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Incidence of Acute Injuries, Active Component, U.S. Armed Forces, 2008–2017

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Injuries have consistently ranked among the top morbidity burdens among U.S. military service members. This report describes the incidence, trends, types, causes, and dispositions of acute injuries among active component service members by anatomic region. From 2008 through 2017, there were more than 3.6 million acute incident injuries among more than 1.6 million individuals. The highest rates were for injuries to the foot/ankle, head/neck, and hand/wrist. Injury incidence decreased during the surveillance period for all anatomic sites except for the leg and knee. In addition, incidence varied by military/demographic characteristics and anatomic site. Overall, service members in the Army and service members in motor transport and/or combat-related occupations tended to have higher incidence rates than their respective counterparts. "Sprains and strains" was the most common type of injury (48.5%), and most injuries were due to undocumented or undetermined causes (69.7%). The most common disposition was "returned to duty with no limitations" (69.8%). Findings suggest that injury prevention strategies should be tailored to different populations with different risk factors. Future analyses will describe the epidemiology of cumulative traumatic injuries.

Service members in the U.S. Armed Forces frequently engage in high levels of physical activity to perform their duties, and such activity can potentially result in training- or duty-related injuries. Injuries have consistently ranked among the highest burden of disease categories for numbers of associated medical encounters and of individuals affected in the U.S. Armed Forces. In 2017, injuries accounted for more medical encounters (n=2,775,393) among active component service members than any other morbidity category and approximately one-quarter of all medical encounters.[1] Knee injuries ranked third in total number of medical encounters, with arm/shoulder and foot/ankle and leg injuries ranking fourth and sixth, respectively.[1]

According to the U.S. Army Public Health Center's 2016 Health of the Force Report, approximately half of all soldiers sustained at least one injury in 2015, with 1,361 new injuries per 1,000 person-years (p-yrs).[2] The incidence rate of injuries was about 34% higher among female soldiers (1,735 per 1,000 p-yrs) than among male soldiers (1,299 per 1,000 p-yrs), and was highest among those in the oldest age category (≥45 yrs).[2] Other risk factors for increased injuries identified in studies of U.S. Army service members or recruits include high amounts of running (frequency and mileage), tobacco use, lack of previous experience with sports and exercise, and having a sedentary lifestyle.[3,4] Some of the most common causes of non-battle-related injuries identified in military populations include military training, sports, falls, and motor vehicle accidents.[5,6]

Injuries are of major significance to the U.S. military because of their potential impact on lost duty or training time, costs, and military readiness. However, much of the Department of Defense's (DoD) research and field investigations of injuries has focused on specific populations such as recruit trainees, Army infantry soldiers, and special operations forces.[7] As such, this report is intended to expand the routine surveillance of injuries among all active component service members, with the goal of identifying high-risk populations and providing data to support the prioritization of research and prevention programs. The focus of this report is on acute injuries associated with a single traumatic event, as opposed to overuse injuries that are the result of cumulative trauma or repetitive use and stress. This report summarizes the incidence, trends, types, external causes, and dispositions of acute injuries among active component U.S. service members over a 10-year surveillance period.

METHODS

The surveillance period was 1 January 2008 through 31 December 2017. The surveillance population included all individuals who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. All data used to determine incident acute injury diagnoses were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System [MHS]) treatment facilities.

For surveillance purposes, acute injuries were defined using records of inpatient and outpatient medical encounters that included injury-specific diagnoses in the first diagnostic position. ICD-9 and ICD-10 codes used to define acute injuries were extracted from the *MSMR* burden dictionary of ICD codes, and included ICD-9 codes in the 800–959 range, ICD-10 codes beginning with "S," and ICD-10 codes in the T07–T32 range. Injuries were categorized by affected anatomic site: head/neck, arm/shoulder, hand/wrist, back/abdomen, knee, leg, and foot/ankle. Excluded were diagnoses of injuries that did not fall under one of these anatomic site categories (e.g., injuries to unspecified or other anatomic sites); environmental injuries (e.g., effects of radiation, reduced temperature, heat and light, air pressure, insect bites, or other external causes); and poisoning. To identify incident cases of injury, a 60-day gap rule was applied. To be counted as a new incident case, at least 60 days must have passed since the last medical encounter with a qualifying injury diagnosis in the first diagnostic position. Incident cases were counted separately for each anatomic site category. For example, an individual could be counted for both "head and neck" and "arm and shoulder" within the same 60-day period but could not be counted twice for "head and neck" injury within the same 60-day period.

Injuries that occurred during a period of deployment were excluded, and deployment-related person-time was excluded from the denominators of incidence rate calculations. In addition, all war- and battle-related causes of injuries were excluded from the analysis. Causes of injuries were assessed based on North Atlantic Treaty Organization Standard Agreement 2050 (STANAG) and ICD-9/ICD-10 "external cause of injury" codes. The same list of "cause of injury" and "external cause of injury" codes that was being used in the Armed Forces Health Surveillance Branch (AFHSB) Installation Injury Report at the time of writing was used in the analyses for this report.[8] For inpatient encounters, STANAG and Trauma codes were prioritized over external cause of injury codes when assigning cause of injury (if both were coded in the same encounter). For encounters that had multiple causes indicated, prioritization was assigned to the first-occurring diagnostic position (second diagnostic position was prioritized over third diagnostic position, etc.).

The type of injury for each acute incident injury was also described, using a modified version of the Centers for Disease Control and Prevention/National Center for Health Statistics Barell Matrix and Injury Mortality Diagnosis Matrix.[9] The codes used to define these type of injury categories are shown in **Table 1**.

Finally, this report presents the disposition of each acute injury (returned to duty with no limitations, returned to duty with limitations, or not returned to duty). Incident acute injuries that were diagnosed in outsourced care settings were excluded from the disposition analysis because disposition data were not available for outsourced care encounters. If there was no indication of disposition in the medical encounter (roughly 7% of outpatient cases and 11% of inpatient cases), then the service member was assumed to be returned to duty with no limitations. This was done to be consistent with the way that dispositions are assigned and categorized in the AFHSB Installation Injury Report.[8]

TABLE 1. ICD-9/ICD-10 codes used to define type of injury categories

Category	ICD-9	ICD-10
Fracture	800–829	S02, S12, S22, S32, S42, S490–S491, S52, S590–S592, S62, S72, S790–S791, S82, S890–S893, S92, S992
Dislocation	830–839	S030–S033, S130–S132, S230–S232, S330–S334, S430–S433, S530–S531, S630–S632, S730, S830, S831, S930–S933
Sprains/strains	840–848	S034, S038, S039, S0911, S134–S135, S138, S139, S161, S233–S234, S238, S239, S2901, S335–S336, S338–S339, S3901, S434–S436, S438–S439, S4601, S4611, S4621, S4631, S4681, S4691, S534, S5601, S5611, S5621, S5631, S5641, S5651, S5681, S5691, S635–S636, S638–S639, S6601, S6611, S6621, S6631, S6641, S6651, S6681, S6691, S731, S7601, S7611, S7621, S7631, S7681, S7691, S834–S836, S838–S839, S8601, S8611, S8621, S8631, S8681, S8691, S934–S936, S9601, S9611, S9621, S9681, S9691
Internal	850–854, 860–869, 952	S06, S140–S141, S240–S241, S260, S261, S27, S2690, S2691, S2699, S340, S341, S343, S36, S37
Open wound	870–884, 890–894	S01, S052–S057, S080, S092, S11, S21, S31, S41, S51, S61, S71, S7602, S81, S91
Amputations	885–887, 895–897	S081, S088, S089, S281, S282, S382, S383, S48, S58, S68, S78, S88, S98
Blood vessels	900–904	S090, S15, S25, S35, S45, S55, S65, S75, S85, S95
Contusion/superficial	910–924	S00, S050, S051, S10, S20, S30, S40, S50, S60, S70, S80, S90
Crush	925–929	S07, S17, S280, S380, S381, S47, S57, S67, S77, S87, S97
Burns	940–949	T20–T28, T30–T32
Nerves	950–951, 953–957	S04, S142–S146, S148, S149, S242–S244, S248, S249, S342, S344–S349, S44, S54, S64, S74, S84, S94
Other/unspecified	All other ICD-9 codes in 800–959	All other ICD-10 codes beginning with "S," or T07–T32

RESULTS

Incidence of injuries

During the surveillance period, more than 3.6 million acute incident injuries were diagnosed among more than 1.6 million individuals **(Table 2)**. The vast majority of acute incident injuries were diagnosed in outpatient settings (99.2%) **(data not shown)**. The highest overall rates were for injuries to the foot/ankle (61.8 per 1,000 p-yrs) **(Table 2)**. From 2008 through 2017, there was a 50% decrease in the annual incidence rates of back/abdomen injuries, a 32% decrease in the rates of foot/ankle injuries, and a 26% decrease in the rates of head/neck injuries. Annual rates of injuries to the hand/wrist and arm/shoulder both decreased by 21% during the surveillance period **(Figure)**. Incidence rates of knee and leg injuries were either stable or decreased from 2008 through 2014 but then increased from 2014 through 2017.

Overall incidence rates of acute injuries to the head/neck and hand/wrist were highest among service members aged 20–24 years **(Table 3)**. Incidence rates of acute injuries to the leg and foot/ankle were highest among those less than 20 years of age and decreased with increasing age. In contrast, overall incidence of acute injuries to the knee and arm/shoulder increased with increasing age. Back/abdomen acute injuries were highest among service members aged 35–39 years. These age trends were similar for both men and women **(Table 3)**.

Male and female service members had similar rates of acute injuries to the head/neck (47.5 per 1,000 p-yrs and 49.4 per 1,000 p-yrs, respectively) as well as to the knee (20.9 per 1,000 p-yrs and 19.5 per 1,000 p-yrs, respectively) **(Table 3)**. Males had higher rates of injury to the arm/shoulder as well as to the hand/wrist, whereas females had higher rates of injury to the back/abdomen, leg, and foot/ankle. In general, rates of acute injuries were relatively similar among the different race/ethnicity groups. However, compared to their respective counterparts, rates of acute injuries to the knee and leg were somewhat higher among non-Hispanic black service members, and rates of injuries to the head/neck and arm/shoulder were somewhat higher among non-Hispanic white service members.

Junior enlisted service members had the highest overall rates of injuries to the head/neck, hand/wrist, leg, and foot/ankle. Senior enlisted service members had the highest rates of injuries to the arm/shoulder, back/abdomen, and knee. In addition, recruits had higher overall rates of injuries to the knee, leg, and foot/ankle. In particular, the rate of acute injuries to the foot/ankle for recruits was three times that among non-recruits (175.4 per 1,000 p-yrs vs. 59.3 per 1,000 p-yrs, respectively). Rates of acute injuries to all other anatomic sites among recruits were similar to or less than rates among non-recruits **(Table 3)**.

