncles/furuncles, and "other SSTI," overall incidence rates were higher among recruits and other junior enlisted members than more senior enlisted members and officers **(Table 3)**. The rate of

TABLE 3. Incident cases and incidence rates of skin and soft tissue infection (SSTI), by type and demographic/military characteristics, active component, U.S. Armed Forces, 2013–2016

	Cellulitis/abscess		Carbuncle/furuncle		Erysipelas		Other SSTI		Total	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	129,730	256	13,064	26	293	1	139,484	276	282,571	558
Inpatient	5,383	10.6	21	0.0	28	0.1	157	0.3	5,589	11.0
Outpatient	124,347	245.6	13,043	25.8	265	0.5	139,327	275.2	276,982	547.1
Sex										
Male	107,860	251.8	10,312	24.1	247	0.6	129,472	302.3	247,891	578.8
Female	21,870	280.5	2,752	35.3	46	0.6	10,012	128.4	34,680	444.9
Race/ethnicity										
Non-Hispanic white	81,598	273.4	7,206	24.1	185	0.6	39,971	133.9	128,960	432.1
Non-Hispanic black	20,164	245.9	3,068	37.4	35	0.4	74,707	911.2	97,974	1,195.0
Hispanic	15,968	228.7	1,555	22.3	34	0.5	14,333	205.3	31,890	456.7
Asian/Pacific Islander	3,922	202.3	438	22.6	15	0.8	1,957	101.0	6,332	326.6
Other/unknown	8,078	220.7	797	21.8	24	0.7	8,516	232.7	17,415	475.9
Age										
<20	14,400	421.9	1,226	35.9	25	0.7	15,935	466.8	31,586	925.4
20–29	72,494	260.6	7,161	25.7	137	0.5	87,147	313.3	166,939	600.1
30–39	31,093	222.6	3,476	24.9	88	0.6	27,584	197.4	62,241	445.5
40–49	10,540	215.6	1,086	22.2	38	0.8	8,136	166.4	19,800	405.0
50+	1,203	224.6	115	21.5	5	0.9	682	127.3	2,005	374.3
Service										
Army	54,211	286.5	6,213	32.8	111	0.6	51,378	271.5	111,913	591.5
Navy	25,774	211.3	2,638	21.6	51	0.4	35,627	292.0	64,090	525.3
Air Force	28,341	231.8	2,900	23.7	89	0.7	37,999	310.8	69,329	567.0
Marine Corps	21,404	294.1	1,313	18.0	42	0.6	14,480	199.0	37,239	511.7
Status										
Recruit	8,288	777.6	482	45.2	11	1.0	13,061	1,225.4	21,842	2,049.3
Nonrecruit	121,442	245.0	12,582	25.4	282	0.6	126,423	255.1	260,729	526.1
Rank										
Junior enlisted	87,201	285.6	8,718	28.5	157	0.5	107,638	352.5	203,714	667.1
Senior enlisted	25,273	226.6	2,670	23.9	73	0.7	20,419	183.1	48,435	434.2
Junior officer	11,124	201.8	1,057	19.2	32	0.6	7,208	130.8	19,421	352.3
Senior officer	6,132	179.1	619	18.1	31	0.9	4,219	123.2	11,001	321.3
Occupation										
Combat-specific[b]	18,517	272.6	1,421	20.9	30	0.4	10,618	156.3	30,586	450.3
Armor/motor transport	4,761	267.3	537	30.1	13	0.7	6,107	342.8	11,418	641.0
Pilot/air crew	3,310	173.1	280	14.6	19	1.0	2,004	104.8	5,613	293.5
Repair/engineering	34,925	234.7	3,554	23.9	73	0.5	37,487	251.9	76,039	510.9
Communications/intelligence	27,011	243.5	3,130	28.2	71	0.6	31,869	287.3	62,081	559.7
Health care	11,833	254.6	1,466	31.5	26	0.6	15,505	333.6	28,830	620.4
Other	29,373	308.6	2,676	28.1	61	0.6	35,894	377.2	68,004	714.6

[a]Rate per 10,000 person-years

[b]Infantry, artillery, combat engineering

cellulitis/abscess was highest among service members in the "other" occupational group compared to the rates among all other occupational groups. Rates of carbuncles/furuncles were highest among those in healthcare and armor/motor transport occupations, respectively. Rates of "other SSTI" were highest among those in "other" and armor/motor transport occupations, respectively **(Table 3)**.

Overall and by year, cellulitis/abscess was the most frequent diagnosis for SSTI-associated hospitalizations. Annual rates of cellulitis/abscess–associated hospitalizations decreased from 12.3 cases per 10,000 p-yrs in 2013 to 8.7 per 10,000 p-yrs in 2016 **(Table 2, Figure 1)**. Hospitalization rates for all other skin infection types remained relatively low and stable throughout the 4-year period.

Overall and by year from 2013 to 2015, "other SSTI" was the most frequent classification among infections treated in outpatient settings; however, during 2016, cellulitis/abscess was the most frequent classification **(Table 2, Figure 2)**. Annual incidence rates of outpatient diagnoses of "other SSTI," carbuncles/furuncles, and cellulitis/abscess decreased during the 4-year period (% change in annual rates, 2013–2016: -71.2%, -31.3%, and -17.7%, respectively). Annual rates of outpatient-treated erysipelas were low and did not change during the surveillance period **(Table 2, Figure 2)**.

Body site

Of the cases of cellulitis/abscess and carbuncle/furuncle for which an affected body site was identified (per ICD-9 or ICD-10) (n=142,214; 50.3% of total inpatient and outpatient diagnoses), the upper extremity was most frequently affected (25.2% of all cases); infections of the upper extremity were more commonly on the arm (50.6%) and finger (40.1%). Lower extremities were affected in 23.7% of all cases with reported sites of infection; infections of lower extremities were most frequently reported on the leg (53.0%) or toe (33.8%). Of the 142,214 total cases, other sites affected by SSTI included the trunk (including buttock) (13.9%); face (8.2%); head/scalp (2.8%); and neck (2.4%) **(data not shown)**.

Time in service

Among individuals who entered military service during the surveillance period, peaks of SSTI-associated medical encounters occurred during the first 3 months of military service; typically, this is the period of initial military training, and military trainees are known to be at increased risk of SSTI. In all service branches except for the Marine Corps, "other SSTI" was the most frequently diagnosed type during the first 3 months of service **(Figures 3a–3c)**. In the Marine Corps, cellulitis/abscess was the most frequently diagnosed type of skin infection during this early period of service **(Figure 3d)**.

FIGURE 1. Annual rates of incident inpatient cases of skin infections, by type, active component, U.S. Armed Forces, 2013–2016

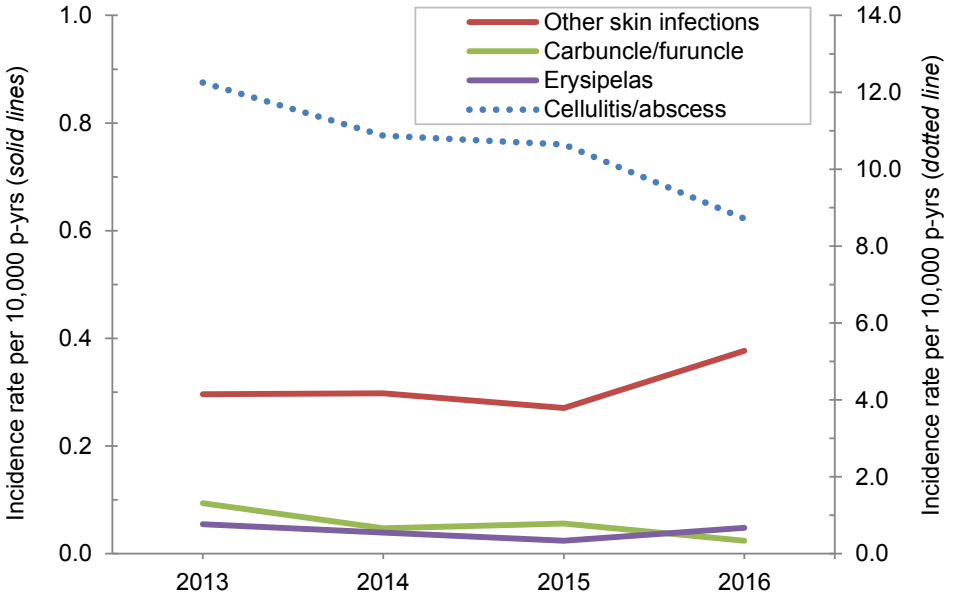
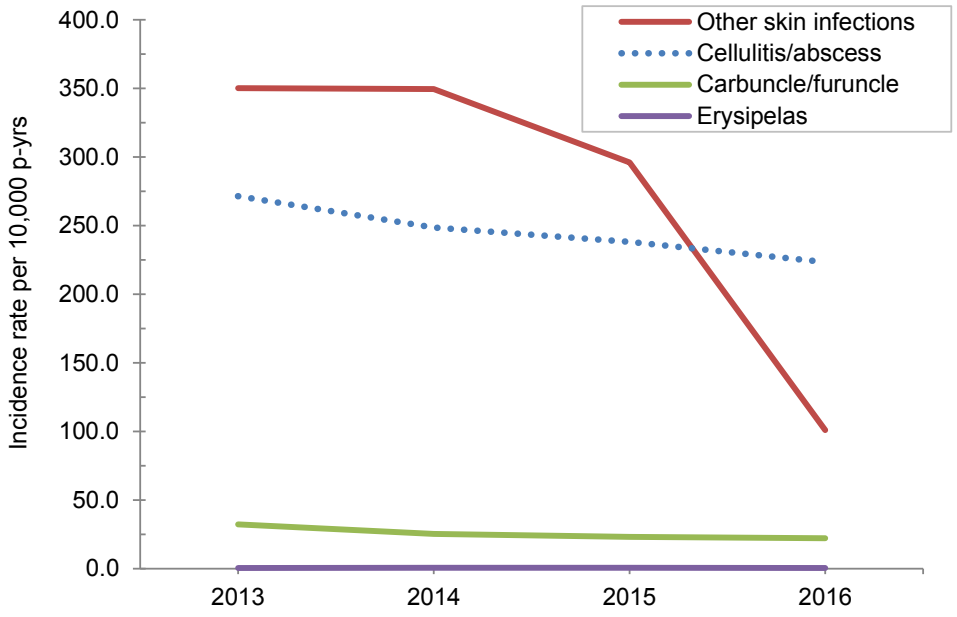


FIGURE 2. Annual rates of incident outpatient cases of skin infections, by type, active component, U.S. Armed Forces, 2013–2016



Burden of disease

During the 4-year surveillance period, 238,924 service members were treated for SSTI in inpatient or outpatient settings; the infections accounted for 395,361 medical encounters and 19,213 hospital bed days **(Table 4)**. Annual numbers of medical encounters and individuals affected decreased 46.2% and 41.9%, respectively, from 2013 to 2016 **(Table 4, Figure 4)**. Annual numbers of hospital bed days decreased 44.8% during the surveillance period **(Table 4, Figure 4)**. Cellulitis/abscess accounted for slightly more than half (53.1%) of all

FIGURE 3a. Number of incident skin infections, by type and time in service (months 0–24), active component, U.S. Army, 2013–2016

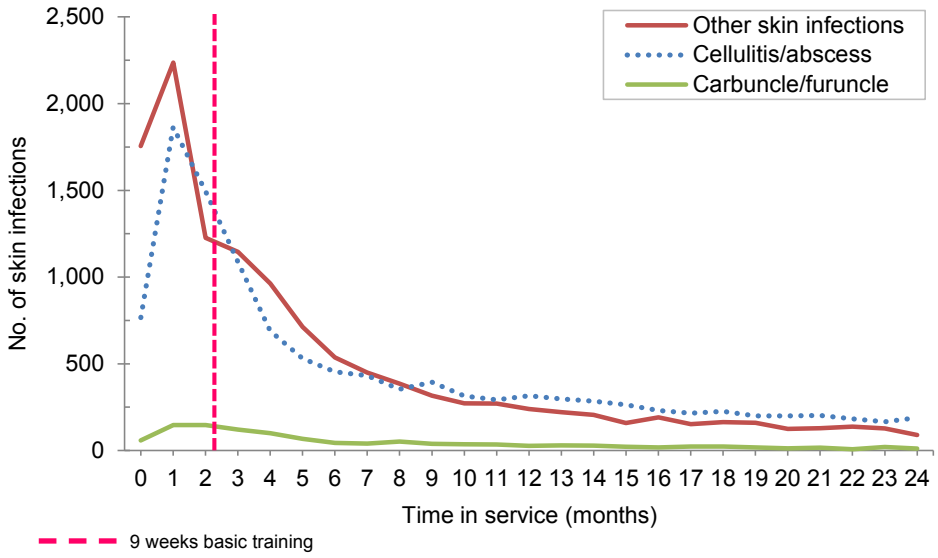
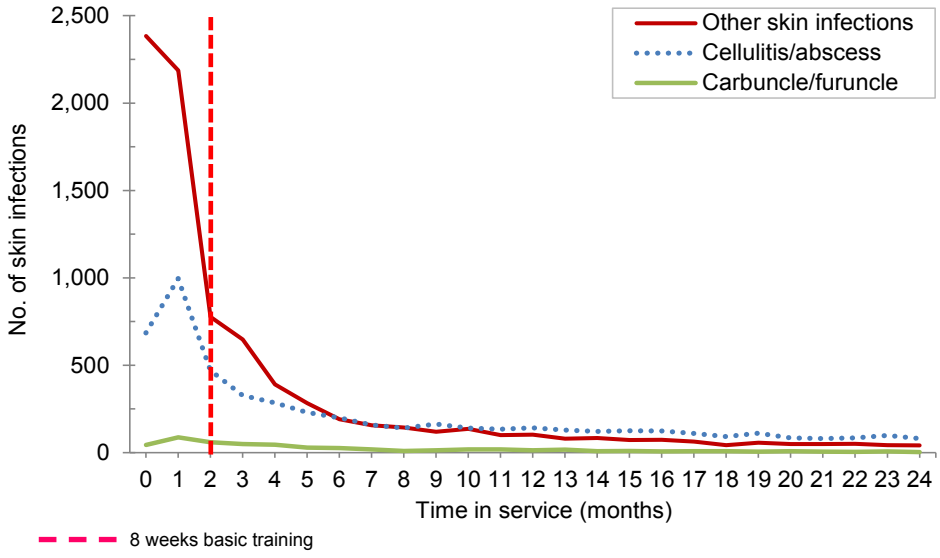


FIGURE 3b. Number of incident skin infections, by type and time in service (months 0–24), active component, U.S. Navy, 2013–2016



SSTI-associated medical encounters and individuals affected (51.1%), and 96.9% of hospital bed days **(Table 4)**.