Service members in the Army had higher overall rates of acute injuries to all anatomic sites, compared to those in the other service branches. In general, rates of injuries to most anatomic sites tended to be higher among service members in motor transport and/or combat-related occupations relative to those in other military occupations. However, rates of

TABLE 2. Incident diagnoses and incidence rates of acute injuries, active component, U.S. Armed Forces, 2008–2017

Category	No. of incident acute injuries	Rate[a]	No. of individuals affected
Head/neck	594,454	47.8	482,515
Arm/shoulder	561,197	45.1	412,209
Hand/wrist	562,400	45.2	456,073
Back/abdomen	502,658	40.4	400,099
Knee	257,009	20.7	184,856
Leg	435,754	35.0	357,102
Foot/ankle	768,973	61.8	589,338
Total	3,682,445	296.0	1,622,586

[a]Rate per 1,000 person-years

FIGURE. Annual incidence rates of acute injuries, by anatomic site category, active component, U.S. Armed Forces, 2008–2017

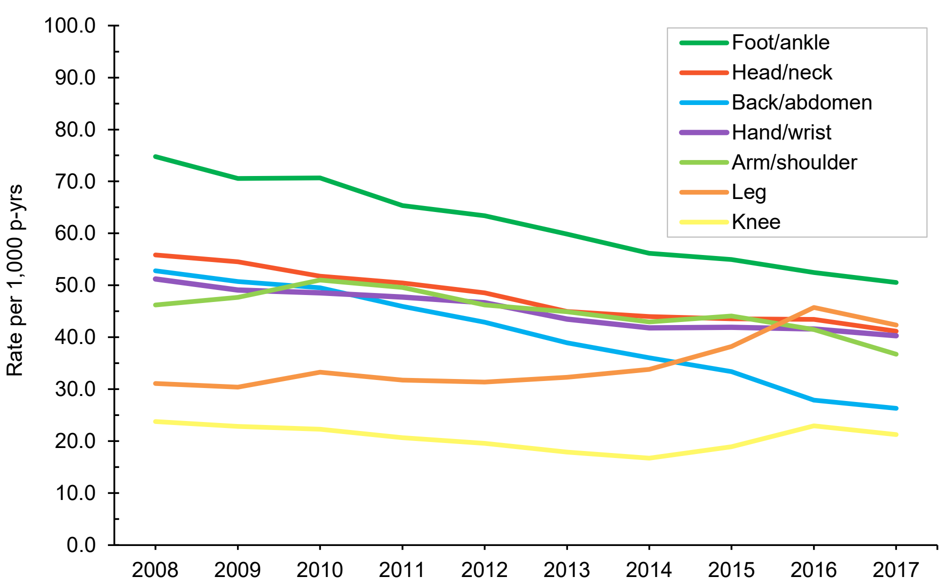

TABLE 3. Incident diagnoses and incidence rates of acute injury, by anatomic site, active component, U.S. Armed Forces, 2008–2017

	Head/neck		Arm/shoulder		Hand/wrist		Back/abdomen		Knee		Leg		Foot/ankle	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Age group														
≤19	41,650	49.5	31,000	36.8	37,767	44.9	25,834	30.7	15,297	18.2	39,875	47.4	80,778	95.9
20–24	218,846	55.7	168,361	42.9	206,785	52.7	149,008	38.0	75,864	19.3	146,994	37.4	280,683	71.5
25–29	144,140	48.8	132,055	44.7	138,306	46.9	124,513	42.2	59,457	20.1	100,390	34.0	183,741	62.2
30–34	82,273	42.4	85,364	44.0	78,558	40.5	82,499	42.5	38,365	19.8	61,601	31.7	102,869	53.0
35–39	56,669	39.3	71,192	49.4	54,626	37.9	64,039	44.4	32,766	22.7	45,998	31.9	67,758	47.0
40–49	45,912	37.9	66,182	54.6	42,124	34.8	51,861	42.8	31,706	26.2	37,196	30.7	48,629	40.1
≥50	4,964	38.8	7,043	55.1	4,234	33.1	4,904	38.4	3,554	27.8	3,700	28.9	4,515	35.3
Sex														
Male	500,759	47.5	488,515	46.3	484,387	45.9	414,527	39.3	220,089	20.9	357,315	33.9	626,578	59.4
Female	93,695	49.4	72,682	38.3	78,013	41.1	88,131	46.5	36,920	19.5	78,439	41.4	142,395	75.1
Sex (by age group)														
Males														
≤19	34,244	48.9	25,350	36.2	31,413	44.9	19,187	27.4	11,766	16.8	28,357	40.5	60,748	86.8
20–24	184,756	55.9	145,776	44.1	177,795	53.8	119,142	36.0	63,976	19.4	118,650	35.9	229,357	69.4
25–29	120,932	48.8	115,136	46.4	118,933	48.0	102,826	41.5	50,919	20.5	83,298	33.6	151,370	61.1
30–34	69,233	42.0	74,745	45.4	68,098	41.3	69,824	42.4	33,449	20.3	52,211	31.7	84,977	51.6
35–39	48,357	38.8	63,232	50.7	47,789	38.3	54,806	44.0	28,945	23.2	39,672	31.8	56,456	45.3
40–49	39,218	37.0	58,426	55.2	36,915	34.9	44,763	42.3	28,029	26.5	32,095	30.3	40,326	38.1
≥50	4,019	37.6	5,850	54.7	3,444	32.2	3,979	37.2	3,005	28.1	3,032	28.3	3,344	31.2
Females														
≤19	7,406	52.0	5,650	39.7	6,354	44.7	6,647	46.7	3,531	24.8	11,518	80.9	20,030	140.8
20–24	34,090	55.0	22,585	36.5	28,990	46.8	29,866	48.2	11,888	19.2	28,344	45.8	51,326	82.9
25–29	23,208	49.1	16,919	35.8	19,373	41.0	21,687	45.9	8,538	18.1	17,092	36.2	32,371	68.5
30–34	13,040	44.5	10,619	36.2	10,460	35.7	12,675	43.2	4,916	16.8	9,390	32.0	17,892	61.0
35–39	8,312	42.5	7,960	40.7	6,837	34.9	9,233	47.2	3,821	19.5	6,326	32.3	11,302	57.7
40–49	6,694	43.9	7,756	50.8	5,209	34.1	7,098	46.5	3,677	24.1	5,101	33.4	8,303	54.4
≥50	945	45.4	1,193	57.4	790	38.0	925	44.5	549	26.4	668	32.1	1,171	56.3
Race/ethnicity														
Non-Hispanic white	368,483	49.2	354,098	47.3	346,884	46.3	307,684	41.1	150,965	20.2	252,594	33.7	462,190	61.7
Non-Hispanic black	96,036	47.8	86,945	43.3	92,628	46.1	84,726	42.2	48,087	24.0	86,691	43.2	127,745	63.6
Hispanic	74,109	46.0	67,984	42.2	69,769	43.3	62,566	38.8	33,564	20.8	57,759	35.8	102,158	63.4
Asian/Pacific Islander	19,037	40.9	18,200	39.1	17,220	37.0	16,792	36.0	8,200	17.6	13,565	29.1	28,198	60.5
Other	36,789	42.3	33,970	39.0	35,899	41.2	30,890	35.5	16,193	18.6	25,145	28.9	48,682	55.9
Military grade														
Jr. Enlisted (E1–E4)	306,896	56.8	246,419	45.6	290,019	53.6	226,746	41.9	112,142	20.7	226,835	42.0	431,270	79.8
Sr. Enlisted (E5–E9)	219,444	44.9	238,105	48.7	206,237	42.2	214,842	44.0	109,068	22.3	156,317	32.0	257,865	52.8
Jr. Officer (O1–O3)	38,827	33.1	36,979	31.5	36,991	31.5	30,626	26.1	16,811	14.3	27,871	23.8	47,191	40.2
Sr. Officer (O4–O10)	23,078	28.7	31,490	39.1	23,478	29.2	23,800	29.6	15,637	19.4	19,682	24.4	26,078	32.4
Warrant Officer (W1–W5)	6,209	36.8	8,204	48.6	5,675	33.7	6,644	39.4	3,351	19.9	5,049	29.9	6,569	39.0
Recruit														
Yes	10,140	37.4	11,436	42.2	8,720	32.2	9,299	34.3	6,430	23.7	16,250	60.0	47,499	175.4
No	584,314	48.0	549,761	45.2	553,680	45.5	493,359	40.5	250,579	20.6	419,504	34.5	721,474	59.3
Service														
Army	273,809	59.5	252,623	54.9	238,045	51.7	229,106	49.8	108,758	23.6	210,962	45.8	343,882	74.7
Navy	106,427	35.6	99,835	33.4	110,071	36.8	91,781	30.7	47,736	16.0	65,575	22.0	134,212	44.9
Air Force	123,626	40.5	125,215	41.1	134,208	44.0	117,800	38.6	62,968	20.6	99,271	32.5	174,735	57.3
Marine Corps	90,592	50.3	83,524	46.4	80,076	44.5	63,971	35.6	37,547	20.9	59,946	33.3	116,144	64.5
Military occupation														
Combat-related[b]	106,979	61.3	86,216	49.4	79,777	45.7	66,274	38.0	36,841	21.1	61,473	35.2	102,334	58.7
Motor transport	20,850	58.0	17,842	49.6	18,256	50.8	16,595	46.2	8,158	22.7	14,085	39.2	24,794	69.0
Pilot/air crew	13,975	30.2	14,849	32.1	13,535	29.3	12,474	27.0	6,969	15.1	9,428	20.4	15,181	32.8
Repair/engineer	166,830	46.3	161,683	44.9	175,480	48.7	145,309	40.4	73,237	20.3	115,248	32.0	209,566	58.2
Communications/intelligence	124,952	45.8	123,430	45.2	115,847	42.4	118,522	43.4	58,150	21.3	102,257	37.4	176,394	64.6
Health care	51,187	45.9	49,956	44.8	51,909	46.5	46,577	41.7	22,120	19.8	36,221	32.4	64,754	58.0
Other	109,681	45.2	107,221	44.2	107,596	44.3	96,907	39.9	51,534	21.2	97,042	40.0	175,950	72.5

[a]Rate per 1,000 person-years
[b]Infantry/artillery/combat engineering/armor

injuries to the leg and foot/ankle were highest among service members in "other" occupations **(Table 3)**.

Type of injury

Overall, sprains/strains (48.5%) was the most common type of injury for all 3,682,445 acute incident injuries to all anatomic sites **(Table 4)**. Sprains/strains comprised 74.3% of back/abdomen injuries, 64.9% of foot/ankle injuries, 60.3% of arm/shoulder injuries, 47.1% of knee injuries, 44.0% of leg injuries. Of all incident head/neck injuries, the largest proportions of injury type categories were for contusion/superficial (21.9%), followed by sprains/strains (20.3%). For hand/wrist injuries, open wounds (27.6%) followed by sprains/strains (25.3%) were most common.

External causes

The majority (69.7%) of acute incident injuries for all anatomic sites were due to undocumented or undetermined causes **(Table 5)**. This percentage remained relatively stable during the surveillance period; however, there was a peak in injuries due to undocumented or undetermined causes in 2010 (79.5%) **(data not shown)**. Knee injuries had the highest percentage of undocumented causes (84.4%) and hand/wrist injuries had the lowest percentage (60.5%) **(Table 5)**. Miscellaneous (9.9%), overexertion (5.3%), slips/trips/falls (4.9%), athletics (3.2%), land transport (3.0%), and machinery/tools (2.4%) were the next most commonly documented external causes of injury for all acute incident injuries. These external causes made up 32.6%, 17.5%, 16.1%, 10.7%, 9.7%, and 7.8% of acute incident injuries with documented external causes of injury, respectively.

Compared to other anatomic sites, a relatively high percentage of head/neck injuries were caused by land transport accidents (7.2% of all head/neck injuries, 20.0% of head/neck injuries with documented external causes) **(Table 5)**. Similarly, a relatively high percentage of leg (5.5% of total, 19.2% of documented) and foot/ankle (4.7% of total, 14.8% of documented) acute incident injuries were caused by athletics. Also of note, 8.3% of total (30.9% of documented) back/abdomen injuries and 9.8% of total (30.8% of documented) foot/ankle injuries were caused by overexertion, and 11.2% of total (28.5% of documented) hand/wrist injuries were caused by machinery/tools.

Disposition

Overall, the most common disposition for incident injuries to all anatomic sites was returned to duty with no limitations (69.8%), followed by returned to duty with limitations (25.9%), and not returned to duty (4.3%) **(Table 6)**. Compared to other anatomic sites, head/neck injuries most commonly resulted in being returned to duty with no limitations (83.6%), whereas

TABLE 4. Type of acute incident injuries, by anatomic site, active component, U.S. Armed Forces, 2008–2017

	Fracture		Dislocation		Sprains/strains		Internal		Open wound		Amputations	
Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Head/neck	32,003	5.38	1,498	0.25	120,594	20.29	104,407	17.56	109,532	18.43	6	0.00
Arm/shoulder	51,987	9.26	51,010	9.09	338,523	60.32	0	0.00	21,575	3.84	408	0.07
Hand/wrist	119,883	21.32	11,597	2.06	142,524	25.34	0	0.00	154,998	27.56	1,646	0.29
Back/abdomen	28,626	5.69	1,367	0.27	373,618	74.33	11,216	2.23	11,395	2.27	4	0.00
Knee	3,873	1.51	78,957	30.72	120,923	47.05	0	0.00	1,631	0.63	0	0.00
Leg	38,614	8.86	893	0.20	191,910	44.04	0	0.00	27,441	6.30	3,188	0.73
Foot/ankle	112,030	14.57	4,344	0.56	499,062	64.90	0	0.00	27,505	3.58	307	0.04
Total	387,016	10.51	149,666	4.06	1,787,154	48.53	115,623	3.14	354,077	9.62	5,559	0.15

	Blood vessels		Contusion/superficial		Crush		Burns		Nerves		Other/ unspecified[a]	
Category	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Head/neck	415	0.07	130,146	21.89	198	0.03	6,797	1.14	1,389	0.23	87,469	14.71
Arm/shoulder	245	0.04	42,401	7.56	400	0.07	6,292	1.12	7,605	1.36	40,751	7.26
Hand/wrist	518	0.09	87,803	15.61	7,877	1.40	11,810	2.10	773	0.14	22,971	4.08
Back/abdomen	342	0.07	55,695	11.08	311	0.06	2,033	0.40	549	0.11	17,502	3.48
Knee	0	0.00	36,708	14.28	197	0.08	243	0.09	0	0.00	14,477	5.63
Leg	389	0.09	49,333	11.32	481	0.11	4,103	0.94	3,027	0.69	116,375	26.71
Foot/ankle	44	0.01	112,080	14.58	2,979	0.39	2,228	0.29	218	0.03	8,176	1.06
Total	1,953	0.05	514,166	13.96	12,443	0.34	33,506	0.91	13,561	0.37	307,721	8.36

[a]Includes effects of foreign bodies, lacerations, traumatic ruptures, "other," and "unspecified" injuries.

TABLE 5. Acute incident Injuries, by external cause category, active component, U.S. Armed Forces, 2008–2017

	Total		Head/neck		Arm/shoulder		Hand/wrist	
Total	No.	%	No.	%	No.	%	No.	%
Unintentional	--	--	--	--	--	--	--	--
Slips/trips/falls	179,720	4.88	30,278	5.09	28,750	5.12	26,763	4.76
Land transport	108,499	2.95	42,869	7.21	17,657	3.15	8,427	1.50
Air transport	1,776	0.05	682	0.11	194	0.03	111	0.02
Parachuting-related	7,243	0.20	2,189	0.37	755	0.13	127	0.02
Water transport	648	0.02	184	0.03	65	0.01	95	0.02
Athletics	119,125	3.23	8,785	1.48	17,203	3.07	11,476	2.04
Overexertion	194,883	5.29	7,316	1.23	27,461	4.89	8,669	1.54
Machinery/tools	87,226	2.37	4,881	0.82	4,371	0.78	63,210	11.24
Environmental factors	20,547	0.56	3,171	0.53	2,873	0.51	10,299	1.83
Poisons/fire	2,480	0.07	678	0.11	408	0.07	782	0.14
Guns/explosives (except war)	4,322	0.12	1,381	0.23	402	0.07	1,166	0.21
Miscellaneous	363,779	9.88	94,888	15.96	30,866	5.50	86,815	15.44
Intentional	--	--	--	--	--	--	--	--
Self-inflicted	3,481	0.09	490	0.08	1,165	0.21	1,435	0.26
Violence	22,570	0.61	16,132	2.71	1,527	0.27	2,692	0.48
Undocumented/undetermined cause	2,566,146	69.69	380,530	64.01	427,500	76.18	340,333	60.51

	Back/abdomen		Knee		Leg		Foot/ankle	
Total	No.	%	No.	%	No.	%	No.	%
Unintentional	--	--	--	--	--	--	--	--
Slips/trips/falls	19,136	3.81	10,910	4.24	20,878	4.79	43,005	5.59
Land transport	20,085	4.00	3,762	1.46	9,796	2.25	5,903	0.77
Air transport	273	0.05	40	0.02	166	0.04	310	0.04
Parachuting-related	1,154	0.23	183	0.07	1,097	0.25	1,738	0.23
Water transport	82	0.02	31	0.01	90	0.02	101	0.01
Athletics	13,490	2.68	7,778	3.03	24,096	5.53	36,297	4.72
Overexertion	41,637	8.28	5,957	2.32	28,172	6.47	75,671	9.84
Machinery/tools	1,457	0.29	224	0.09	5,304	1.22	7,779	1.01
Environmental factors	668	0.13	117	0.05	2,324	0.53	1,095	0.14
Poisons/fire	118	0.02	19	0.01	298	0.07	177	0.02
Guns/explosives (except war)	368	0.07	22	0.01	728	0.17	255	0.03
Miscellaneous	35,045	6.97	11,059	4.30	32,204	7.39	72,902	9.48
Intentional	--	--	--	--	--	--	--	--
Self-inflicted	177	0.04	7	0.00	146	0.03	61	0.01
Violence	1,272	0.25	124	0.05	510	0.12	313	0.04
Undocumented/undetermined cause	367,696	73.15	216,776	84.35	309,945	71.13	523,366	68.06

foot/ankle injuries were the least common (60.2%). In 2010, there was a spike in incident injuries that resulted in being returned to duty with no limitations accompanied by a corresponding drop in injuries that resulted in being returned to duty with limitations **(data not shown)**.

EDITORIAL COMMENT

This report summarizes the incidence, type, external causes, and disposition of acute injuries among active component U.S. service members from 2008 through 2017. The highest overall incidence rates during the surveillance period were for injuries to the foot/ankle, followed by head/neck, and hand/wrist. Rates of injuries to the leg and those to the foot/ankle were higher among younger service members, whereas incidence of injuries to the knee and to the arm/shoulder increased with increasing age. Males had higher rates of injuries to the arm/shoulder as well as to the hand/wrist, whereas females had higher rates of injuries to the back/abdomen, leg, and foot/ankle. Recruits also had higher rates of injuries to the knee, leg, and foot/ankle. Service members in the Army had higher rates of acute injuries to all anatomic sites, compared to the other service branches. In general, rates of injuries to most anatomic sites tended to be higher among service members in motor transport and/or combat-related occupations.

Data presented in this report suggest that injury prevention strategies should be tailored to different populations with different risk factors, including training and occupational exposures. For example, female soldiers have traditionally been

TABLE 6. Disposition of acute incident injuries diagnosed in military treatment facility inpatient or outpatient encounters, active component, U.S. Armed Forces, 2008–2017

Disposition	Total: No. of incident encounters	Total: %	Head/neck: No. of incident encounters	Head/neck: %	Arm/shoulder: No. of incident encounters	Arm/shoulder: %	Hand/wrist: No. of incident encounters	Hand/wrist: %
Returned to duty with no limitations	1,960,104	69.8	344,894	83.6	304,800	71.7	322,713	76.8
Returned to duty with limitations	727,710	25.9	33,839	8.2	107,408	25.3	85,115	20.3
Not returned to duty	120,175	4.3	33,864	8.2	12,763	3.0	12,142	2.9
Total incident encounters	2,807,989	100.0	412,597	100.0	424,971	100.0	419,970	100.0

Disposition	Back/abdomen: No. of incident encounters	Back/abdomen: %	Knee: No. of incident encounters	Knee: %	Leg: No. of incident encounters	Leg: %	Foot/ankle: No. of incident encounters	Foot/ankle: %
Returned to duty with no limitations	280,193	70.5	116,770	64.3	202,090	61.9	388,644	60.2
Returned to duty with limitations	92,375	23.2	60,741	33.5	112,320	34.4	235,912	36.6
Not returned to duty	24,900	6.3	4,055	2.2	11,839	3.6	20,612	3.2
Total incident encounters	397,468	100.0	181,566	100.0	326,249	100.0	645,168	100.0

shown to be at much higher risk of lower extremity musculoskeletal injuries during training, and this is further supported by the high rate of foot/ankle injuries among young female service members observed in this study.[10] Physical training is also the leading cause of injuries among service members, which is supported by the finding of high rates of lower extremity injuries among recruit trainees identified in this study.[5,7,10,11] However, aside from increasing physical fitness requirements, there is little opportunity for military intervention to prevent injuries among recruits before the start of basic training. Instead, interventions for training-related injuries must focus on the training regimens themselves. In addition, different occupations for active component service members have different physical demands. Such differences should be considered when deciding whether specialized protective equipment or training is needed. For example, paratroopers have traditionally been identified as being at high risk of ankle injuries and have benefitted by the use of parachute ankle braces during airborne operations.[13]

In 2004, the Military Training Task Force of the Defense Safety Oversight Council chartered a working group to identify, evaluate, and assess the level of scientific evidence for various physical training-related injury prevention strategies through an expedited systematic review process.[13] This working group identified six interventions that were recommended for implementation in the military: prevention of overtraining, agility-like training, mouthguards, semirigid ankle braces, nutrient replacement, and synthetic socks.[13] In contrast, the use of back braces and pre-exercise administration of anti-inflammatory medication were not recommended due to evidence of ineffectiveness or harm.[13] The working group also identified education, leader support, and surveillance as essential factors that are needed for successful injury prevention programs.[13]

There are several limitations to this study. The high level of missing data for external cause codes hinders the ability to make prevention recommendations based on the causes of injury. Although external cause coding is not mandatory, the ICD-10-CM Official Guidelines for Coding and Reporting strongly encourage medical professionals to code external causes to "provide valuable data for injury research and evaluation of injury prevention strategies."[14] There were several substantial changes in the number and structure of injury codes in the transition from ICD-9 to ICD-10 coding systems (which occurred on 1 October 2015); the impact of this transition on coding practices is not yet fully understood.[9] Therefore, time trends should be interpreted with caution.