SSTI during deployment

During 2013–2016, there were 10,904 incident cases of SSTI in theaters of operation, corresponding to an overall incidence of 460.0 cases per 10,000 p-yrs. "Other SSTI" (58.4%) and cellulitis/abscess (35.3%) were the most frequent classifications. Frequencies of carbuncles/furuncles (6.2%) and erysipelas (0.1%) were low. Overall rates of SSTI increased from 404.2 cases per 10,000 p-yrs in 2013 to 551.5 per 10,000 p-yrs in 2015, and then decreased to 474.8 per 10,000 p-yrs in 2016 **(Table 2)**. Lastly, there were 17 SSTI-associated medical evacuations from wartime theaters. All were classified as cellulitis/abscess **(data not shown)**.

Rates of cellulitis/abscess by installation, service, and recruit status

Among Army training centers, cellulitis/abscess rates in the recruit population were as follows: Fort Benning (763.4 per 10,000 p-yrs), Fort Jackson (686.1 per 10,000 p-yrs), Fort Sill (661.7 per 10,000 p-yrs), and Fort Leonard Wood (619.3 per 10,000 p-yrs) **(Figure 5a)**. Among nonrecruits, limited to Army installations where more than 500 cases were diagnosed, rates were highest at Fort Benning (560.5 per 10,000 p-yrs), followed by Fort Eustis (410.3 per 10,000 p-yrs) and Fort Jackson (400.8 per 10,000 p-yrs).

The cellulitis/abscess rate in the Navy recruit population at Naval Station (NS) Great Lakes was 760.2 cases per 10,000 p-yrs **(Figure 5b)**. Among nonrecruits at Navy installations where more than 500 cases were diagnosed, rates were highest at Naval Air Station (NAS) Pensacola (315.1 per 10,000 p-yrs), NS Great Lakes (302.0 per 10,000 p-yrs), and NAS Jacksonville (296.4 per 10,000 p-yrs).

Among Marine Corps training centers, cellulitis/abscess rates in the recruit population were as follows: Marine Corps Recruit Depot (MCRD) Parris Island (1,421.3 per 10,000 p-yrs) **(Figure 5c)** and MCRD San Diego (1,162.0 per 10,000 p-yrs). Among nonrecruits at Marine Corps installations where more than 300 cases were diagnosed, the rate was highest at MCRD Parris Island (677.5 per 10,000 p-yrs), followed by MCRD San Diego (535.9 per 10,000 p-yrs).

The cellulitis/abscess rate in the Air Force recruit population at Lackland Air Force Base (AFB) was 429.7 cases per 10,000 p-yrs **(Figure 5d)**. Among nonrecruits at Air Force installations where more than 500 cases were diagnosed, rates were highest at Barksdale AFB (314.2 per 10,000 p-yrs), Lackland AFB (311.0 per 10,000 p-yrs), and Keesler AFB (299.4 per 10,000 p-yrs).

FIGURE 3c. Number of incident skin infections, by type and time in service (months 0–24), active component, U.S. Air Force, 2013–2016

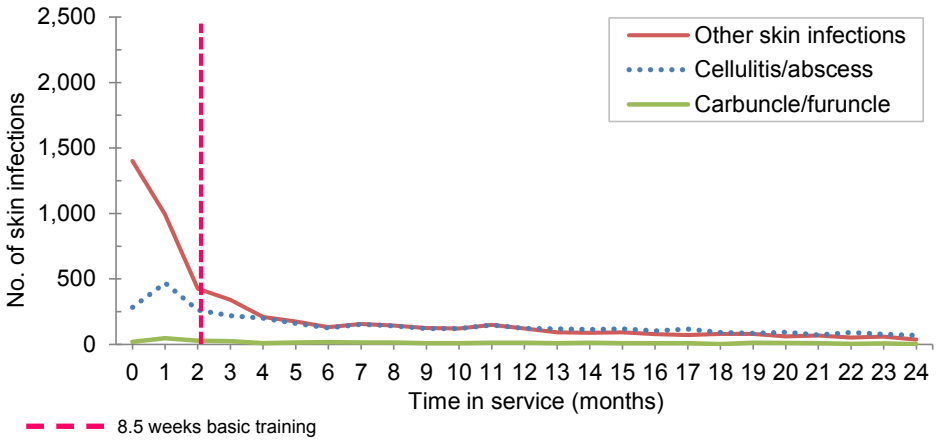


FIGURE 3d. Number of incident skin infections, by type and time in service (months 0–24), active component, U.S. Marine Corps, 2013–2016

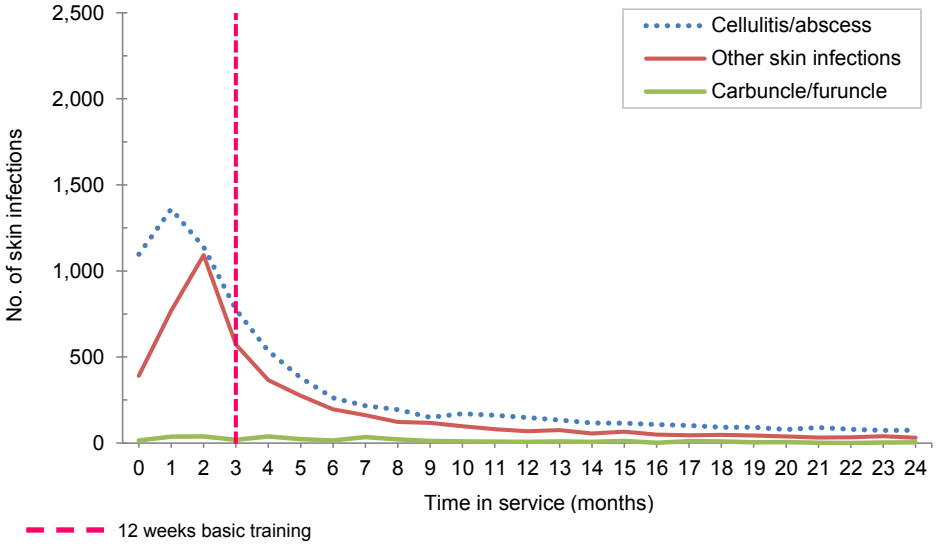
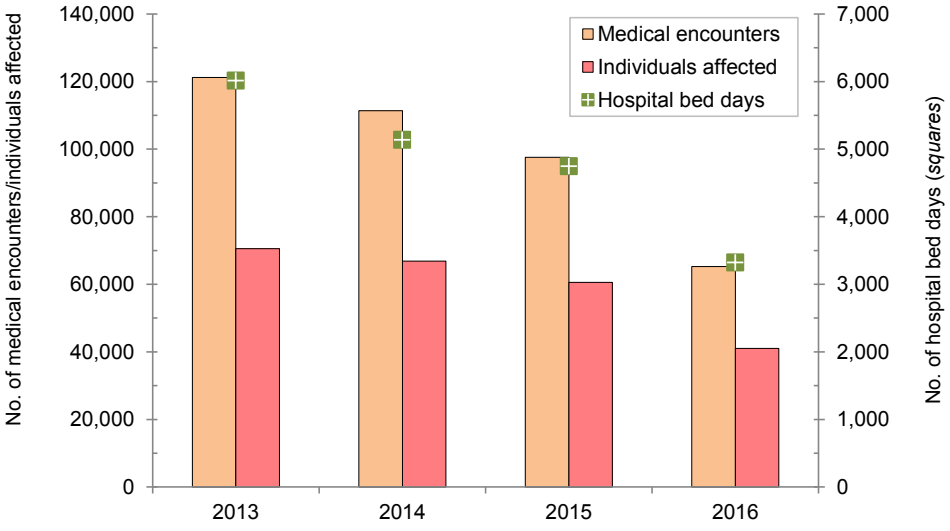


FIGURE 4. Numbers of medical encounters, individuals affected, and hospital bed days for skin infections, active component, U.S. Armed Forces, 2013–2016



EDITORIAL COMMENT

This review of U.S. Armed Forces disease surveillance data during 2013–2016 demonstrates that the burden of SSTI in military populations remains high. The overall rate of SSTI (558.2 cases per 10,000 p-yrs) is 21% higher than that of a similarly aged, nonmilitary population in Northern California (462 cases per 10,000 p-yrs).[6] Rate differences are likely due to military members' frequent engagement in physical activities with limited access to good hygiene. Such activities include field training exercises that increase the frequency of minor traumatic injuries (e.g., abrasions, cuts, scrapes) and thus members' susceptibility to SSTI.

This report provides additional evidence that, among all military personnel, new recruits/trainees are disproportionately affected by these infections.[1-3] Across the services, SSTI rates in the recruit population were 1.4–2.5 times higher than those among nonrecruit populations at the same installations. Conditions of the military training setting (i.e., crowding, infrequent hand washing/bathing, and environmental contamination) favor the transmission of bacterial pathogens and thereby increase infection risk in this particular population.[7] Recruit trainees may therefore be a targeted group for which medical countermeasures may be most cost effective.

For all recruit populations, SSTI rates were highest among Marines. The reasons for these service-specific differences in risk of SSTI have not been explored to date and are likely multifactorial. SSTI outbreaks have been reported in various training settings in California, Texas, and Georgia.[1,2,7] Further evaluation of personal/environmental hygiene practices, specific training activities associated with peak incidence of SSTI, and degree of environmental contamination with SSTI-associated pathogens is warranted.

The long history of the military operational significance of SSTIs, the high healthcare costs associated with evaluating and treating them, and the U.S. military's recent experience with skin infections in general and antibiotic-resistant infections in particular highlight the importance of

TABLE 4. Burden of skin and soft tissue infection (SSTI), active component, U.S. Armed Forces, 2013–2016

		2013	2014	2015	2016	Total 2013–2016
		No.	No.	No.	No.	No.
Cellulitis/abscess	Medical encounters[a]	61,329	53,596	49,413	45,663	210,001
	Individuals affected[b]	33,993	31,251	29,357	27,451	122,052
	Hospital bed days	5,810	4,975	4,638	3,204	18,627
Erysipelas	Medical encounters[a]	107	153	116	98	474
	Individuals affected[b]	81	108	87	75	351
	Hospital bed days	42	44	21	11	118
Carbuncle/furuncle	Medical encounters[a]	7,020	5,304	4,638	4,508	21,470
	Individuals affected[b]	4,818	3,853	3,510	3,356	15,537
	Hospital bed days	27	14	12	17	70
Other SSTI	Medical encounters[a]	52,725	52,342	43,394	14,955	163,416
	Individuals affected[b]	35,429	34,960	30,572	12,388	113,349
	Hospital bed days	135	101	74	88	398
Total	Medical encounters[a]	121,181	111,395	97,561	65,224	395,361
	Individuals affected[b]	70,547	66,829	60,536	41,012	238,924
	Hospital bed days	6,014	5,134	4,745	3,320	19,213

[a]"Medical encounters" are defined as the total number of inpatient and outpatient visits for an SSTI in the first diagnostic position (with no more than one encounter per individual per day).
[b]"Individuals affected" is defined as individuals with at least one inpatient or outpatient visit.

FIGURE 5a. Numbers of incident diagnoses and rates of cellulitis/abscess at U.S. Army installations with more than 500 cases, 2013–2016

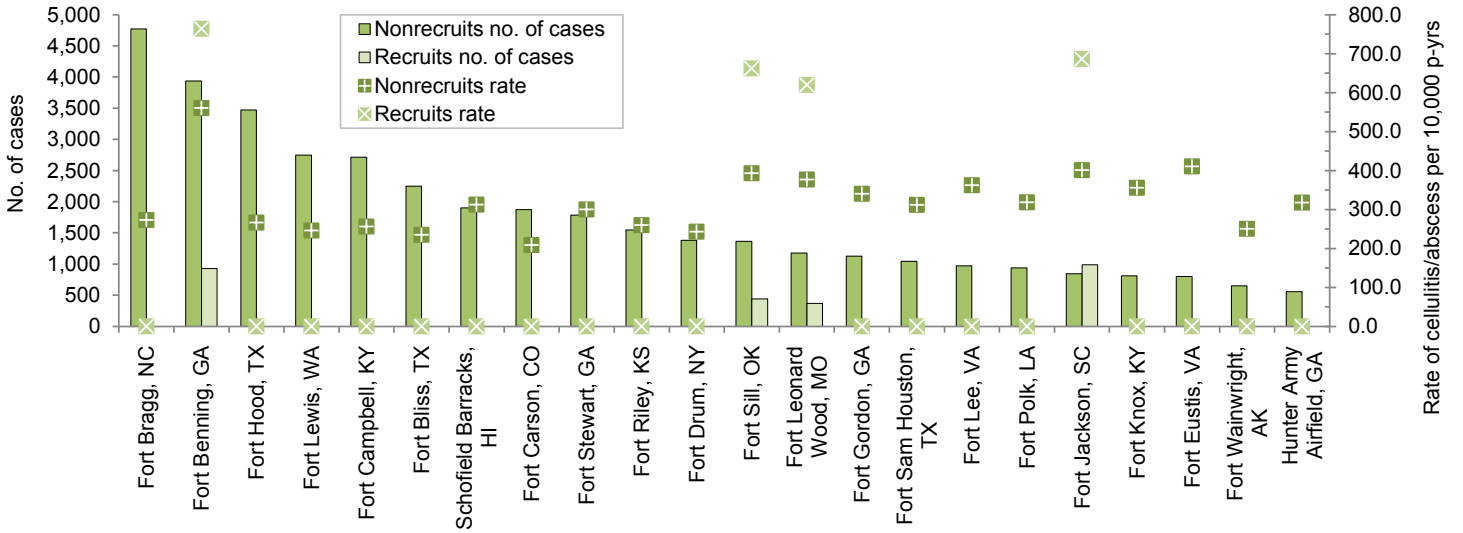
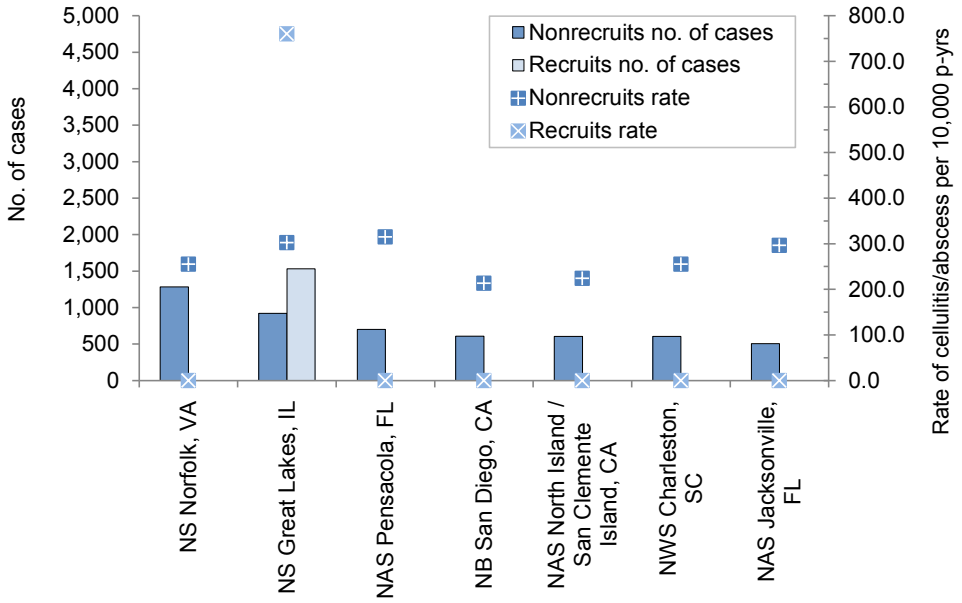


FIGURE 5b. Numbers of incident diagnoses and rates of cellulitis/abscess at U.S. Navy installations with more than 500 cases, 2013–2016



NS, Naval Station; NAS, Naval Air Station; NB, Naval Base; NWS, Naval Weapons Station

prevention, early diagnosis, and definitive treatment of skin infections—particularly in high-risk settings such as recruit/basic training and special operations training. The design and execution of research, education, and training programs focused on the prevention, early diagnosis, and definitive treatment of bacterial skin infections should be high priorities. Specific recommendations to prevent, evaluate, diagnose, and treat MRSA infections in U.S. military populations are summarized at: https://phc.amedd.army.mil/topics/discond/diseases/Pages/MRSA-InformationSources.aspx.