Not all types of injuries were included in this report. Because one of the goals of this report was to categorize incidence of injury by anatomic site, injuries to unspecified or "other" sites, environmental injuries, and poisonings were excluded. Other studies have included selected diagnoses of musculoskeletal disorders (e.g., stress fractures, tendonitis, bursitis) in the definition of injury[6]; however, this analysis focused on only "acute" injuries included in the ICD-9 800–999 and ICD-10 S-T code series. Injuries that occur during deployment were also not included in this analysis. However, some injuries that occurred during deployment may have been unintentionally included if a service member was medically evacuated out of theater and treated in an inpatient or outpatient setting. Because data were based on diagnoses made using ICD-9 and ICD-10 codes, the severity of various injuries could not be quantified (aside from the type of injuries). In addition, data were not available to quantify time lost due to injuries.

MHS GENESIS, the new electronic health record for the MHS, was implemented at several military treatment facilities during 2017. Medical data from sites that are using MHS GENESIS are not available in 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 excluded from analysis.

This report aims to broaden the surveillance of acute injuries across the DoD. Future efforts could provide additional data on cumulative traumatic injuries, as well as breakdowns by installation and/or region. The epidemiology of overuse injuries resulting from cumulative trauma or repetitive use and stress will be particularly important to quantify to provide a more complete picture of the burden of injuries in the U.S. Armed Forces. Coupled with the most recent research findings on the effectiveness of various injury prevention strategies, the surveillance data presented here can help to identify the military's most at-risk groups and target them for injury prevention interventions.

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Major Deployment-related Amputations of Lower and Upper Limbs, Active and Reserve Components, U.S. Armed Forces, 2001–2017

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Major amputations of the lower and upper limbs are among the most life-altering and debilitating combat injuries. From 1 January 2001 through 31 October 2017, a total of 1,705 service members sustained major deployment-related lower and upper limb amputations. Lower limb amputations were far more common than upper limb amputations, with a total of 1,914 lower limb amputations, compared to 302 upper limb amputations. The greatest single-year number of amputations occurred in 2011, with a reported total of 273 service members who sustained 403 major limb amputations. The injured cohort mostly comprised non-Hispanic white male service members aged 21–29 years. Furthermore, the majority of the injured cohort included active component, mid-level or junior enlisted members of the Army or Marine Corps, in combat-specific occupations. These findings reiterate and extend previous reports of the annual numbers, types, and anatomic locations of deployment-related limb amputations, along with the demographics and military characteristics of the injured cohort from the Iraq and Afghanistan conflicts.

Major limb amputations are life-threatening and life-altering events for service members injured in combat. While amputations are viewed as lifesaving procedures in many cases, limb loss can often result in immediate and long-term decline in physical, social, and financial well-being of the injured service members.[1] Additionally, caring for service members with limb loss places a tremendous burden on their families, as well as the Departments of Defense (DoD) and Veteran Affairs (VA) health systems.[2,3] As a result of the extensive advanced medical and rehabilitative care provided within the DoD and VA healthcare systems, young, otherwise healthy combat amputees may now live active and productive lives.[4-7] As a result, better understanding of the size and characteristics of the combat-injured amputee population is critical to formulate sound strategies for current and future policy, healthcare, and readiness decisions.

On 8 April 2015, the Defense Health Board published a series of recommendations in a report entitled "Sustainment and Advancement of Amputee Care" focused on maintaining the current level of military competency and clinical readiness in the event of future conflicts.[8] One of the core recommendations of this report described the need for better characterization of the current landscape of military amputee care, to gain a better understanding for the health, healthcare needs, and healthcare utilization of the amputee population.[8] A fundamental step toward achieving this goal requires a thorough and up-to-date understanding of the numbers, types, and anatomic locations of the upper and lower limb amputations, along with demographic and military characteristics of this injured cohort.

In 2012, the *MSMR* reported a summary of the annual numbers and the types of upper and lower limb traumatic amputations in service members between the years 2000 and 2011.[9] Not surprisingly, relatively large numbers of major limb amputations (i.e., loss of a hand or foot or more) were reported during the period of more widespread and intense ground combat operational activities in Afghanistan and Iraq. For example, there were large numbers of major lower limb amputations from 2003 through 2007 and again during 2010 and 2011 among junior enlisted members of the Marine Corps and Army serving in combat-specific military occupations (i.e., infantry/artillery/combat engineering/armor). The current report reiterates and extends details from the previous report on the numbers, types, and anatomic locations of deployment-related major lower and upper limb amputations, along with the demographics and military characteristics of this cohort from 2001 through 2017.

METHODS

The surveillance period for this report was 1 January 2001 through 31 October 2017. The surveillance population consisted of all individuals who served in an active and/or reserve component of the U.S. Armed Forces at any time during the surveillance period. Diagnosis codes from the International Classification of Diseases, 9th and 10th Revisions, Clinical Modifications (ICD-9/ICD-10) specific for amputations were used to identify major amputations among service members during the surveillance period **(Table 1)**.

All data to determine the numbers, types, and anatomic locations of lower and upper limb amputations were derived from records routinely maintained in the Expeditionary Medical Encounter Database (EMED). The EMED is a comprehensive

TABLE 1. ICD-9/ICD-10 diagnostic codes for major traumatic lower and upper limb amputations

	Diagnostic codes	
Upper extremity	ICD-9	ICD-10
Traumatic amputation of arm and hand (complete) (partial)		
Unilateral, below elbow	887.0, 887.1	S58.111A, S58.112A, S58.119A, S58.121A, S58.122A, S58.129A, S68.411A, S68.412A, S68.419A, S68.421A, S68.422A, S68.429A
Unilateral, at or above elbow	887.2, 887.3	S48.012A, S48.019A, S48.021A, S48.022A, S48.029A, S48.111A, S48.112A, S48.119A, S48.121A, S48.122A, S48.129A, S48.921A, S48.922A, S58.019A, S58.029A
Bilateral (any level)	887.6, 887.7	S48.911A, S48.912A
Unilateral, unspecified	887.4, 887.5	S48.919A, S48.929A
Lower extremity		
Traumatic amputation of foot – unilateral (complete) (partial)		
Unilateral (complete) (partial)	896.0, 896.1	S98.011A, S98.012A, S98.019A, S98.021A, S98.022A, S98.029A, S98.311A, S98.312A, S98.319A, S98.321A, S98.322A, S98.329A, S98.919A, S98.929A
Bilateral	896.2, 896.3	S98.911A, S98.912A, S98.921A, S98.922A
Traumatic amputation of leg(s) (complete) (partial)		
Unilateral, below knee	897.0, 897.1	S88.111A, S88.112A, S88.119A, S88.121A, S88.122A, S88.129A
Unilateral, at or above knee	897.2, 897.3	S78.019A, S78.029A, S78.119A, S78.129A, S78.919A, S78.929A, S88.011A, S88.012A, S88.019A, S88.021A, S88.022A, S88.029A
Bilateral (any level)	897.6, 897.7	S78.011A, S78.012A, S78.021A, S78.022A, S78.111A, S78.112A, S78.121A, S78.122A, S88.911A, S88.912A
Unilateral, unspecified	897, 897.4, 897.5	S78.911A, S78.912A, S78.921A, S78.922A, S88.919A, S88.921A, S88.922A, S88.929A

deployment-related data repository that provides a high-quality source of clinical, tactical, and personnel data for each casualty, sickness or injury, during deployment.[10] These data are used for determining theater medical requirements (modeling and simulation) and for performing research. For each casualty, sick or injured, in overseas contingency operations, a comprehensive clinical record is established beginning with the first medical treatment at the point of injury. As the patient moves through the medical chain of evacuation, additional clinical data are added to the EMED, including injury, disease, and psychiatric profile, procedures administered, clinical complications of care, and patient outcomes. In addition, ICD-9 and ICD-10 clinical diagnoses and injury severity codes are assigned by trained clinicians. Finally, tactical data describing the circumstances that generated the casualty and personnel data describing the casualty's pre- and post-injury military and medical histories are added.

For surveillance purposes, the EMED was queried for case-defining ICD-9 (for amputations before 1 October 2015) and ICD-10 (for amputations on or after 1 October 2015) diagnostic codes for all amputations of partial hand or foot and greater from 1 January 2001 through 31 October 2017. The Extremity Trauma and Amputation Center of Excellence Amputation Registry also was utilized for confirmation of identified cases. Additional data collected from the EMED included anatomic amputation information, gender, age, branch of service, and military paygrade, all at time of injury. Other demographic variables such as active or reserve status, race/ethnicity, and military occupation were obtained from the Defense Manpower Data Center Contingency Tracking System.

Amputations of fingers or toes were excluded. Service members who were determined to have been killed in action or to have died of wounds were also excluded from this report. Service members with multiple amputations were counted only once in the population as individuals; however, each amputation was included separately in total counts and analyses of amputations.

RESULTS

During the surveillance period, a total of 1,705 service members sustained deployment-related, major amputations **(Table 2)**. Lower limb amputations were far more common than upper limb amputations, with 1,496 service members sustaining a total of 1,914 lower limb amputations compared to 284 service members sustaining a total 302 upper limb amputations. During the surveillance period, bilateral amputations were more common in the lower extremities (n=418; 25% of all individuals who had amputations), compared to the upper extremities (n=18; 1%; **Table 2**). Additionally, there were 46 service members who sustained triple amputations and six service members who sustained quadruple amputations during the surveillance period **(data not shown)**.

Of the lower limb amputations, the most common type was transtibial (n=995; 52%), followed by transfemoral (n=469; 25%), knee disarticulation (n=266; 14%), foot or partial foot (n=115; 6%), ankle

TABLE 2. Distribution of upper and lower limb amputations, by number of individuals, active and reserve components, U.S. Armed Forces, 2001–2017

		Upper limb amputations			
		Unilateral	Bilateral	No upper	Total
Lower limb amputations	Unilateral	23	2	1,053	1,078
	Bilateral	44	6	368	418
	No lower	199	10	-	209
	Total	266	18	1,421	1,705

(n=46; 2%), and hip disarticulation (n=23; 1%) **(Figure 1)**. During the surveillance period, the number of lower limb amputations increased each year from 80 in 2003 to 234 in 2007, before decreasing to 117 and 111 in 2008 and 2009, respectively. The number of lower limb amputations began to increase again in 2010, peaking at 377 in 2011, the most of any year during the surveillance period **(Figure 1)**. Bilateral lower limb amputations followed a similar trend **(data not shown)**, with spikes in 2007 (n=46) and 2011 (n=111).

Of the upper limb amputations, the most common type was transradial (n=114; 38%), followed by transhumeral (n=78; 26%), hand or partial hand (n=51; 17%), wrist disarticulation (n=32; 11%), elbow disarticulation (n=18; 6%), and shoulder disarticulation (n=8; 3%) **(Figure 2)**. The highest numbers of upper limb amputations were observed in 2004 (n=47) and 2005 (n=42), followed by 2007 (n=39). Declines in upper limb amputations were observed in 2008 (n=13) and 2009 (n=12), before again increasing in 2010 (n=35). After 2012, the number of upper limb amputations declined sharply from 23 in 2012 to six in 2013 followed by two in 2014 **(Figure 2)**. The number of bilateral upper limb amputations was relatively stable and low throughout the surveillance period, with none occurring in 2001, 2002, 2006, 2008, or after 2013 **(data not shown)**.

The injured cohort mostly comprised male service members (n=1,677; 98%), of non-Hispanic white race/ethnicity (n=1,299; 76%), and aged 21–29 (n=1,132; 66%) **(Table 3)**. Furthermore, the majority of the injured cohort were members of the active component (n=1,497; 88%), served in the Army (n=1,141; 67%) or Marine Corps (n=493; 29%), were junior or mid-level enlisted (E1–E6; n=1,494; 88%), in combat-specific occupations (n=1,067; 63%) **(Table 3)**. Additionally, the most frequent cause of major limb amputation for the cohort was a blast injury (n = 1,545; 91%) **(Table 3)**.

From 2003 through 2009, more than three-quarters of those with limb amputations were Army members **(Figure 3)**.

FIGURE 1. Numbers of major deployment-related lower limb amputations, by anatomic location, active and reserve components, U.S. Armed Forces, 2001–2017

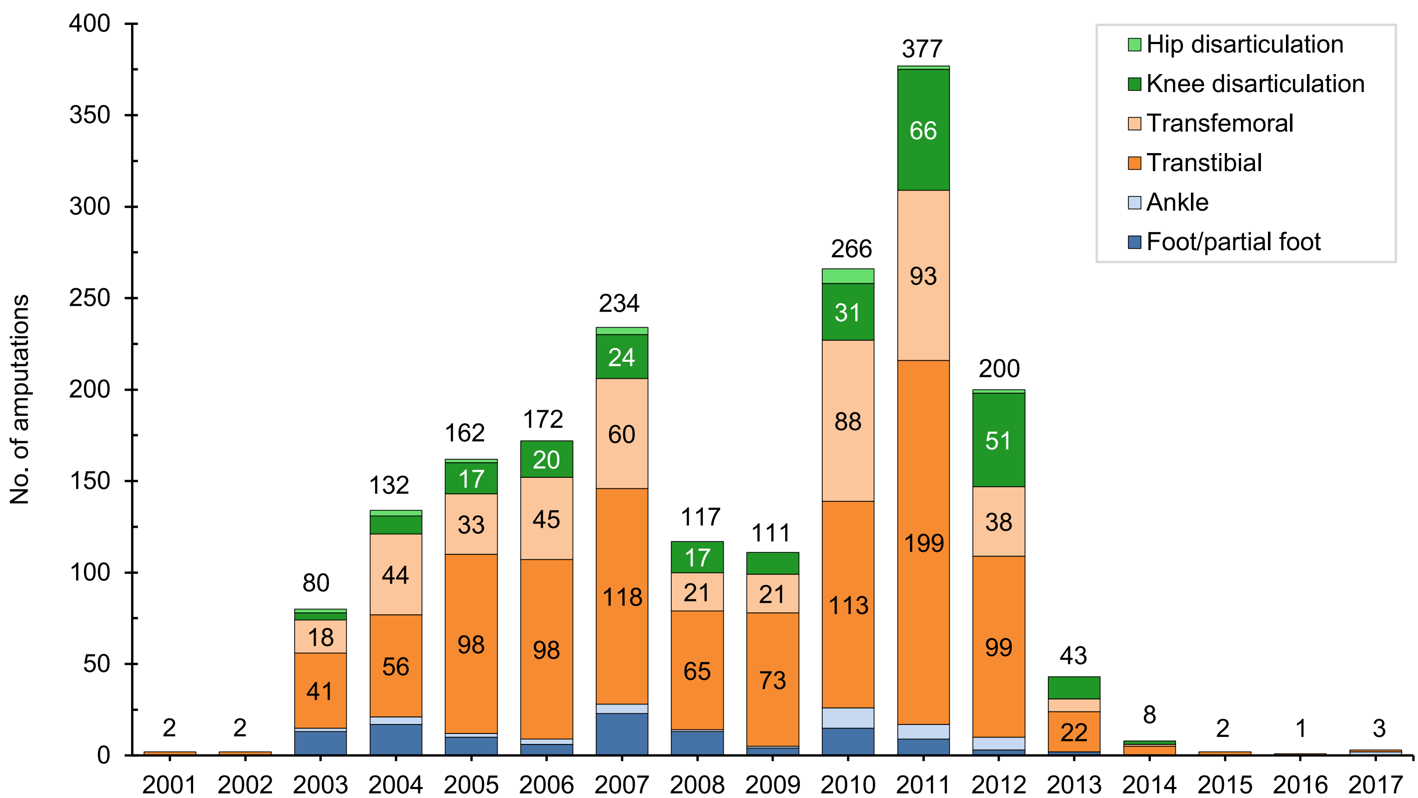
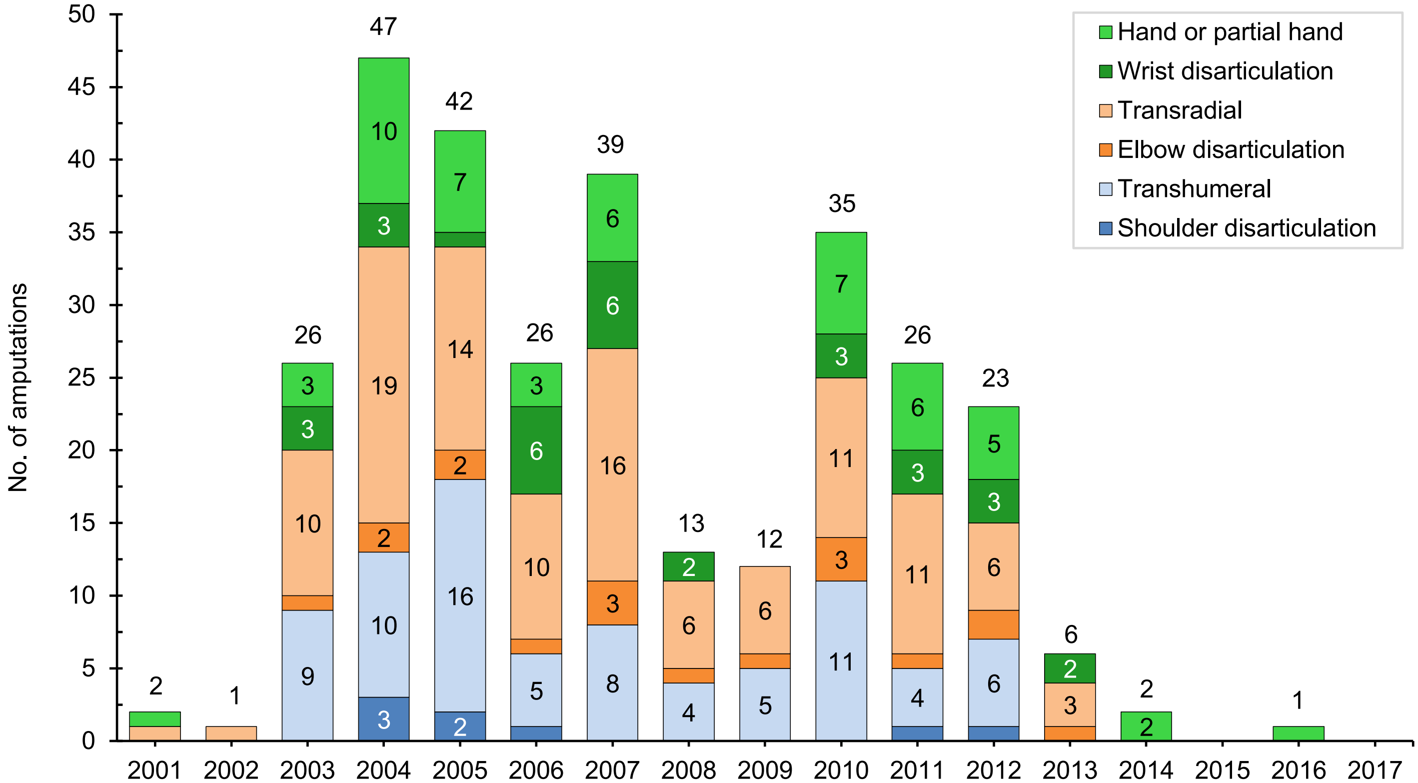


FIGURE 2. Numbers of major deployment-related upper limb amputations, by anatomic location, active and reserve components, U.S. Armed Forces, 2001–2017



Note: One upper extremity amputation categorized as "other" was excluded.

However, after 2009, the frequency of Marine Corps members sustaining amputations increased dramatically, going from 22 in 2009 to 91 in 2010 and 155 in 2011, representing 23%, 43% and 57% of injured service members for each year, respectively. In 2011, the year with the most amputations for the whole surveillance period, members of the Marine Corps made up the majority of service members with amputations **(Figure 3)**.

Throughout the entire surveillance period, mid-level enlisted (E4–E6) service members comprised the majority of the deployment-related amputation population, followed by junior enlisted (E1–E3) service members **(Figure 4)**. However, the numbers and proportions of junior enlisted service members sustaining amputations increased markedly from 2010 through 2011, with junior enlisted service members representing 32% and 40% of all injured service members, respectively.

The vast majority of deployment-related major amputations were sustained by active component service members as compared to those in the Reserve/Guard components **(Figure 5)**. Between 2003 and 2006, the active component service members accounted for 74%–84% of each year's total amputation injuries. However, from 2007 through 2014, the annual proportions for the active component increased to 91%–100% **(Figure 5)**.

EDITORIAL COMMENT

This report reiterates and extends the findings of previous surveillance reports in describing the annual numbers, types, and anatomic locations of deployment-related major limb amputations during the 16 years and 10 months of the surveillance period. The report also compares trend differences regarding major lower and upper limb amputations, overall and in relation to various demographic and military characteristics. During 2001–2017, there were a total of 2,216 reported cases of deployment-related, major lower and upper limb amputations sustained by 1,705 service members. The greatest number of amputations in a single year occurred in 2011 at the height of the surge in operations in Afghanistan, with a reported total of 403 major lower and upper limb amputations sustained by 273 service members.