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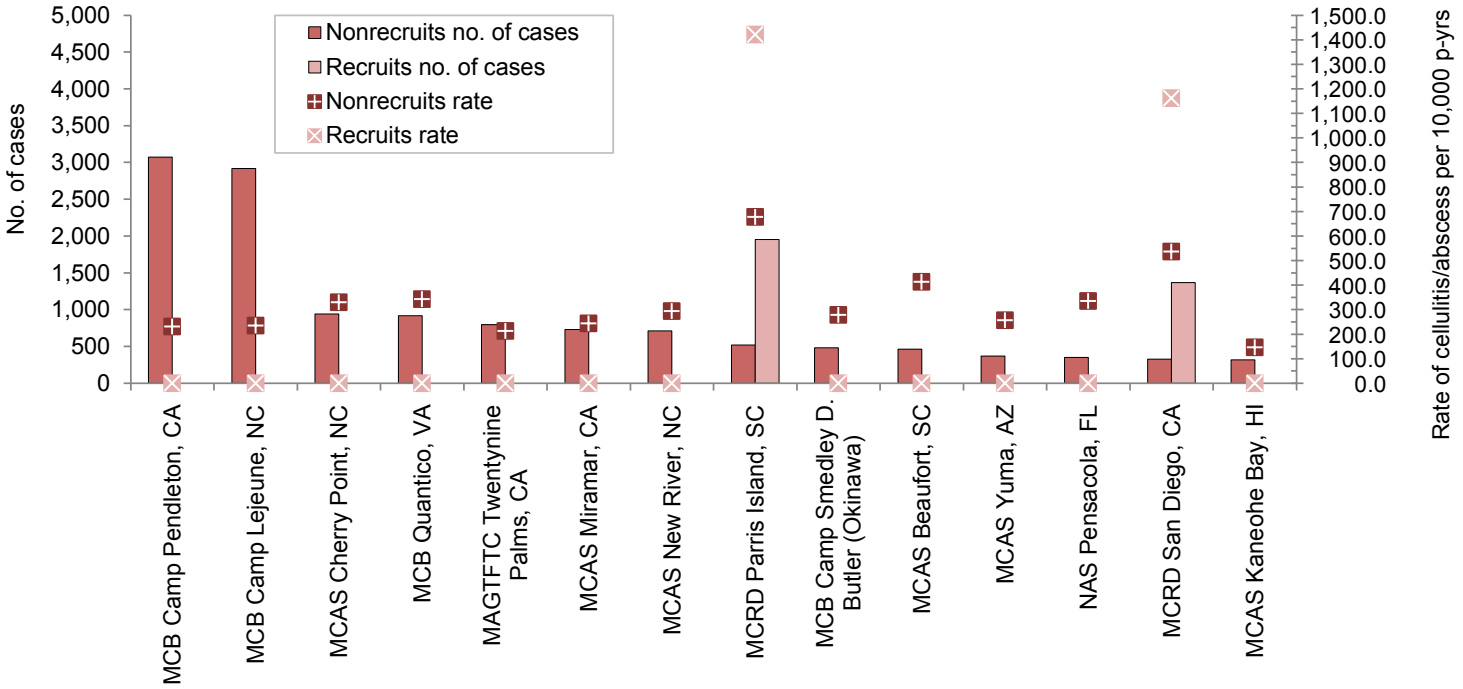
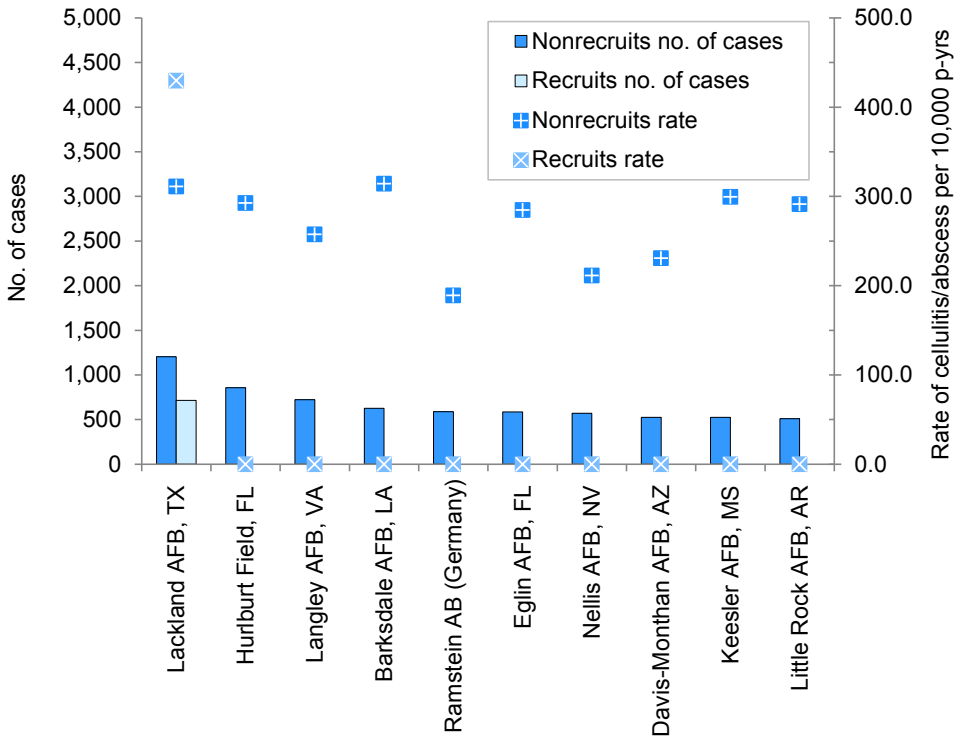
FIGURE 5c. Numbers of incident diagnoses and rates of cellulitis/abscess at U.S. Marine Corps installations with more than 300 cases, 2013–2016



MCB, Marine Corps Base; MCAS, Marine Corps Air Station; MAGTFTC, Marine Corps Air Ground Combat Center; MCRD, Marine Corps Recruit Depot

FIGURE 5d. Numbers of incident diagnoses and rates of cellulitis/abscess at U.S. Air Force installations with more than 500 cases, 2013–2016



AFB, Air Force Base; AB, Air Base

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Age-Period-Cohort Analysis of Colorectal Cancer, Service Members Aged 20–59 Years, Active Component, U.S. Armed Forces, 1997–2016

Shauna Stahlman, PhD, MPH; Alexis Oetting, MPH

In the U.S. general population, incidence of colorectal cancer appears to be increasing in younger age groups since the mid-1980s. The objective of this report was to better understand the time-varying elements (age, period, and birth cohort effects) in the epidemiology of colorectal cancer among the active component of the U.S. Armed Forces. During 1997–2016, there were 1,108 incident cases of colorectal cancer among service members aged 20–59 years, corresponding to an overall incidence rate of 4.3 per 100,000 person-years (p-yrs). Rates were particularly high among men (4.4 per 100,000 p-yrs) and non-Hispanic black service members (5.3 per 100,000 p-yrs). Overall crude incidence of colorectal cancer increased in an exponential fashion with increasing age groups until the oldest age group (55–59 years), in which the increase was attenuated. No birth cohort or period effects were identified in the age-period-cohort analysis. This finding could be due to limited power, selection bias, better screening practices in the Military Health System (MHS) compared with the general population, or true lack of effects. Continued population-based screening for colorectal cancer in the MHS is recommended to maintain low and decreasing incidence in the U.S. Armed Forces.

Among cancers affecting both men and women, colorectal cancer is the third most common cancer and the second leading cause of death from cancer in the U.S.[1] Risk factors for colorectal cancer include having a family history of adenomatous polyps, being older than 50 years of age, being overweight or obese, being physically inactive, having a low-fiber and high-fat diet, heavy alcohol use, and smoking.[2] Early and regular screening is important because colorectal cancer survival is significantly improved when diagnosed while the cancer is still localized.[1] As a result, the U.S. Preventive Services Task Force (USPSTF) recommends periodic screening for colorectal cancer beginning at age 50 years and continuing until age 75 years.[3] The joint task force of the American Cancer Society, the U.S. Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology has also released tailored guidelines to encourage screening for various risk groups.[1]

Rates of colorectal cancer among U.S. military service members tend to be lower than age-adjusted rates in the general U.S. population.[4] During 2005–2014, the rate of colorectal cancer among active component U.S. service members was 4.5 cases per 100,000 person-years, with higher rates among men and African Americans.[5] Although rates appear to be decreasing, colorectal cancer has been identified as a leading cause of cancer-related deaths among active component service members.[5]

A recent study of colorectal cancer incidence patterns in the U.S. indicated that the incidence of colorectal cancer has been increasing in younger age groups since the mid-1980s.[6] In particular, compared with adults born around 1950, those born in 1990 had twice the rate of colon cancer (incidence rate ratio [IRR]=2.40, 95% confidence interval [CI]=1.11, 5.19) and four times the rate of rectal cancer (IRR=4.32, 95% CI=2.19, 8.51). The authors proposed that these birth cohort effects could be due to recent changes in lifestyle factors associated with increased risk of colorectal cancer, such as a low-fiber and high-fat diet, low physical activity, and obesity. In recent years, the increasing prevalence of obesity in the U.S. has been accompanied by an increase in the proportion of U.S. service members who are overweight and obese.[7] However, it remains to be seen whether an increase in colorectal cancer is occurring among U.S. military service members, who have greater levels of physical activity and generally unlimited access to free healthcare services, including cancer screening.

The objective of this report is to better understand the time-varying elements (age, period, and birth cohort effects) in the epidemiology of colorectal cancer among service members in the active component of the U.S. Armed Forces. In age-period-cohort (APC) studies, age effects pertain to individual-level physiologic and social changes of aging, whereas period and cohort variations are the result of population-level social, environmental, and cultural changes.[8]

METHODS

The surveillance period was 1 January 1997 through 31 December 2016. These years were selected to utilize the most recent available data and to maintain equivalent time period and age intervals, which are required for age-period-cohort (APC) modeling. 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. The surveillance population was further restricted to service members aged 20–59 years to allow for the creation of equally spaced 5-year age groups and surveillance periods in the APC analysis. In addition, the 5-year age groupings allowed for at least two age groups with individuals older than the recommended age for initial screening for colorectal cancer. All data used to determine incident colorectal cancer cases were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). DMSS includes administrative records of all medical encounters of service members who received care in fixed (i.e., not deployed or at sea) medical facilities of the MHS or civilian facilities in the purchased care system.

ICD-9 and ICD-10 codes were used to define incident cases of colon and rectum cancer **(Table 1)**. Cases of appendiceal malignancies were excluded, as these are rare and can be considered biologically and histologically distinct from colorectal cancer.[9] For surveillance purposes, an incident case of colorectal cancer was defined as one inpatient encounter with a defining diagnosis in the first diagnostic position (or in the second diagnostic position if the first code was a V-code indicating radiotherapy or chemotherapy treatment [ICD-9: V58.0–V58.12; ICD-10: Z51.0, Z51.1, Z51.11, Z51.12]), or three or more outpatient encounters within a 90-day period with a case-defining diagnosis in the first or second diagnostic position.

For surveillance purposes, incident dates of cancer diagnoses were the dates of the first medical encounters of affected individuals that included case-defining diagnoses. Individuals could be counted as incident cancer cases only once during the surveillance period. Military members with case-defining cancer diagnoses prior to the start of the surveillance period were excluded from the analysis because they were not considered at risk of incident (first-ever) cancer diagnoses during the period. Outpatient visits that occurred through 31 March 2017 were included to fully capture incident cases through the end of the surveillance period (31 December 2016).

TABLE 1. ICD-9 /ICD-10 diagnostic codes used for colorectal cancer case classification

Description	ICD-9	ICD-10
Malignant neoplasm of colon (excluding malignant neoplasm of appendix)	153, 153.0–153.4, 153.6–153.9	C18.0, C18.2–C18.9
Malignant neoplasm of intestinal tract, part unspecified	159.0	C26.0
Malignant neoplasm of rectosigmoid junction	154.0	C19
Malignant neoplasm of rectum	154.1	C20

Crude (i.e., unadjusted) incidence rates of colorectal cancer were calculated for age group, surveillance period, and birth cohort groups, as well as for subgroups of demographic and military characteristics over time. APC models were fitted using NCI's Age Period Cohort Analysis Web Tool to estimate age, period, and cohort effects.[10] Data input into the web tool were case and population person-time for eight 5-year age groups (20–24, 25–29, 30–34, 35–39, 40–44, 45–49, 50–54, 55–59) and four 5-year time periods (1997–2001, 2002–2006, 2007–2011, 2012–2016), which spanned 11 partially overlapping 9-year birth cohorts from 1938 to 1996. The default (central) reference groups for age, period, and cohort groups were used.[10]

Net drift was calculated from the APC models, which estimates the annual percentage change of the model-fitted rates over time.[10]Local drift was also calculated, which estimates the age-specific net annual percent change in incidence rates. Wald chi-square tests were calculated to evaluate whether net drift statistically significantly differed from 0 and whether local drifts differed from the net drift. Graphically, age effects were presented using a longitudinal age curve, which describes the model fitted age-specific rates in the reference birth cohort adjusted for period effects. Period effects were presented graphically using period rate ratios, which are the relative rates of cancer in each period relative to the reference period, adjusted for age and nonlinear cohort effects. Fitted temporal trends were also presented, showing the expected colorectal cancer incidence rates over time in the reference age group, adjusted for cohort effects. Cohort effects were presented graphically using cohort rate ratios, which are the relative rates of cancer in each birth cohort relative to the reference cohort, adjusted for age and nonlinear period effects.

RESULTS

Crude analysis

There were 1,108 incident cases of colorectal cancer among active component service members during the surveillance period, corresponding to an overall incidence rate of 4.3 cases per 100,000 person-years (p-yrs) **(Table 2)**. Crude rates were highest among Air Force members (4.9 per 100,000 p-yrs) and lowest among service members in the Marine Corps (2.2 per 100,000 p-yrs). Crude rates were higher among men compared to women (4.4 vs. 4.1 per 100,000 p-yrs), and among officers compared to enlisted personnel (7.9 vs. 3.6 per 100,000 p-yrs). In addition, crude rates were highest among non-Hispanic black service members (5.3 per 100,000 p-yrs), compared to other race/ethnicity groups. Overall crude incidence rates of colorectal cancer increased in an exponential fashion with increasing age groups until the oldest age group (55–59 years), in which the increase was attenuated.

The median age at incident diagnosis was 39 years, and did not vary substantially by race/ethnicity (median age=39 years for non-Hispanic white and "Other/unknown," 40 years for non-Hispanic black) or sex (40 years for men and 39 years for women) **(data not shown)**.

TABLE 2. Incident cases and incidence rates[a] of colon and rectal cancer, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016

	Total		
	No.	Rate*	IRR
Total	1,108	4.3	.
Service			
Army	423	4.5	Ref
Navy	299	4.6	1.0
Air Force	316	4.9	1.1
Marine Corps	70	2.2	0.5
Sex			
Male	958	4.4	Ref
Female	150	4.1	0.9
Race/ethnicity			
Non-Hispanic white	704	4.5	Ref
Non-Hispanic black	240	5.3	1.2
Other/unknown	164	3.1	0.7
Age group			
20–24	52	0.6	Ref
25–29	103	1.7	2.9
30–34	166	4.0	6.8
35–39	238	6.9	11.8
40–44	255	13.4	23.0
45–49	171	24.6	42.0
50–54	100	52.7	90.2
55–59	23	59.4	101.6
Period			
1997–2001	276	4.4	Ref
2002–2006	286	4.5	1.0
2007–2011	297	4.6	1.0
2012–2016	249	4.0	0.9
Birth cohort			
1990–1999	7	0.3	Ref
1980–1989	128	1.5	4.2
1970–1979	296	3.3	9.6
1960–1969	427	9.3	26.8
1950–1959	213	20.4	59.0
1940–1949	36	49.2	142.1
1930–1939	1	199.2	575.1
Military grade			
Enlisted	750	3.6	Ref
Officer	358	7.9	2.2
Military occupation			
Combat-specifc[b]	125	3.6	Ref
Armor/motor transport	27	3.5	1.0
Health care	116	5.2	1.4
Pilot/air crew	64	6.3	1.7
Other	776	4.3	1.2

IRR, incidence rate ratio

[a]Rate per 100,000 person-years

[b]Infantry, artillery, combat engineering

Overall crude incidence rates peaked in 2006 at 5.4 cases per 100,000 p-yrs and then gradually decreased throughout the remainder of the surveillance period **(Figure 1)**. During the surveillance period, the crude rate of colorectal cancer appeared to decrease primarily for service members aged 55–59 years and to a lesser extent for those aged 45–49 years. Rates increased in 2012–2016 for those aged 50–54 years and remained relatively stable for the other age groups **(Figure 2)**. The crude rate of colorectal cancer over time by birth cohort showed modest increasing rates for all birth cohorts during the surveillance period **(Figure 3)**.

Age-period-cohort analysis

The net drift was -0.948% per year, indicating a net decrease in model-fitted rates during the surveillance period. However, the Wald chi-square test for net drift = 0 was not statistically significant (p=.23). During the surveillance period, there were net annual decreases in incidence rates in almost every age group, as indicated by negative local drift values for all but 30- to 34-year olds **(Figure 4)**. The Wald chi-square test for all local drifts = net drift was not significant (p=.97), suggesting that temporal trends were similar in each age group.

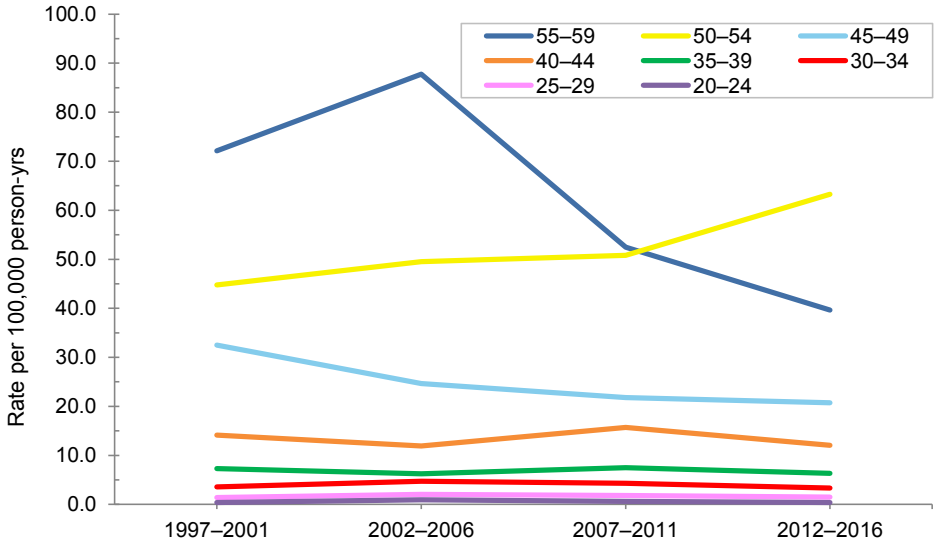
After adjusting for period effects, the age-specific incidence rates for colorectal cancer in the reference birth cohort (1963–1971) increased in an exponential fashion with older age groups and leveled off in the oldest age group, similar to the pattern observed in the crude age-specific rates **(Figure 5)**. However, the confidence intervals were wide, particularly in the older age groups.

Figure 6 shows the period rate ratios. Although there was a decrease in 2012–2016, the adjusted rate ratios did not significantly differ across periods, as indicated by the overlap of the confidence intervals with the reference value. Fitted temporal trends showed a modestly decreased incidence rate during 2012–2016 in the reference age group (35–39 years), although confidence intervals were wide and overlapping **(Figure 7)**. None of the adjusted cohort rate ratios were significantly different from the reference cohort **(Figure 8)**.

FIGURE 1. Crude annual incidence rates of colorectal cancer among service members aged 20-59 years, active component, U.S. Armed Forces, 1997–2016

Note: Dashed line represents the overall crude incidence rate of colorectal cancer.

FIGURE 2. Crude incidence rates of colorectal cancer, by age group, active component, U.S. Armed Forces, 1997–2016

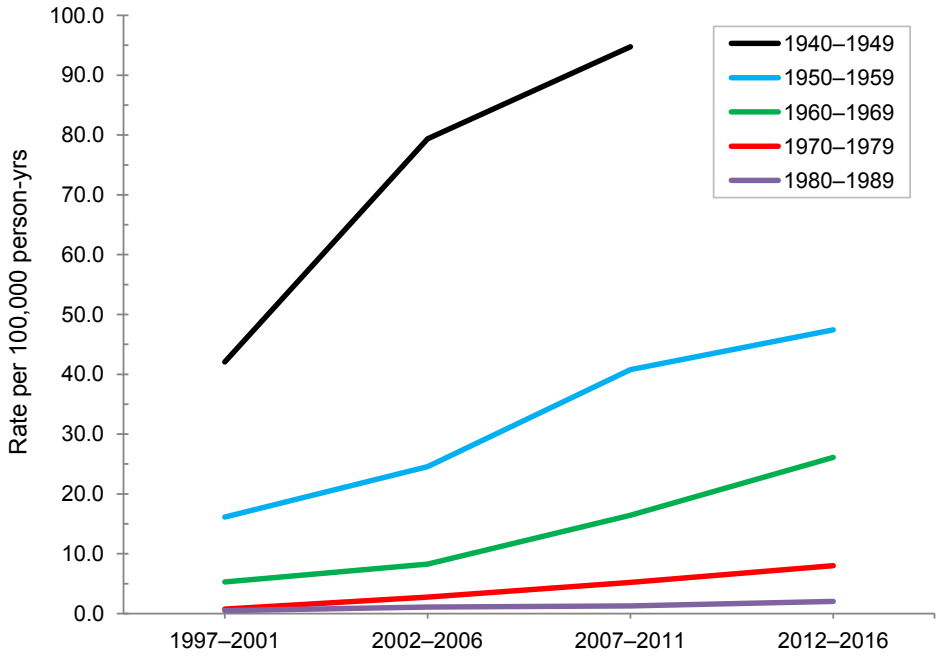


EDITORIAL COMMENT

Results from this analysis suggest that the rate of colorectal cancer among active component U.S. military service members was higher among those who are older, male, and non-Hispanic black. Although crude incidence rates increased in 2006 and decreased in 2013, the APC analysis suggested more constant temporal trends after adjusting for age. In addition, the APC analysis did not identify any birth cohort effects, as indicated by little variation in local drift and by adjusted cohort rate ratios that were not significantly different from the reference group.

There are several reasons no birth cohort effects were identified in this active component military population, but were identified in a study of U.S. civilians.[6] First, results from this APC analysis have limited power due to the small number of cancer cases identified in the active component military population, particularly in the youngest and oldest age groups. The study conducted by Siegel et al. was carried out on a much larger population of cases (490,305 cases compared with 1,108 in the current analysis). Because the active component of the U.S. Armed Forces is primarily a young and healthy population, trends could be analyzed only for individuals aged 20–59 years; this constraint limits generalizability, particularly for age groups past the recommended screening age. It is also an explanation for the younger age at first diagnosis (median=39 years) as compared with civilians (median=67 years).[11] Second, the results presented here are likely influenced by selection bias, in that service members with higher risk for colorectal cancer due to being older, overweight, obese, or to other

FIGURE 3. Crude incidence rates of colorectal cancer, by birth cohort, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



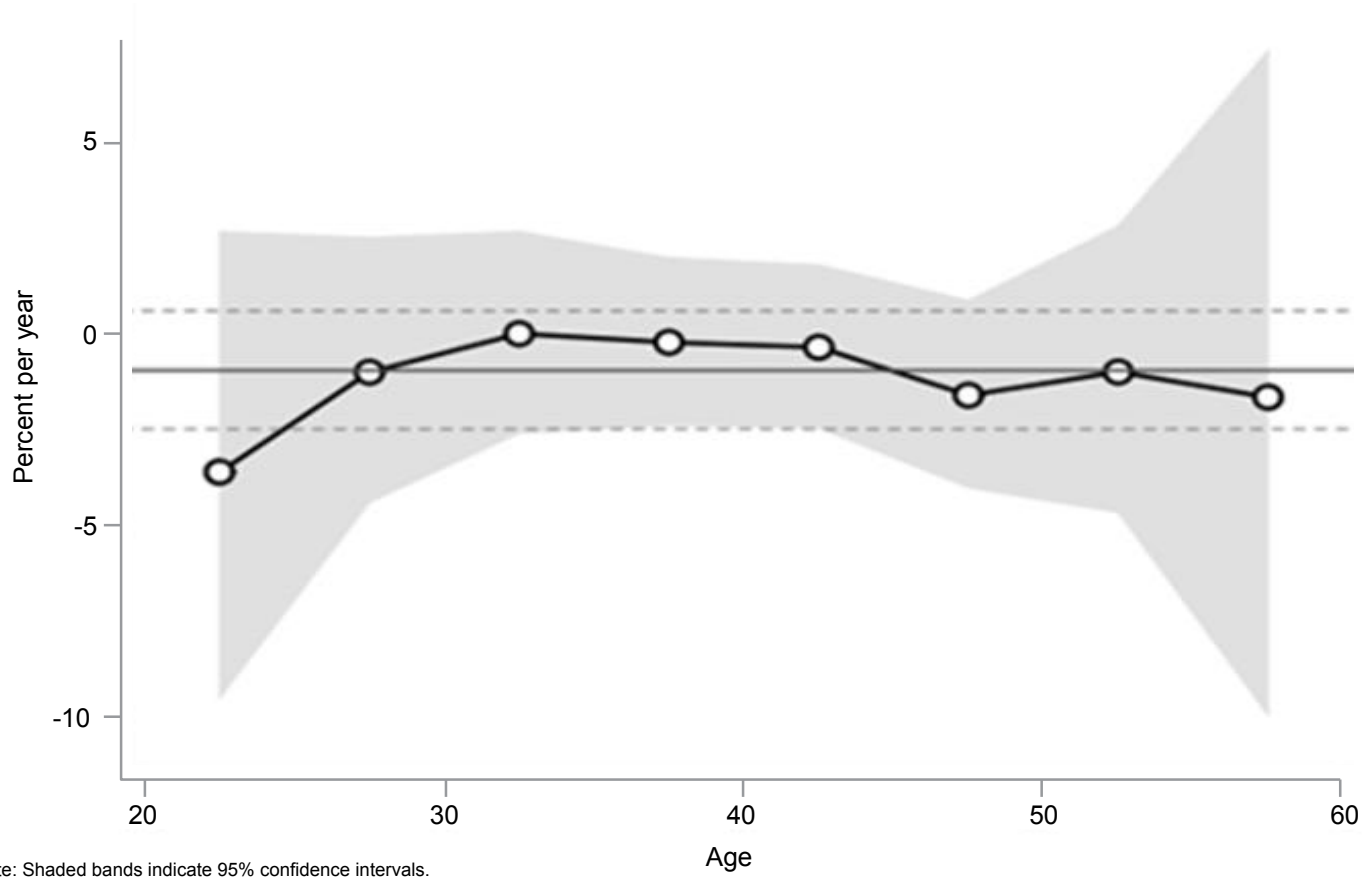
Note: 2012–2016 was omitted for the 1940–1949 birth cohort due to lack of person-time.

factors, may be more likely to leave military service prior to diagnosis and would not be captured in this report.

Third, active component service members may be less susceptible to the changing lifestyle factors that increase colorectal cancer risk. Although the prevalence of service members who are obese or overweight has been increasing, it is still much lower than the estimate of almost three-quarters of U.S. adults.[12] Service members must maintain physical fitness requirements to enter and remain in service, and in recent years there has been an emphasis on improving holistic health management, including better fitness, proper nutrition, and tobacco-free living through initiatives such as the Department of Defense's Operation Live Well.