Overall, and consistent with a previous report,[9] relatively large numbers of major limb amputations were observed during periods of more widespread and intense ground combat operational activities. More specifically, an increasing number of major lower limb amputations were observed between 2003 through 2007 and again

TABLE 3. Demographic and military characteristics of service members with major limb amputations, active and reserve components, U.S. Armed Forces, 2001–2017

	N	%
Total	1,705	100.0
Sex		
Female	28	1.6
Male	1,677	98.4
Age group		
≤20	272	16.0
21–24	694	40.7
25–29	438	25.7
30–34	180	10.6
35–39	82	4.8
≥40	38	2.2
Missing	1	0.1
Race/ethnicity		
Non-Hispanic white	1,299	76.2
Non-Hispanic black	112	6.6
Hispanic	174	10.2
Asian/Pacific Islander	45	2.6
American Indian/Alaska Native	20	1.2
Missing	55	3.2
Service		
Army	1,141	66.9
Navy	46	2.7
Air Force	25	1.5
Marine Corps	493	28.9
Component		
Active	1,497	87.8
Reserve/Guard	195	11.4
Missing	13	0.8
Grade		
Jr. Enlisted (E1–E3)	484	28.4
Mid-level Enlisted (E4–E6)	1,010	59.2
Sr. Enlisted (E7–E9)	80	4.7
Officer	129	7.6
Missing	2	0.1
Occupation		
Combat-specific[a]	1,067	62.6
Support services/admin[b]	257	15.1
Communications/intelligence/ops	213	12.5
Repair/engineer	76	4.5
Healthcare	58	3.4
Other/unknown	12	0.7
Missing	22	1.3
Mechanism of injury		
Blast	1,545	90.6
Gunshot wounds	73	4.3
Other	87	5.1

[a]Infantry/artillery/combat engineering/armor
[b]Includes motor transport.

between 2010 through 2012. Of note, the time period between 2009 and 2011 represented a sharp increase in numbers of lower limb amputations—particularly among junior enlisted members of the Marine Corps and the Army, reflecting a surge in the extent and intensity of dismounted ground combat operations. Although 2012 marked a decline in the number of major lower limb amputations, compared to the previous 2 years, a substantial number of almost 200 lower limb amputations were still sustained.

During the surveillance period, the numbers of major amputations of the upper limbs were much smaller, compared to the numbers of major amputations of the lower limbs. The highest numbers of upper limb amputation occurred between 2004 and 2005, in 2007, and between 2010 and 2012. The smaller number of upper limb amputations (n=302), compared to lower limb amputations (n=1,914) is most likely the result of the lower limbs accounting for a greater body surface area and being more exposed to blast trauma.[11]

The results of this report should be interpreted with consideration of its limitations. For example, the analyses were based on high-quality clinical, tactical, and personnel data from the EMED for service members injured during deployment. As such, the summaries reported here do not include non-deployment limb amputations due to training accidents, motor vehicle accidents, or sports-related injuries in the military. In addition, minor traumatic amputations of the fingers and toes were also not considered, due to the imprecise nature of reporting such procedures within the medical records. Misclassification and incomplete capture of limb amputations in the military medical surveillance data were also possible, given the reliance of coders on provider documentation, which may be nonspecific or unclear. Finally, some injured service members, especially those with delayed amputations, may have received care outside of the Military Health System (e.g., at civilian trauma centers and VA hospitals); in such cases, amputations were not documented in records used for this analysis.

In summary, a large number of deployment-related, major amputations of the upper and lower limbs have occurred since 2001. In general, lower limb amputations have occurred at a much higher rate compared to upper limb amputations, due to the predominance of blast injuries caused by improvised explosive devices. Additionally, the demographics and military characteristics of the injured cohort includes a substantially greater proportion of young, white male, junior to mid-level enlisted members of the Army and the Marine Corps. Although improvements in protective gear and body armor, and advancements in military medicine, particularly in acute in-field care and aeromedical patient transport, have significantly improved survival from traumatic injury, limb loss continues to pose new challenges for the military and VA health systems.[8] To this end, the growing number of young, high-performing service members living with amputated limbs has created a unique amputee population with specific, long-term needs requiring considerable attention and resource allocation.

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FIGURE 3. Numbers of service members with deployment-related amputations, by service, active and reserve components, U.S. Armed Forces, 2001–2017

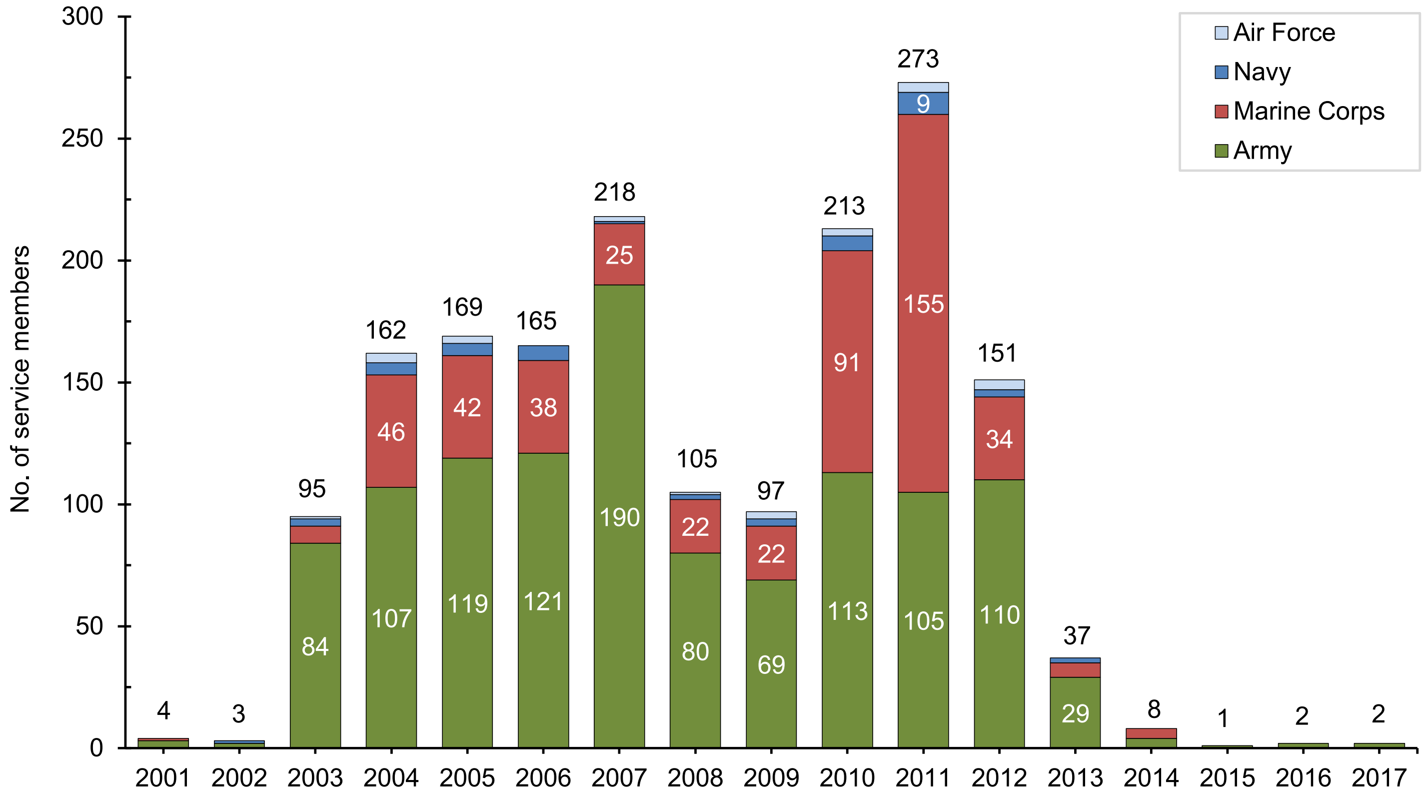
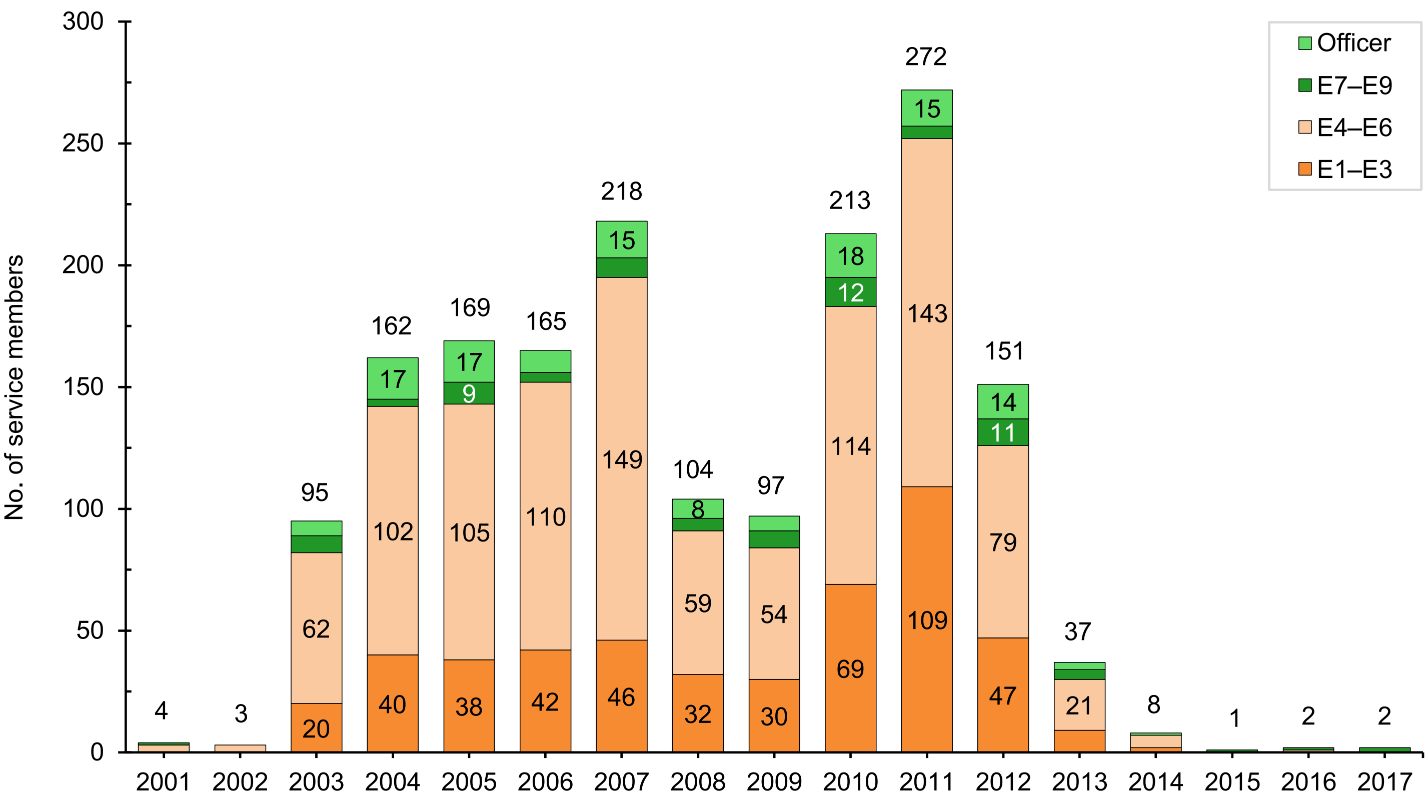
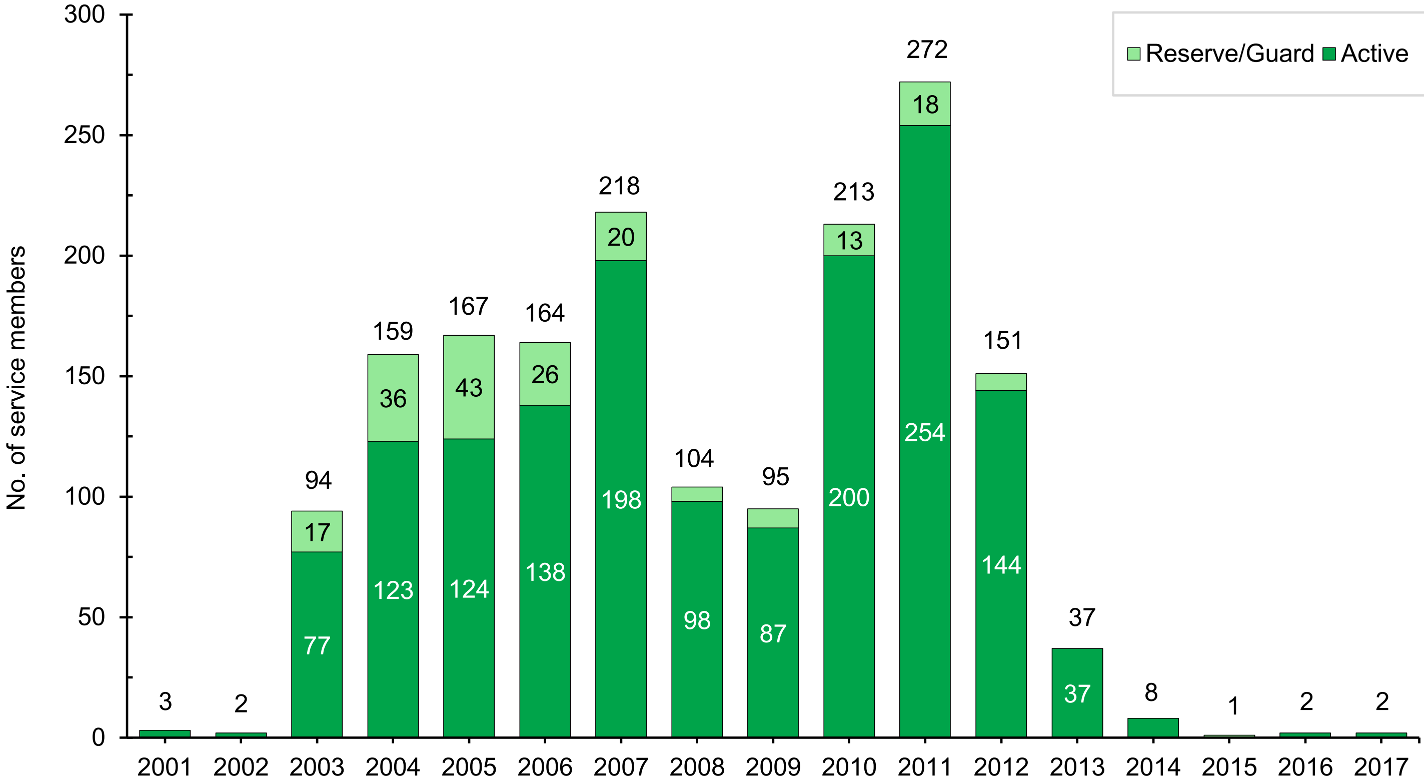