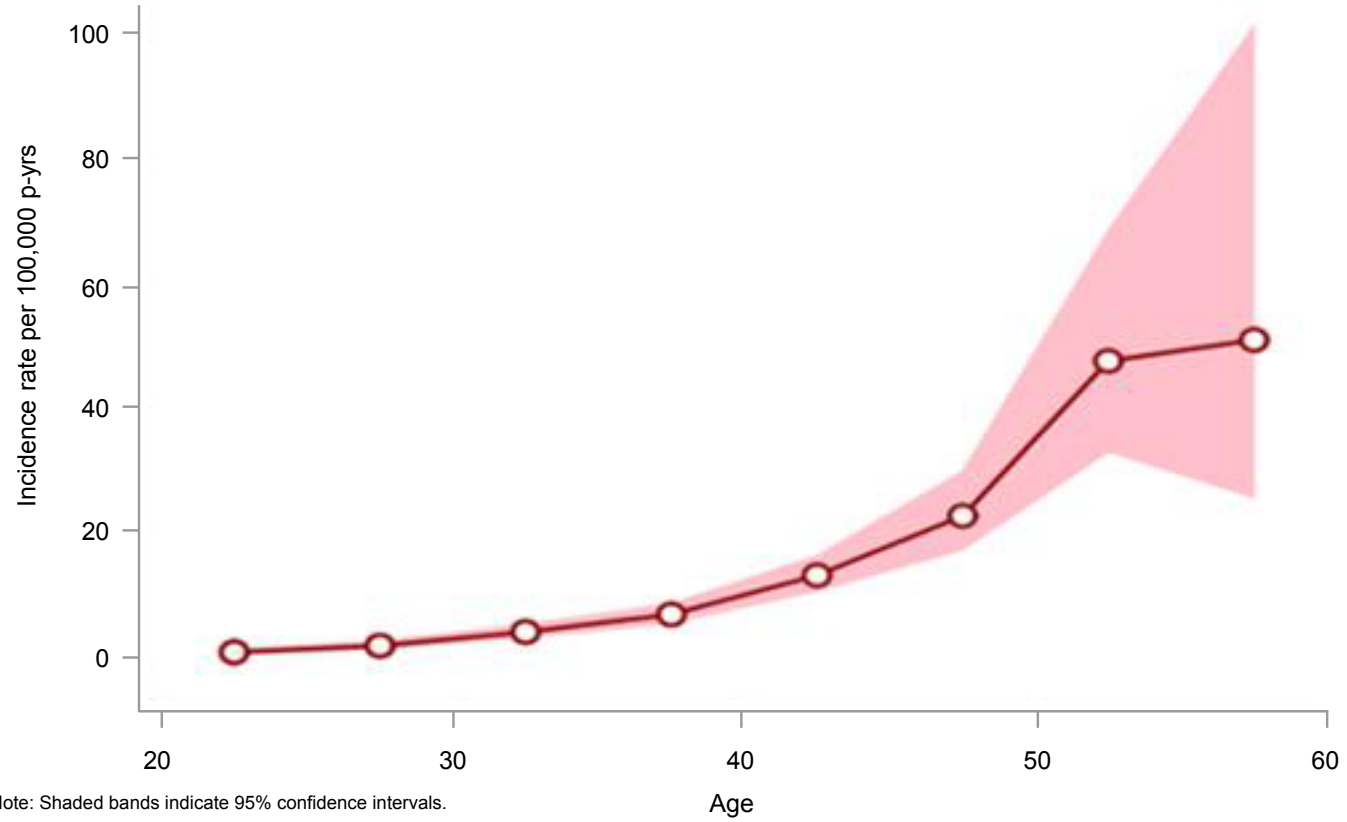
Finally, active component service members have better access to medical care in the MHS. The MHS currently supports a population-based screening strategy with outreach programs through

FIGURE 4. Local drifts with net drift, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



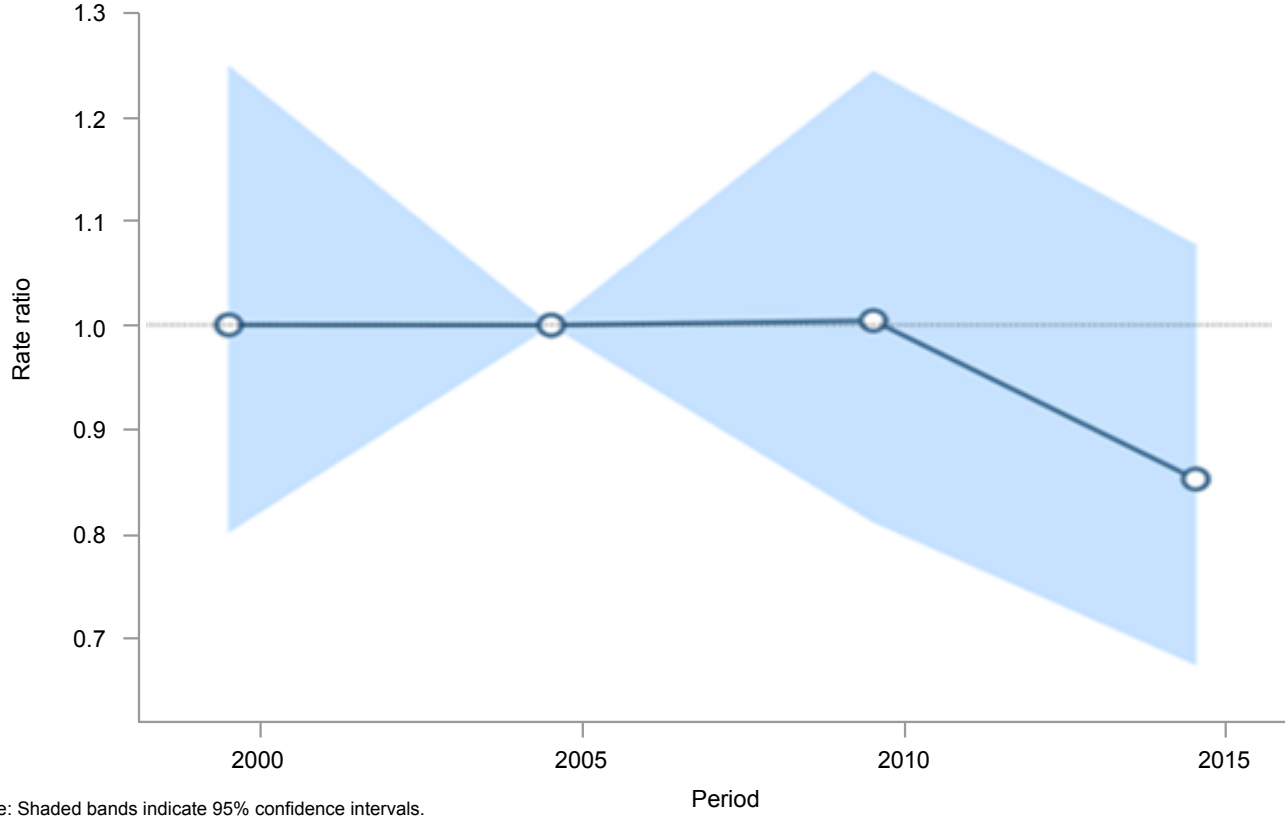
Note: Shaded bands indicate 95% confidence intervals.

FIGURE 5. Longitudinal age curve of colorectal cancer incidence rates, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



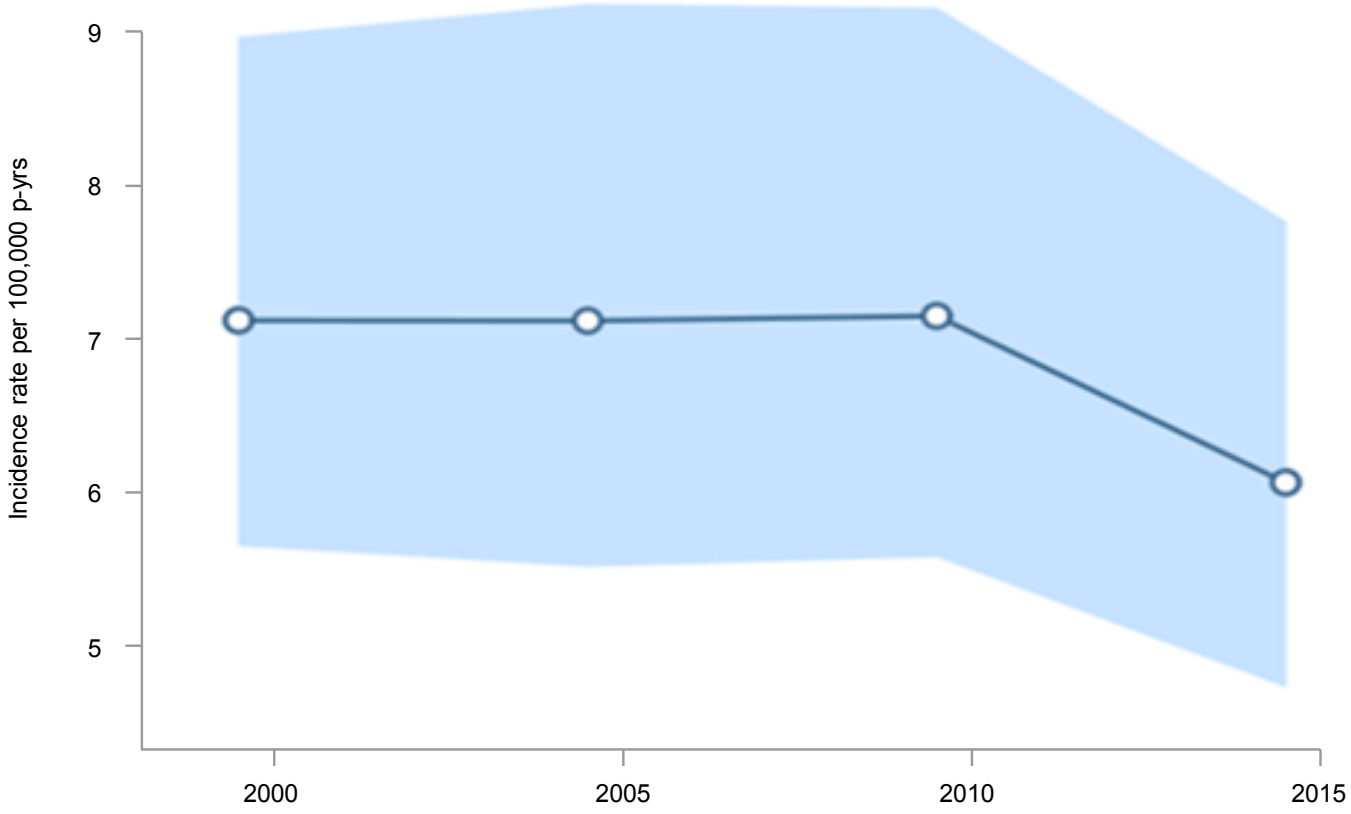
Note: Shaded bands indicate 95% confidence intervals.

FIGURE 6. Period rate ratios for colorectal cancer, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



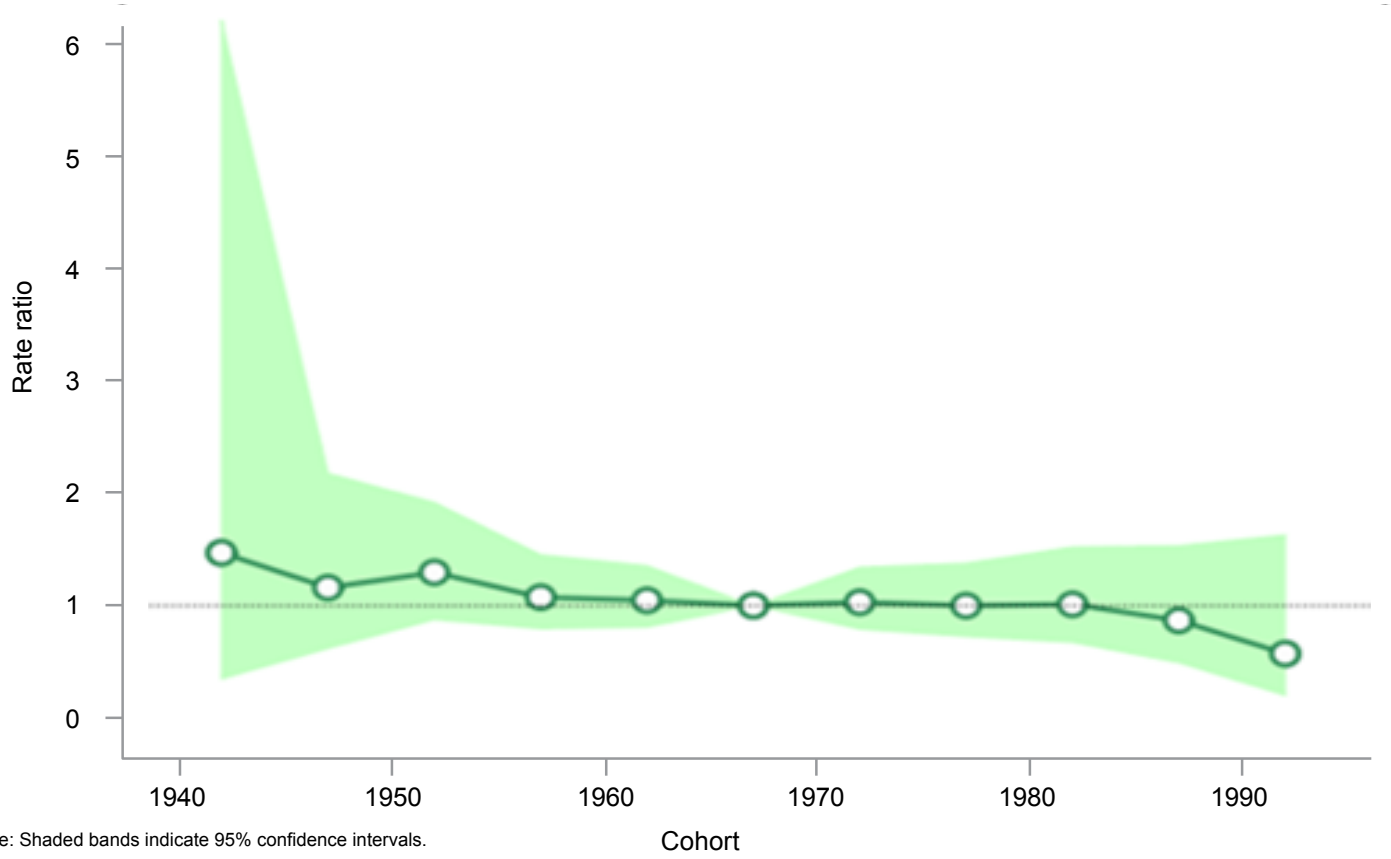
Note: Shaded bands indicate 95% confidence intervals.

FIGURE 7. Fitted temporal trend, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



Note: Shaded bands indicate 95% confidence intervals.

FIGURE 8. Cohort rate ratios, service members aged 20–59 years, active component, U.S. Armed Forces, 1997–2016



Note: Shaded bands indicate 95% confidence intervals.

electronic medical records with an electronic reminder system, the MHS Population Health Portal, and patient and provider education campaigns, all of which have likely contributed to high screening rates.[13]

The results presented in this analysis further iterate that African Americans have the highest incidence of colorectal cancer compared to other race/ethnicity groups in the active component U.S. military. Compared to whites, African Americans in the U.S. are 38%–43% more likely to die from colorectal cancer.[14] African Americans tend to be diagnosed at an older age and to have worse prognoses.[14] However, the results from the current analysis suggested similar age at diagnosis among all race/ethnicity groups. This finding could be the result of higher overall screening rates in the MHS (71%), compared to national averages of 50%–65%.[13]

Traditional screening methods for colorectal cancer include fecal occult blood testing, fecal immunochemical testing, double-contrast barium enema, flexible sigmoidoscopy, and colonoscopy.[13] In addition, there has been a recent increase in the number of technologies available, including CT colonography and fecal DNA testing, which aim to detect both premalignant and malignant lesions.[13] Continued population-based screening for colorectal cancer in the MHS is recommended to maintain low and decreasing incidence in the U.S. Armed Forces.

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Incidence of Gastrointestinal Infections Among U.S. Active Component Service Members Stationed in the U.S. Compared to U.S. Civilians, 2012–2014

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Gastrointestinal (GI) infections in the U.S. Armed Forces have consistently been among the most frequent disease and non–battle injury diagnoses. A retrospective analysis of surveillance data categorized as GI infections among active component service members during 2012–2014 was performed. During the study period, 99% of inpatient and outpatient GI encounters were reported as nonspecific GI infection (13,331 cases per 100,000 people), leaving only a small percentage of cases attributed to specific causes. The five most common organisms associated with GI infections were *Campylobacter* (10.30 per 100,000 people), nontyphoidal *Salmonella* (7.43), *Giardia* (3.15), *Shigella* (2.11), and norovirus (1.25). The civilian population incidence rates of foodborne diseases during the same time period are significantly greater than incidence rates within the U.S. active component for all select bacterial and parasitic pathogens, except *Campylobacter*. Nonspecific gastroenteritis incidence increased during winter months, which is similar to the seasonal pattern for viruses such as norovirus. The preponderance of nonspecific infections highlights the need for increased testing and a more in-depth review of the impact of GI infections on operational effectiveness within the U.S.

National estimates indicate that one in six Americans (48 million people) contract a foodborne illness annually.[1] Among active component service members of the U.S. Armed Forces in 2012, diarrheal diseases accounted for 17,675 healthcare encounters affecting 15,273 service members and around 1% of total annual lost duty days for 2012, even with force health protection measures, including access to clean water and safe food.[2] Further studies indicated that the most common diagnosis of gastrointestinal (GI) infection among members of the active component between 2002 and 2012 was "diarrhea" without attribution to a specific causative agent. Among those diagnoses that did specify an etiologic agent, bacterial causes were the most frequently reported.[3] Of these bacterial causes, annual incidence rates of *Campylobacter* infections among active component service members increased between 2008 and 2012. The trend observed in the average annual incidence rates between 2010 and 2012 is reflected in the U.S. civilian population data, which, according to the Centers for Disease Control and Prevention (CDC), demonstrated a 1% increase in *Campylobacter* infections in 2013.[3-5] Additionally, the annual incidence rates of *Salmonella* infections decreased between 2000 and 2013 in the active component and within the U.S. civilian population.[5,6] Outbreaks of GI infections have resulted in significant degradation of military operations in deployed environments. GI pathogens, such as *Salmonella* and *Campylobacter,* are endemic in the U.S. and have a similar ability to degrade military operational effectiveness within the U.S.[7]

GI infections encompass many infectious diseases, the majority of which result from food or waterborne transmission, with symptoms including diarrhea and vomiting. However, person-to-person transmission (e.g., norovirus) and contact with infected animals (e.g., *Salmonella*) are also possible routes of transmission.

The purpose of this report is to summarize the incidence rates of GI infections in the active component that are known for causing foodborne illness and to compare these incidence rates to reported incidence rates in the U.S. civilian population and the *Healthy People 2020* goals.

METHODS

The study population consisted of active component service members in the U.S. Armed Forces (Army, Navy, Air Force, and Marine Corps) who served within the 50 U.S. states between 1 January 2012 and 31 December 2014. A unit zip code was used to identify case location, but, if a unit zip code was missing, the treatment facility's Defense Medical Information Identification (DMISID) code was utilized. All individuals with a unit zip code or military treatment facility zip code outside of the U.S. states were excluded from the study population. Incidence rates were calculated per 100,000

members of the active component to mirror CDC data for comparison purposes. Confirmed cases with a specific etiology were reported in the Reportable Medical Events (RME) data from the Defense Medical Surveillance System (DMSS); infections included in this report are those identified by the CDC as pathogens that are known for causing foodborne illness **(Table 1)**.[8] These data were used to calculate the incidence rate for the specific pathogens over the 3-year study period. The denominator data for all annual incidence rates in the active component in this study were obtained from the Defense Manpower Data Center (DMDC).[9] The sum of Army, Navy, Air Force, and Marine Corps population data within the 50 U.S. states on 30 September for each year of the study was used to calculate the incidence rate among the active component. The sum of the populations for each year was used for overall incidence rates of the study period.

Utilizing RME records, annual incidence rates of confirmed cases were compared to CDC FoodNet civilian population rates for each year. The same DMDC denominator data were used to calculate the incidence rate among the active component for that particular year. CDC FoodNet data are derived from active surveillance of laboratory confirmed infections of nine pathogens—*Campylobacter*, *Listeria*, *Salmonella*, Shiga toxin–producing *Escherichia coli* (STEC), *Shigella*, *Vibrio*, *Yersinia, Cyclospora,* and *Cryptosproidium*—from 10 state health departments; approximately 15% of the U.S. civilian population are surveyed by CDC FoodNet surveillance using these 10 health departments. CDC's civilian population rates are determined using census population data from the surveillance areas.[5,10,11] Age and sex adjustment to better match the active component with the U.S. civilian population was not possible due to lack of granularity in the data; age group and gender breakdowns were provided in the 2012 CDC data but not in the data from either 2013 or 2014.

Service-specific annual incidence rates of GI infections were calculated using ICD-9 codes from records of hospitalizations and outpatient encounters in fixed medical facilities. These records are maintained in DMSS, which contains electronic records of all active component military members' inpatient and outpatient encounters in U.S. military and civilian (visits funded by TRICARE) medical facilities worldwide. The same DMDC denominator data were used to calculate the incidence rate among the active component for each particular year. Hospitalizations and outpatient records were reviewed, and U.S. encounters that contained an ICD-9 code indicative of GI infection in the first or second diagnostic position were included in the study. A person could be considered as a new infection only once every 60 days. If a case was seen for a GI encounter outside the 60-day period for the same diagnosis, this was counted as a second case as it likely represented a new GI infection. Cases were deconflicted based on personal identifiers, dates of encounters, and dates of diagnoses for both hospitalizations and outpatient records. For example, if an individual had a medical encounter for *Campylobacter* infection and a hospitalization within the 60-day period, this was counted as one case in these analyses. Cases of typhoidal *Salmonella* were counted only once per lifetime for each individual in the study due to the possibility of lifetime infection. Cases of hepatitis A were not included in these analyses. RMEs were not included in the service-specific GI rates analyses; only medical encounter and hospitalization data were used.

TABLE 1. Gastrointestinal infection–related ICD-9 diagnostic codes

ICD-9	Group name
008.66	Astrovirus
005.89	*Bacillus cereus*
008.43	*Campylobacter*
005.1	*Clostridium botulinum*
005.2	*Clostridium perfringens*
007.4	*Cryptosporidium*
007.5	*Cyclospora*
008.0, 008.01–008.03, 008.09, 041.43, 041.49	Diarrheagenic *E. coli*
007.1	*Giardia*
027.0	*Listeria monocytogenes*
005.9, 008, 008.8, 009, 009.0–009.3, 536.2, 558.2, 787, 787.0, 787.01–787.03, 787.91	Non-specific gastroenteritis
003.0, 003.1, 003.2, 003.20–003.24, 003.29, 003.8, 003.9	Non-typhoidal *Salmonella*
008.63, 078.82	Norovirus
008.61	Rotavirus
002.0–002.3, 002.9	Typhoidal *Salmonella*
004.0–004.3, 004.8, 004.9	*Shigella*
005.0, 008.41	*Staphylococcus*
008.04, 041.42	STEC non-O157
041.41	STEC O157
124	*Trichinella spp.*
005.3, 005.8, 008.4, 008.46, 008.47, 008.49, 008.5	Unspecified bacteria
007.8, 007.9	Unspecified parasite
008.6, 008.64, 008.69	Unspecified virus
005.4	*Vibrio parahaemolyticus*
005.81	*V. vulnificus*
001.0, 001.1, 001.9	*V. cholerae*
008.44	*Yersinia enterocolitica*

STEC, Shiga toxin–producing *Escherichia coli*

RESULTS

Between 1 January 2012 and 31 December 2014, bacterial pathogens were the most frequently reported GI infection etiologies with a rate of 20.41 RMEs per 100,000 people, followed by parasites (4.24) and viruses (1.25) **(Table 2)**. The five most common etiologic agents reported from the 873 GI infection RMEs were *Campylobacter* (10.30 cases per 100,000 people), nontyphoidal *Salmonella* (7.43), *Giardia* (3.15), *Shigella* (2.11), and norovirus (1.25). When confirmed cases of

GI infection from the RME data were compared to CDC FoodNet GI infection incidence rates, members of the active component had lower rates of GI infection than the CDC sample of the U.S. civilian population. All pathogens had lower incidence rates in the active component population compared to the CDC sample of the U.S. civilian population, except for *Cyclospora* infection in 2013 **(Table 3)**. The incidence of GI infections in the active component during this time frame were lower than the *Healthy People 2020* goals for *Listeria*, *Salmonella*, *Vibrio*, STEC, and *Yersinia* in 2012, 2013, and 2014. However, during this period, the incidence rates among active component service members exceeded the *Healthy People 2020* goal for *Campylobacter* infections.

During the 3-year study period, there were a total of 454,250 GI disease-related ICD-9 diagnoses. Nonspecific gastroenteritis was the most frequently reported GI infection ICD-9 diagnosis with 448,889 (98.8%) cases reported (13,331 cases per 100,000 service members) **(data not shown)**. The Army had the highest incidence rates of GI infection diagnoses for outpatient clinic visits and hospitalizations (16,099 cases per 100,000 service members) throughout the 3-year study period. The Air Force accounted for 15,006 cases per 100,000 people, followed by the

TABLE 2. Etiologic groupings, incident counts, and rates of gastrointestinal infection, active component, U.S. Armed Forces, 2012–2014

Agent	Reportable medical events (N)	Rate[a]
Total	873	25.90
Bacteria		
Brucella	1	0.03
Campylobacter	347	10.30
Clostridium botulinum	0	N/A
STEC non-O157	5	0.15
Diarrheagenic *E. coli*	8	0.24
Listeria monocytogenes	0	N/A
Nontyphoidal *Salmonella*	251	7.43
Typhoidal *Salmonella*	3	0.09
Shigella	71	2.11
Vibrio cholerae	2	0.06
Subtotal	688	20.41
Parasites		
Cryptosporidium	25	0.74
Cyclospora	1	0.03
Giardia	106	3.15
Trichinella	11	0.33
Subtotal	143	4.24
Virus		
Norovirus	42	1.25
Subtotal	42	1.25

STEC, Shiga toxin–producing *Escherichia coli*

[a]Incidence rate per 100,000 active component service members

TABLE 3. Reportable medical event rates of gastrointestinal infections in the active component, U.S. Armed Forces, compared to CDC FoodNet rates and *Healthy People 2020* goals, 2012–2014

	2012		2013		2014		*Healthy People 2020* goals
Agent	Active component rate[a]	CDC FoodNet rate[a]	Active component rate[a]	CDC FoodNet rate[a]	Active component rate[a]	CDC FoodNet rate[a]	Rate[a]
Campylobacter	10.66	14.22	11.5	13.73	9.07	13.29	8.5
Listeria	0	0.26	0	0.25	0	0.24	0.2
Salmonella	9.85	16.37	8.02	15.15	9.31	15.29	11.4
Shigella	2.14	4.47	2.05	4.83	2.19	5.7	N/A
STEC	0.36	2.27	0.45	2.33	0.37	2.34	0.6
Vibrio	0.09	0.41	0.09	0.52	0.09	0.45	0.2
Yersinia	0	0.33	0	0.36	0	0.28	0.3
Cryptosporidium	0.72	2.63	0.89	2.52	0.64	2.44	N/A
Cyclospora	0	0.03	0.09	0.03	0	0.05	N/A

CDC, Centers for Disease Control and Prevention; STEC, Shiga toxin–producing *Escherichia coli*

[a]Incidence rate per 100,000 people

TABLE 4. Rates and counts of outpatient encounters and hospitalizations due to gastrointestinal infections, by service, active component, U.S. Armed Forces, 2012–2014

	2012	Rate[a]	2013	Rate[a]	2014	Rate[a]	Total 2012–2014	Rate[a]
Army	71,756	16,464	66,969	15,574	68,671	16,257	207,396	16,099
Air Force	39,792	15,391	38,034	14,639	37,337	14,989	115,163	15,006
Marine Corps	16,038	9,764	15,970	10,125	16,217	10,694	48,225	10,189
Navy	27,759	10,764	28,427	10,445	27,280	10,050	83,466	10,413
Total	155,345	13,913	149,400	12,890	149,505	13,659	454,250	13,479

[a]Incidence rate per 100,000 active component members

FIGURE 1a. Counts of cases of nonspecific gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014

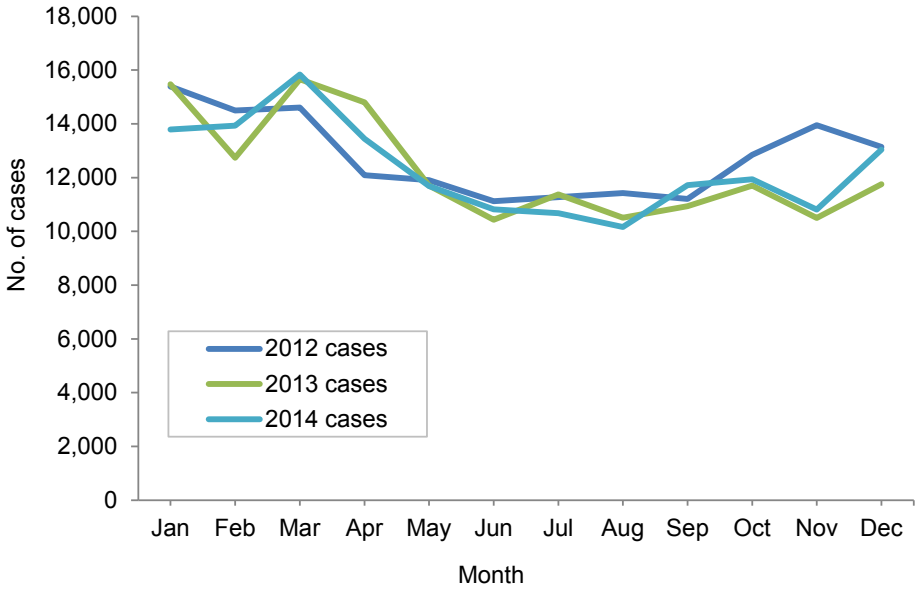
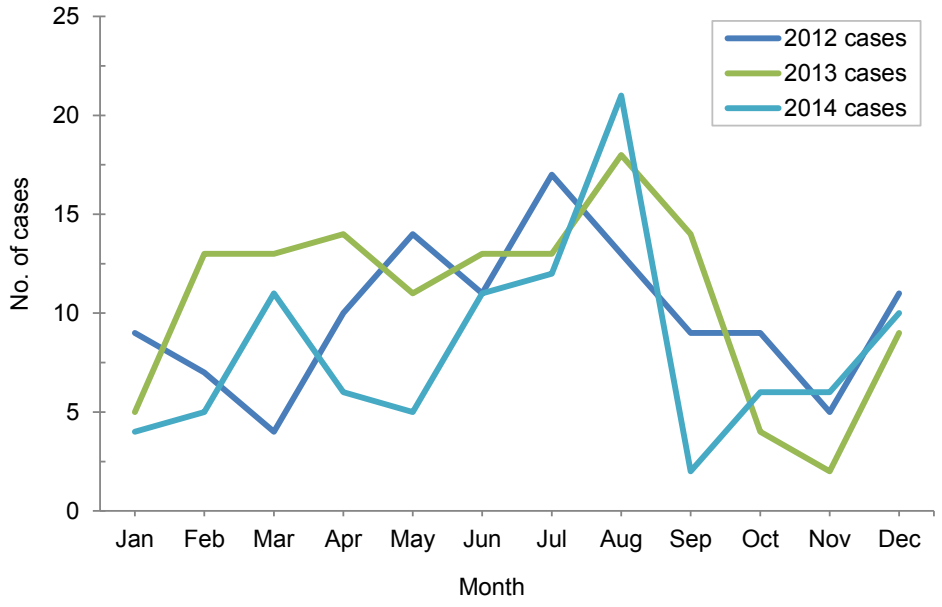