FIGURE 4. Numbers of service members with deployment-related amputations, by grade, active and reserve components, U.S. Armed Forces, 2001–2017



Note: Two service members with missing grade information at the time of analysis were excluded.

FIGURE 5. Numbers of service members with deployment-related amputations, by component, U.S. Armed Forces, 2001–2017



Note: A total of 13 service members with missing or unknown component information at time of analysis were excluded.

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Update: Medical Evacuations, Active and Reserve Components, U.S. Armed Forces, 2017

In 2017, a total of 626 medical evacuations of service members from the U.S. Central Command area of responsibility were followed by at least one medical encounter in a fixed medical facility outside the operational theater. There were more medical evacuations for mental health disorders than for any other category of illnesses or injuries. Annual rates of medical evacuations attributable to battle injuries decreased from 3.5 per 1,000 deployed person-years [dp-yrs] (n=317) in 2013 to a low of 0.73 per 1,000 dp-yrs (n=28) in 2016, and then increased to 1.4 per 1,000 dp-yrs (n=53) in 2017. Annual rates of medical evacuations attributable to non-battle injuries and illnesses were relatively stable from 2015 through 2017. Compared to their respective counterparts, medical evacuation rates were highest among non-Hispanic black service members, among those aged 19 years or younger or aged 45 years or older, among Army members, and among those in combat-specific occupations. Most service members who were evacuated were returned to normal duty status following their post-evacuation hospitalizations or outpatient encounters.

In recent years, there have been substantial reductions in combat operations taking place in the U.S. Central Command (CENTCOM) area of responsibility (AOR) in Southwest Asia.[1-3] However, the number of service members deployed to CENTCOM AOR since 2012 is still significant. From 1 January 2013 through 31 December 2017, there were more than 650,000 deployments in support of CENTCOM AOR operations, including Operation Enduring Freedom (OEF), Operation Freedom's Sentinel (OFS), Operation New Dawn (OND), and Operation Inherent Resolve (OIR). In theaters of operations such as Afghanistan, most medical care is provided by deployed military medical personnel; however, some injuries and illnesses require medical management outside the operational theater. In these cases, the affected individuals are usually transported by air to a fixed military medical facility in Europe or the U.S. At the fixed facility, the service members receive the specialized, technically advanced, and/or prolonged diagnostic, therapeutic, and rehabilitative care required.

Medical air transports ("medical evacuations") are costly and generally indicative of serious medical conditions. Some serious conditions are directly related to participation in or support of combat operations (e.g., battle wounds); however, many others are unrelated to combat and may be preventable. This report summarizes the natures, numbers, rates, and trends of conditions for which male and female military members were medically evacuated from CENTCOM AOR operations during 2017 and compares them to the previous 4 years.

METHODS

The surveillance period was 1 January 2013 through 31 December 2017. The surveillance population included all members of the active and reserve components of the U.S. Army, Navy, Air Force, and Marine Corps who were deployed as part of CENTCOM AOR operations during the period. The outcomes of interest in this analysis reflected individuals who were medically evacuated during the surveillance period from CENTCOM AOR (e.g., Afghanistan, Iraq) to a medical treatment facility outside the CENTCOM AOR. Evacuations were included in analyses if the affected service member had at least one inpatient or outpatient medical encounter in a permanent military medical facility in the U.S. or Europe during a time interval extending from 5 days before to 10 days after the reported evacuation date. Evacuations were included only if they occurred during the time frames documented in service members' CENTCOM AOR deployment records or within 90 days after. Deployment records were available from the Defense Manpower Data Center Contingency Tracking System in the Defense Medical Surveillance System (DMSS). Records of all medical evacuations conducted by the U.S. Transportation Command (TRANSCOM), maintained in the TRANSCOM Regulating and Command & Control Evacuation System (TRAC2ES), were also utilized.

Medical evacuations included in the analyses were classified by the causes and natures of the precipitating medical conditions (based on information reported in relevant evacuation and medical encounter records). First, all medical conditions that resulted in evacuations were classified as "battle injuries" or "non-battle injuries and illnesses" (based on entries in an indicator field of the TRAC2ES evacuation record). Evacuations due to non-battle injuries and illnesses were subclassified into 17 illness/injury categories based on International Classification of Diseases (ICD-9/ICD-10) diagnostic codes reported on records of medical encounters after evacuation. For this purpose, all records of hospitalizations and ambulatory visits from 5 days before to 10 days after the reported date of each medical evacuation were identified. In most cases, the primary (first-listed) diagnosis for either a hospitalization (if one occurred) or the earliest ambulatory visit after evacuation was considered indicative of the condition responsible for the evacuation. However, if the first-listed diagnostic code specified the external cause (rather than the nature) of an injury (ICD-9 E-code/ICD-10 V-, W-, X-, Y-code) or an encounter for something other than a current illness or injury (e.g., observation, medical examination, vaccination [ICD-9 V-codes/ICD-10 Z-codes other than those related to pregnancy]), then secondary diagnoses that specified illnesses and injuries (ICD-9: 001–999/ICD-10: A00–T88) were considered the likely reasons for the subject evacuations. If there was no secondary diagnosis, or the secondary diagnosis also was an external cause code, then the first-listed diagnostic code of a subsequent encounter was used. For this analysis, one medical evacuation per deployment per service member was counted.

Denominators for rates of medical evacuations were calculated by determining the length of each individual's deployment and summing the person-time of all deployers. If the deployment end date was missing, the end date was imputed based on average deployment times per service, component, and deployment location.

The disposition after each medical evacuation was determined by using the disposition code associated with the medical encounter that was used for determining the category of the medical evacuation. Inpatient disposition categories were: returned to duty (code: 01), transferred/discharged to other facility (codes: 02–04, 09, 21–28, 43, 61–66), died (codes: 20, 30, 40–42, 50, 51), separated from service (codes: 10–15), and other/unknown. Outpatient disposition categories were: released without limitation (code: 1), released with work/duty limitation (code: 2), immediate referral (code: 4), sick at home/quarters (codes: 3, S), admitted/transferred to civilian hospital (codes: 7, 9, A–D, U), died (codes: 8, G), discharged home (code: F), and other/unknown.

TABLE 1. Numbers and rates of medical encounters following medical evacuation from theater, by ICD-9/ICD-10 diagnostic category, U.S. Armed Forces, 2017

	Total			Males			Females			Rate ratio	Rate difference
Diagnostic category (ICD-9/ICD-10)	No.	%	Rate[a]	No.	%	Rate[a]	No.	%	Rate[a]	Female: Male	Female–Male
Mental disorders (ICD-9: 290–319, ICD-10: F01–F99)	148	23.64	3.80	119	22.24	3.47	29	31.87	6.26	1.80	2.79
Non-battle injury and poisoning (ICD-9: 800–999, ICD-10: S00–T88, DOD0101–DOD0105)	132	21.09	3.39	116	21.68	3.38	16	17.58	3.45	1.02	0.07
Musculoskeletal system (ICD-9: 710–739, ICD-10: M00–M99)	74	11.82	1.90	68	12.71	1.98	6	6.59	1.30	0.65	-0.69
Signs, symptoms, and ill-defined conditions (ICD-9: 780–799, ICD-10: R00–R99)	69	11.02	1.77	59	11.03	1.72	10	10.99	2.16	1.25	0.44
Battle injury (from TRAC2ES records)	53	8.47	1.36	52	9.72	1.52	1	1.10	0.22	0.14	-1.30
Digestive system (ICD-9: 520–579, ICD-10: K00–K95)	37	5.91	0.95	31	5.79	0.90	6	6.59	1.30	1.43	0.39
Nervous system and sense organs (ICD-9: 320–389, ICD-10: G00–G99, H00–H95)	23	3.67	0.59	22	4.11	0.64	1	1.10	0.22	0.34	-0.43
Genitourinary system (ICD-9: 580–629, ICD-10: N00–N99)	21	3.35	0.54	11	2.06	0.32	10	10.99	2.16	6.73	1.84
Circulatory system (ICD-9: 390–459, ICD-10: I00–I99)	20	3.19	0.51	17	3.18	0.50	3	3.30	0.65	1.31	0.15
Neoplasms (ICD-9: 140–239, ICD-10: C00–D49)	14	2.24	0.36	12	2.24	0.35	2	2.20	0.43	1.23	0.08
Other (ICD-9: V01–V99, except pregnancy-related, ICD-10: Z00–Z99, except pregnancy-related)	9	1.44	0.23	7	1.31	0.20	2	2.20	0.43	2.12	0.23
Respiratory system (ICD-9: 460–519, ICD-10: J00–J99)	6	0.96	0.15	6	1.12	0.17	0	0.00	0.00	--	--
Skin and subcutaneous tissue (ICD-9: 680–709, ICD-10: L00–L99)	6	0.96	0.15	4	0.75	0.12	2	2.20	0.43	3.70	0.32
Endocrine, nutrition, immunity (ICD-9: 240–279, ICD-10: E00–E89)	5	0.80	0.13	3	0.56	0.09	2	2.20	0.43	4.94	0.34
Infectious and parasitic diseases (ICD-9: 001–139, ICD-10: A00–B99)	5	0.80	0.13	5	0.93	0.15	0	0.00	0.00	0.00	-0.15
Hematologic disorders (ICD-9: 279–289, ICD-10: D50–D89)	3	0.48	0.08	2	0.37	0.06	1	1.10	0.22	3.70	0.16
Congenital anomalies (ICD-9: 740–759, ICD-10: Q00–Q99)	1	0.16	0.03	1	0.19	0.03	0	0.00	0.00	0.00	-0.03
Pregnancy and childbirth (ICD-9: 630–679, relevant V-codes, ICD-10: O00–O99, relevant Z-codes)	0	0.00	0.00	--	--	--	0	0.00	0.00	--	--
Total	626	100.00	16.08	535	100.00	15.59	91	100.00	19.64	1.26	4.05