FIGURE 1b. Counts of cases of *Campylobacter* gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014



Navy (10,413 cases per 100,000 service members) and the Marine Corps (10,189 cases per 100,000 service members) **(Table 4)**. With regard to the seasonality of case counts of diagnoses of GI infections, the numbers of nonspecific GI infection medical encounters were highest during winter months (November–March) **(Figure 1a)**. In contrast, the numbers of RME cases of *Campylobacter* and *Salmonella* infection were highest during the summer months (June–September) **(Figures 1b, 1c)**. No seasonality in case counts was observed in *Giardia*, norovirus, or *Shigella* infections; only occasional monthly sporadic peaks in incidence occurred between 2012 and 2014 **(Figures 1d–1f)**.

EDITORIAL COMMENT

During the 3-year study period, 98.8% of GI infection-related ICD-9 records were classified as nonspecific GI infection, which greatly limited the extent to which GI infection in the active component could be investigated on an etiologic level. The seasonality of nonspecific GI infections observed during the winter months may indicate that these cases are predominantly caused by viruses such as norovirus, which according to CDC, is most common in the winter.[12] Although this surveillance provides the rate of GI infection incidence, data on outbreaks or outbreak-associated cases were not available. Outbreak surveillance reports and data may provide further context in regards to the etiology of nonspecific GI infections and possibly attribute the

FIGURE 1c. Counts of cases of *Salmonella* gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014

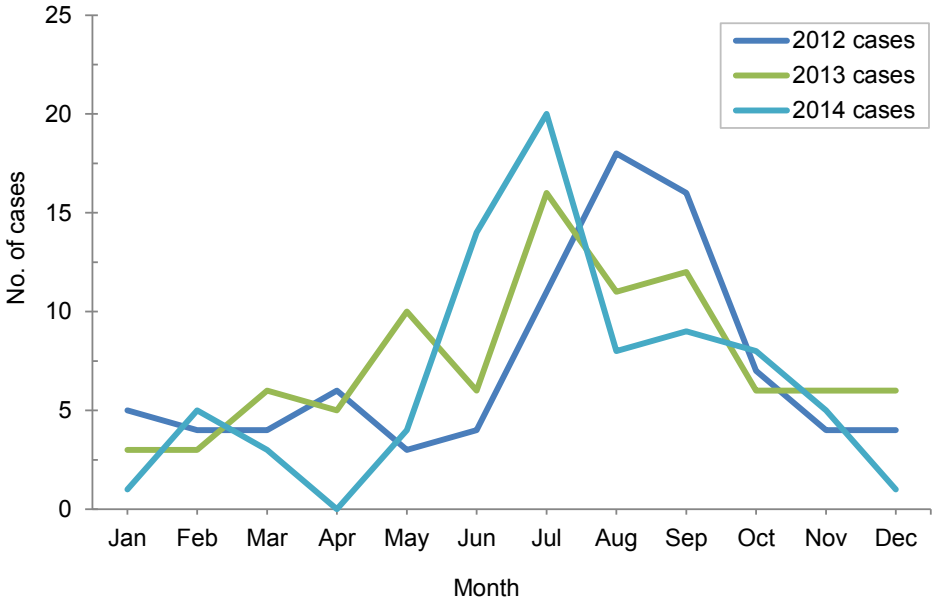
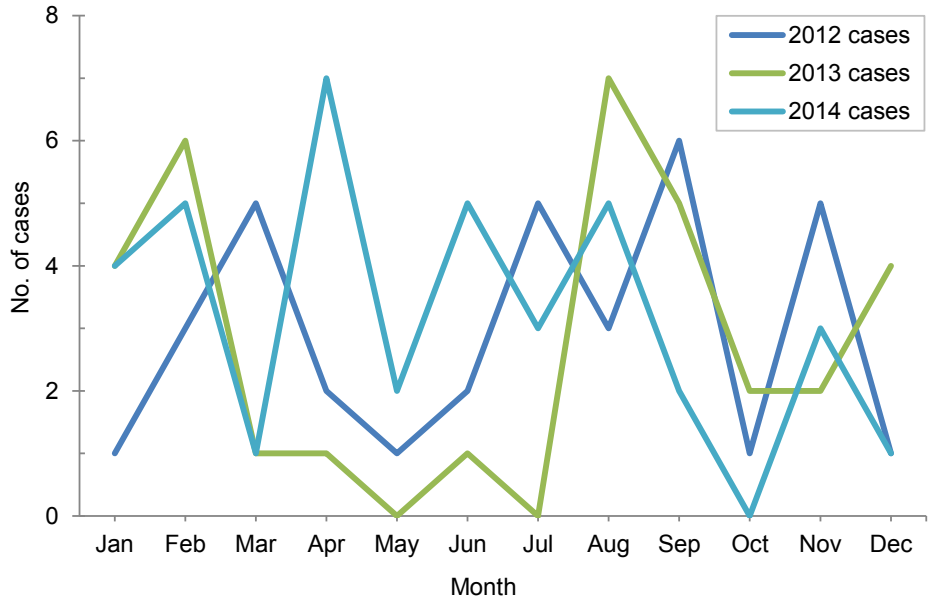


FIGURE 1d. Counts of cases of *Giardia* gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014



sporadic monthly peaks displayed by norovirus, *Shigella*, and *Giardia* to outbreak situations.

Active component incidence rates of GI infections were significantly lower than civilian incidence rates reported by FoodNet for several pathogens. This finding may be due to the inclusion of more susceptible groups in civilian population data (children and elderly), while the majority of the active duty population are healthy young adults. The inability to standardize these rates was a significant methodologic limitation of these analyses. Standardization of these rates based on age and gender would have provided a more accurate comparison of these two populations. Another reason for the difference could be that food safety and sanitation measures that are applied within the Department of Defense through the Tri-Service Food Code require more frequent inspection/evaluation and greater food protection measures compared to the Food and Drug Administration's Food Code. Despite the limitations due to population composition, comparison to CDC data is warranted to assist in the evaluation of the effectiveness of stringent Department of Defense food safety programs and determine whether these countermeasures actually contribute to decreased disease incidence in the active component. Although active component incidence rates were lower than those in the surveyed civilian population, the potential operational impact of GI infections within the active component requires a more in-depth analysis and estimation of disease burden.

Outbreaks of GI infections have the potential to significantly degrade operations and should be analyzed to develop targeted prevention programs. Increased diagnostic testing of nonspecific GI infections is necessary to further elucidate which GI pathogens are the most prevalent in the active component. This information would help evaluate the impact of these pathogens on operational efficacy and validate the effectiveness of U.S. Armed Forces food and water safety programs.

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FIGURE 1e. Counts of cases of norovirus gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014

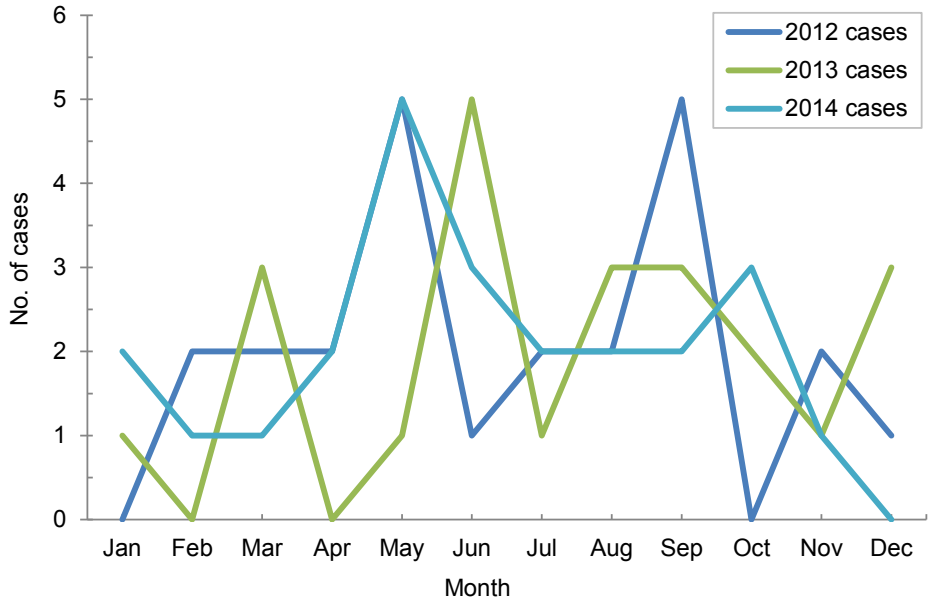
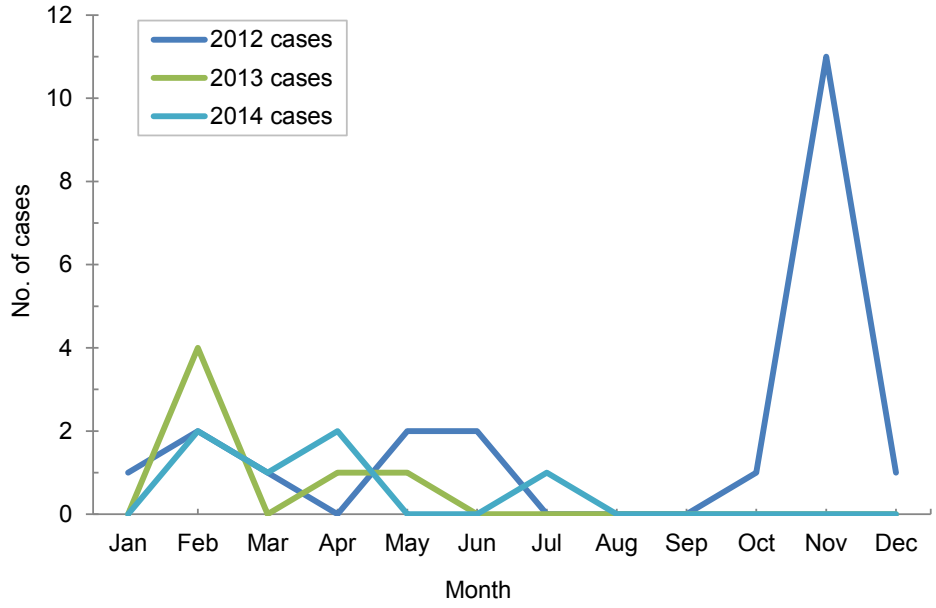


FIGURE 1f. Counts of cases of *Shigella* gastrointestinal infection, by calendar month for each year of the surveillance period, active component, U.S. Armed Forces, 2012–2014



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Brief Report

Laboratory Characterization of Noroviruses Identified in Specimens from Military Health System Beneficiaries During an Outbreak in Germany, 2016–2017

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Although infectious gastroenteritis is one of the most common illnesses associated with military deployments, such illness is also relatively frequent in service members who are not deployed and in civilian populations in developed countries.[1] Military personnel have a particularly high risk of acute gastroenteritis due in part to their close proximity or contact with one another in closed environments which facilitate transmission of viral pathogens.[2] Although gastroenteritis can be bacterial, viral, or parasitic in nature, norovirus has been identified as one of the top five etiologic agents of gastroenteritis among military populations.[3] Norovirus is classified as a non-enveloped, single-strand RNA virus that is highly contagious. The incubation period for norovirus illness is 24–72 hours.[4] Symptoms of norovirus infections typically last 1–3 days and rarely require hospitalization.[4] Six genogroups of norovirus have been identified; of these, genogroup I (GI), genogroup II (GII), and genogroup IV (GIV) affect humans.[5] A total of 25 different genotypes have been identified within the three human genogroups, although since 2002, variants of the GII.4 genotype have been most commonly identified among norovirus outbreaks.[6]

In 2016, among residents of the Federal Republic of Germany, norovirus incidence reported during the winter season was unusually high and reported earlier than usual.[7] In November 2016, at least 14,872 laboratory-confirmed cases were reported in Germany, representing almost twice the median number of cases reported (7,810 cases) in the same month over the past 5 years.[7] During the 2016–2017 norovirus season (October–March, Epidemiological Weeks 39–13), a total of 79,378 cases were reported by the Robert Koch Institute.[8] The total case count was greater than the counts during each of the previous four seasons (42,621 cases in 2015–2016; 67,646 cases in 2014–2015; 59,587 cases in 2013–2014; and 66,783 cases in 2012–2013). The largest number of norovirus cases in recent years in Germany was the 95,575 cases reported during the 2011–2012 season.[8]

The Robert Koch Institute reported an emerging norovirus recombinant strain (GII.P16–G.II.2) during the 2016–2017 outbreak. The strain was identified in nine federal states across Germany by sequencing two open reading frames: ORF1 (polymerase) and ORF2 (capsid).[7] Herd immunity in the German civilian population was likely attained against previously circulating norovirus strains; however, Niendorf et al. concluded that the acquired immunity against previous strains may not have been effective against the emerging variant strain, further propagating the outbreak.[7] This study characterizes norovirus isolates from Military Health System (MHS) beneficiaries which corresponded temporally and geographically with the 2016–2017 outbreak in Germany.

MATERIALS AND METHODS

During the 2016–2017 norovirus season in Germany, stool samples from MHS beneficiaries with gastroenteritis were collected at various military treatment facilities (MTFs) in the U.S. European Command (EUCOM) between August 2016 and March 2017; one sample collection site was unspecified. Samples were sent to Landstuhl Regional Medical Center (LRMC) for testing using the FilmArray® Gastrointestinal Panel (BioFire®). Potential exposure location data for affected individuals were retrospectively identified using the Armed Forces Health Longitudinal Technology Application (AHLTA). Of all samples received by LRMC during this surveillance period, a total of 41 tested positive for norovirus. Norovirus sequencing was not available at LRMC at the time of this study. Therefore, all 41 samples were shipped in April 2017 to the Naval Health Research Center (NHRC), San Diego, CA, for sequencing.

Upon receipt at NHRC, stool samples were initially diluted to 20% in phosphate-buffered saline without Ca^{2+}/Mg^{2+}. The resulting solution was processed for total RNA content using the QIAamp Viral RNA Mini kit (Qiagen, Valencia, CA). RNA samples were subjected to a one-step, real-time, TaqMan®, RT-PCR assay developed by the Centers for Disease Control and Prevention's CaliciNet Program for the simultaneous detection of norovirus GI and GII. Norovirus-positive samples were genotyped based on sequences obtained from the amplification of partial regions of ORF1 (polymerase) and/or ORF2 (capsid). Phylogenetic analysis was performed using the Lasergene Molecular Biology Suite in conjunction with National Center for Biotechnology Information Basic Local Alignment Search Tool.

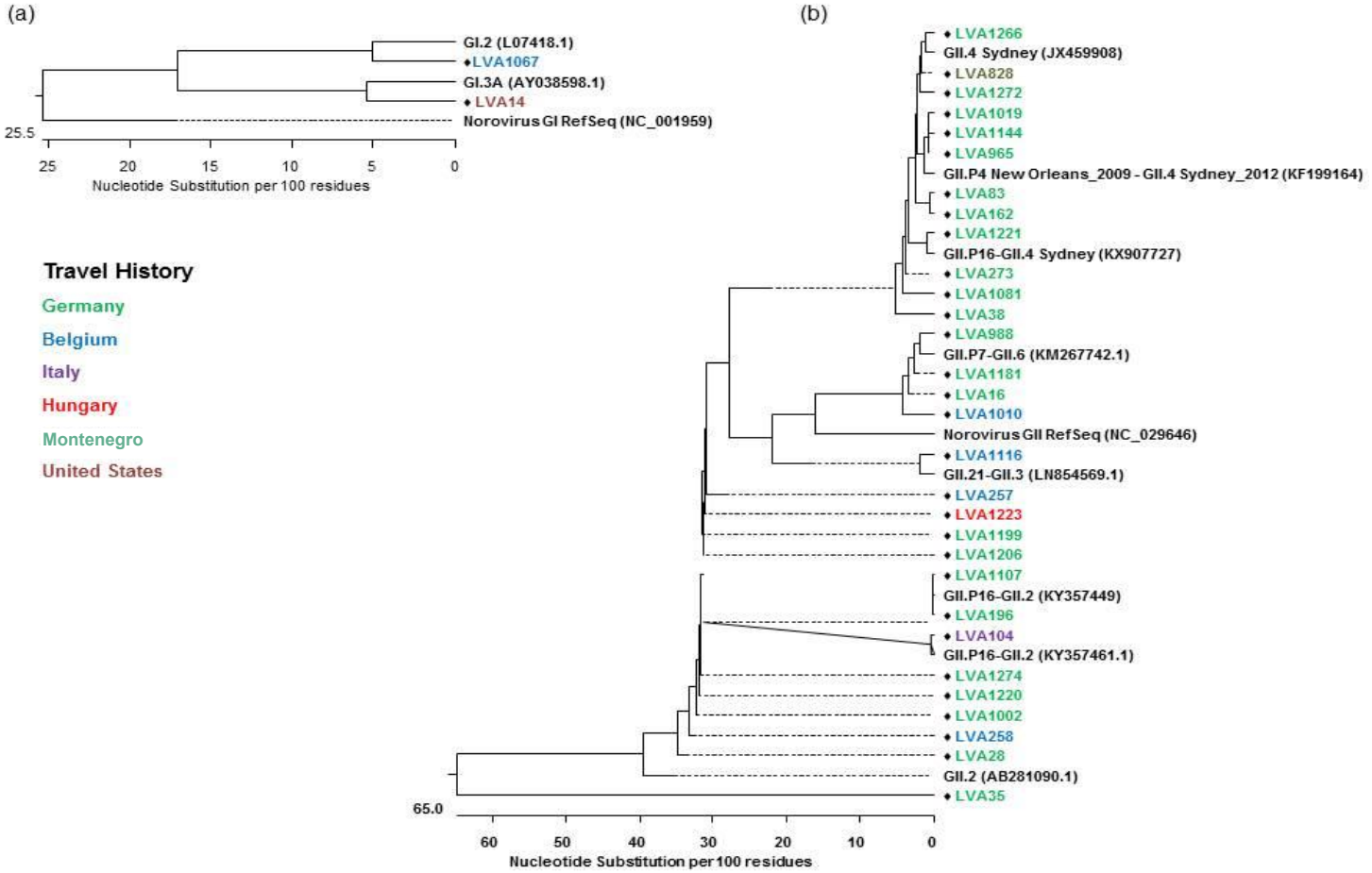
RESULTS

All 41 samples received by NHRC had tested positive for norovirus GI or GII at LRMC, using a commercial multiplex gastrointestinal PCR panel cleared by the Food and Drug Administration. Of the 41 samples, a total of 33 tested positive for norovirus at NHRC. Two samples tested positive for norovirus GI, and 31 tested positive for norovirus GII. Eight samples were found to be negative for both norovirus GI and GII by two different molecular assays at NHRC. To determine whether the sensitivity of the different testing platforms was the underlying factor for the discrepant testing results between sites, one positive and

TABLE 1. Norovirus sequences and potential exposure location in Military Health System beneficiaries during the 2016–2017 winter season (N=31)

Norovirus genotype	Country (N, %)
GI.P2–GI.2	Belgium (1, 3%)
GI.3A	U.S. (1, 3%)
GII.P16–GII.2	Germany (7, 22%); Belgium (2, 6%); Italy (1, 3%); Hungary (1, 3%)
GII.P16–GII.4 Sydney	Germany (5, 16%)
GII.2	Germany (1, 3%)
GII.P21–GII.3	Belgium (1, 3%)
GII.P4 NewOrleans 2009–GII.4 Sydney 2012	Germany (3, 9%)
GII.4 Sydney	Germany (2, 6%); Montenegro (1, 3%)
GII.Pe–GII.4 Sydney	Germany (1, 3%)
GII.P7–GII.6	Germany (3, 9%); Belgium (1, 3%)
Total no. of samples	Germany (22), Belgium (5), Italy (1), Montenegro (1), U.S. (1), Hungary (1)

FIGURE. Phylogenetic analysis of norovirus GI and GII sequences based on ORF1 (polymerase) and ORF2 (capsid) regions



Note: Reference strains of norovirus genotypes are listed with their respective accession numbers. Landstuhl Regional Medical Center samples are color-coded according to the subject's travel history. (a) Norovirus GI phylogenetic analysis. (b) Norovirus GII phylogenetic analysis.

TABLE 2. NHRC sequencing results for Military Health System beneficiary norovirus specimen samples obtained from LRMC during 2016–2017 (N=41)

Group	No. of samples (N)	% distribution of NHRC results	% distribution by genotype per Niendorf et al.
GI.P2–GI.2	1	3%	0%
GI.3A	1	3%	4%
GII.2	1	3%	1%
GII.P16–GII.2	11	35%	45%
GII.P16–GII.4 Sydney	5	16%	10%
GII.4 Sydney	3	10%	10%
GII.Pe–GII.4 Sydney	1	3%	
GII.P4 NewOrleans2009–GII.4 Sydney2012	3	10%	9%
GII.P7–GII.6	4	13%	4%
GII.P21–GII.3	1	3%	2%
Total no. of samples sequenced	31	100%	-
Failed[a]	2	-	N/A
Negative[b] by real-time and conventional PCR	8	-	-
Total no. of samples received	41	-	-

NHRC, Naval Health Research Center; LRMC, Landstuhl Regional Medical Center

[a]NHRC was able to identify norovirus GI or GII in the sample but was not able to sequence it successfully for genotype assignment.

[b]The sample was negative by real-time RT-PCR and RT-PCR for norovirus GI and/or GII.

four negative specimens were processed at NHRC through the same multiplex PCR system as at LRMC. The results confirmed the one positive and four negative findings previously obtained by NHRC using the TaqMan®, RT-PCR assay **(Table 1)**. Phylogenetic analysis was completed on the 31 GII-positive samples **(Figure)**. Norovirus recombinant genotypes were characterized in 25 out of the 31 specimens analyzed **(Table 2)**. The most abundant recombinant strains were GII.P16–GII.2 (35%) and GII.P16–GII.4 Sydney (16%). These data are comparable to the findings from a study by Niendorf et al., which assessed the norovirus strains circulating in Germany during the winter season of 2016–2017. That study reported nearly half of the civilian samples genotyped were GII.P16–GII.2.[7] A variety of other norovirus genotypes were also found by Niendorf et al. to be co-circulating during the same time frame but were detected less frequently than these dominant strains.[7]

Among the 31 individuals who had norovirus GII samples sequenced, 22 had histories of travel to, or lived in, Germany. Because of the limited data available, it was difficult to distinguish between travel history and previous residence. The remaining individuals reported travel or residence in other countries: Belgium, Italy, Montenegro, U.S., and Hungary **(Table 1)**.

EDITORIAL COMMENT

Eight of the 41 specimens that had tested positive at LRMC tested negative for both norovirus GI and GII at NHRC. The manufacturer of the multiplex PCR kits recommends that specimens be processed and tested as soon as possible (within 4 days of collection) to ensure accurate test results. Discrepant multiplex PCR panel results between the two testing sites could be due to a variety of factors, including RNA degradation during storage at and/or transit from LRMC to NHRC. Furthermore, the possibility of initial false-positive results at LRMC could not be ruled out.

The LRMC laboratory received samples collected from patients located throughout Europe, providing a range of travel histories and likely contributing to the variety of norovirus strains obtained in the sequencing results. However, the finding that 7 (32%) of 22 specimens from Germany were positive for the emerging recombinant strain (GII.P16–GII.2) suggests that the outbreak in the German population this past winter was genetically similar to the incident norovirus cases in the MHS beneficiary population in Germany. More than 50% of the samples tested yielded at least one of the two ORF genes characterized in the outbreak strain identified in the study by Niendorf et al. These observations exemplify the extent of integration between the MHS beneficiary population and the local German population and the impact on outbreak dynamics.

Transmission within the MHS beneficiary community and the local German community likely occurred through common exposure points. Locations such as workplaces, restaurants, grocery stores, and day care facilities could have been frequented by both military personnel and the local German population. The results highlight the importance of understanding disease risk and transmission characteristics within the local population in Germany because it is likely that for certain diseases, risk will similarly affect the MHS beneficiary population living in the German community. Moreover, timely collection of samples and rapid diagnosis of an etiologic agent in conjunction with other biosurveillance activities may help to provide early warning for future gastrointestinal outbreaks. Beginning in late 2017, LRMC will have enhanced gastrointestinal surveillance capability that can inform development of appropriate Force

Health Protection guidance and aid in prevention of disease transmission as well as mitigate possible operational impacts.

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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).

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Surveillance Snapshot: Norovirus Outbreaks Among Military Forces, 2008–2016

TABLE. Reported outbreaks of acute norovirus (NoV) gastroenteritis outbreaks among U.S. and foreign military forces, 2008–2016

Month/year of outbreak onset	Setting	Estimated attack rate (EAR)/ no. of NoV cases	Description	Reference
June 2008	U.S. Navy ship	EAR: 28.3% (65 of 230 cases)	NoV GI and enterotoxigenic *Escherichia coli* were both detected in tested specimens	4
October 2008	Military training camp, Singapore	156 AGE cases; 24 samples (15.4%) tested positive for NoV	Environmental contamination suspected as all food handlers tested negative for NoV	5
May 2009	U.S. military base, Turkey	187 AGE cases; 22 of 37 stool samples tested positive for NoV	Multiple NoV and co-pathogens detected; civilian community outbreak at the same time; significant operational impact due to ~20% of base population affected during 1-month period	6
December 2009	Military base, Germany	EAR: 12.4% (101 of 815 cases)	NoV GII.4; likely source was salad served in military canteen	7
April 2011	Military parachuting unit, France	147 AGE cases	Presumed NoV GI based on a single positive sample from a cook; preceded by community outbreak; significant operational impact on parachuting exercise	8
July 2011	U.S. Air Force Academy, Colorado	EAR: 18% (290 of 1,359 cases)	NoV likely initially introduced via food workers	9
November 2011	Two U.S. Army camps, Kuwait	Camp 1, AGE cases: 127 Camp 2, AGE cases: 88	Enhanced laboratory surveillance enabled onsite testing of specimens	10
September 2013	Two military camps, Singapore	Camp 1, EAR: 15% Camp 2, EAR: 8.3% (Total no. of cases=775)	Preceded by community outbreak; primarily NoV G.I2	11
October 2013	Military training center, Peru	EAR: 45.2% (164 of 363 cases)	13 stool samples tested positive for NoV GII via RT-PCR	12
April 2015	Army base, Portugal	EAR: 4.9% (46 of 938 cases)	NoV GI.9 identified in 7 specimens	13
February 2016	Military unit, France	EAR: 34% (103 of 300 cases)	Likely spread by food worker; NoV GII.17	14

AGE, acute gastroenteritis; GI, genogroup I; GII, genogroup II; RT-PCR, reverse transcription polymerase chain reaction

Acute gastroenteritis (AGE) and diarrheal disease have historically posed a constant threat to military forces. Norovirus (NoV) infections specifically have been the cause of significant morbidity in military personnel and are especially problematic because outbreaks can result in sudden and widespread reductions in the operational efficiency of affected units.[1]

Noroviruses have several attributes that enable their role as a leading cause of acute gastrointestinal illness outbreaks. The viruses can be transmitted through multiple routes, including person-to-person direct contact and exposure to contaminated food, water, aerosols, and fomites. NoV are very stable in the environment; of note in this regard, they are resistant to temperature extremes and standard disinfection methods. NoV are highly infectious agents; as such, they require low doses to establish infections in susceptible human hosts. Individuals who are infected with NoV have a prolonged shedding period which promotes secondary transmissions. Finally, infections with NoV do not confer lasting immunity (partially due to the diversity of NoV strains).[2]

Previously, the *MSMR* summarized published reports of NoV outbreaks in deployed forces during Operation Enduring Freedom and Operation Iraqi Freedom.[3] The **Table** in this report summarizes outbreaks in military forces in both garrison and deployed settings which occurred between 2008–2016. Attack rates are provided when explicitly stated or they could be derived from the data provided in the article. This summary does not include reports of AGE or diarrheal outbreaks in military settings where the authors did not explicitly report NoV as a primary cause of the outbreak. There are numerous reports of outbreaks of AGE and diarrheal disease in military settings that implicate other enteropathogens as the predominant causative agent that are not included in this summary.

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