TRAC2ES, U.S. Transportation Command (TRANSCOM) Regulating and Command & Control Evacuation System
[a]Rate per 1,000 deployed person-years

RESULTS

In 2017, a total of 626 medical evacuations of service members from CENTCOM AOR were followed by at least one medical encounter in a fixed medical facility outside the operational theater **(Table 1)**. Overall, there were more medical evacuations for mental health disorders (n=148, 23.6% of all evacuations; rate: 3.8 per 1,000 deployed person-years [dp-yrs]) than for any other category of illnesses or injuries **(Table 1)**. In addition, rates of evacuation for non-battle injuries and poisonings (3.4 per 1,000 dp-yrs), musculoskeletal system disorders (1.9 per 1,000 dp-yrs), and signs and symptoms (1.8 per 1,000 dp-yrs) were higher than the rate for battle injuries (1.4 per 1,000 dp-yrs).

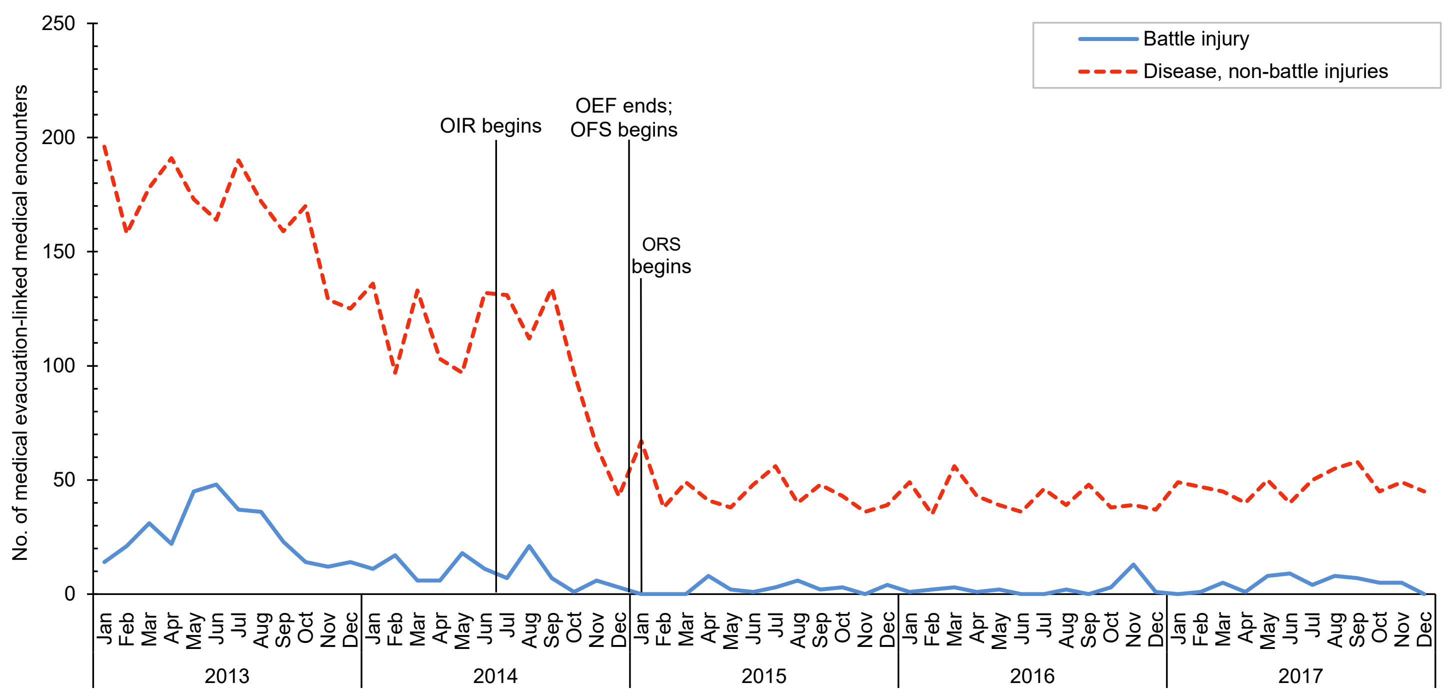
During 2013–2017, annual rates of medical evacuations attributable to battle injuries decreased from 3.5 per 1,000 dp-yrs (n=317) in 2013 to a low of 0.73 per 1,000 dp-yrs (n=28) in 2016, and then increased to 1.4 per 1,000 dp-yrs (n=53) in 2017. These data represent an overall decline of 61.1% in the rate of battle injury medical evacuations from 2013 through 2017. Annual rates of medical evacuations attributable to non-battle injuries and illnesses were relatively stable during 2015–2017. In general, the numbers of medical evacuations over the course of the period varied in relation to the numbers of deployed service members with most medical evacuations occurring during the period of deployment to OEF. In addition, numbers of medical evacuations decreased considerably in the months leading up to 1 January 2015, when U.S. Forces-Afghanistan formally ended its combat mission, OEF, and commenced its new mission, OFS **(Figure)**.

In 2017, three categories of illnesses and non-battle injuries accounted for more than half (56.6%) of all evacuations **(Table 1)**. Mental health disorders (most frequently adjustment and depressive disorders) accounted for almost one-quarter (23.6%) of evacuations; non-battle injuries (primarily fractures of extremities, strains, and sprains) accounted for approximately one in five (21.1%) evacuations; and musculoskeletal disorders (primarily affecting the back and knee) accounted for roughly one in nine (11.8%) medical evacuations. Similarly, signs, symptoms, and ill-defined conditions (primarily pain and swelling) accounted for slightly less than one in nine (11.0%) evacuations.

Demographic and military characteristics

The rate of medical evacuations in 2017 was 26.0% higher among females (19.6 per 1,000 dp-yrs) than males (15.6 per 1,000 dp-yrs) **(Table 2)**. The diagnoses with the highest rates of medical evacuations among male service members were mental health disorders (3.5 per 1,000 dp-yrs), non-battle injury and poisoning (3.4 per 1,000 dp-yrs), musculoskeletal disorders (2.0 per 1,000 dp-yrs), and signs, symptoms, and ill-defined conditions (1.7 per 1,000 dp-yrs) **(Table 1)**. Among female service members, the highest rates of medical evacuations were for mental health disorders (6.3 per 1,000 dp-yrs), non-battle injury and poisoning (3.5 per 1,000 dp-yrs), genitourinary system disorders (2.2 per 1,000 dp-yrs), and signs, symptoms, and ill-defined conditions (2.2 per 1,000 dp-yrs).

FIGURE. Numbers of battle injury and disease/non-battle injury medical evacuations of U.S. service members, by month, 2013–2017



OIR, Operation Inherent Resolve; OEF, Operation Enduring Freedom; OFS, Operation Freedom's Sentinel; ORS, Operation Resolute Support

TABLE 2. Numbers and rates of medical encounters following medical evacuation, by demographic and military characteristics, U.S. Armed Forces, 2017

	No. of medevacs	Rate[a]
Total	626	16.1
Sex		
Male	535	15.6
Female	91	19.6
Race/ethnicity		
Non-Hispanic white	376	15.5
Non-Hispanic black	116	19.7
Hispanic	90	16.0
Asian/Pacific Islander	19	15.9
Other/unknown	25	12.7
Age group		
≤19	27	29.8
20–24	200	16.6
25–29	127	12.9
30–34	95	14.6
35–39	68	14.9
40–44	43	17.8
≥45	66	25.6
Service		
Army	507	23.5
Navy	23	9.8
Air Force	70	6.2
Marine Corps	26	6.8
Component		
Active	434	15.9
Reserve/Guard	192	16.4
Rank		
Jr. Enlisted (E1–E4)	263	16.4
Sr. Enlisted (E5–E9)	250	16.3
Jr. Officer (O1–O3, W1–W3)	64	12.8
Sr. Officer (O4–O10, W4–W5)	49	19.0
Occupation		
Combat-specific[b]	194	23.3
Motor transport	20	19.3
Repair/engineering	137	13.0
Communications/ intelligence	146	16.6
Health care	40	19.4
Other	89	10.9
Precedence		
Routine	524	
Priority	88	
Urgent	14	
Transport_mode_num[c]		
Military	620	
Commercial	6	

[a]Rate per 1,000 deployed person-years
[b]Infantry/artillery/combat engineering/armor
[c]Data field within the U.S. Transportation Command (TRANSCOM) Regulating and Command & Control Evacuation System (TRAC2ES)

Despite having a much lower number of medical evacuations compared to males (n=535), females (n=91) had higher rates of evacuations for almost all illness and injury categories. Female service members had particularly higher rates of medical evacuations for genitourinary system disorders (female:male rate ratio [RR]: 6.7; rate difference [RD]: 1.8 per 1,000 dp-yrs) and mental health disorders (RR: 1.8; RD: 2.8 per 1,000 dp-yrs), compared to males **(Table 1)**. In contrast, male service members had higher evacuation rates for battle injuries (RR: 0.14; RD: -1.30 per 1,000 dp-yrs), disorders of the nervous system and sense organs (RR: 0.3; RD: -0.43 per 1,000 dp-yrs), and musculoskeletal disorders (RR: 0.65; RD: -0.7 per 1,000 dp-yrs). However, there was only one medical evacuation of a female service member during 2017 for each of the categories of battle injury and nervous system disorders.

Overall, medical evacuation rates were highest among non-Hispanic black service members (19.7 per 1,000 dp-yrs) and lowest among service members of "other" or unknown race/ethnicity (12.7 per 1,000 dp-yrs) **(Table 2)**. Rates of medical evacuation were lowest among those aged 25–29 years (12.9 per 1,000 dp-yrs) and highest among those aged 19 years or younger (29.8 per 1,000 dp-yrs) or aged 45 years or older (25.6 per 1,000 dp-yrs). Compared to their respective counterparts, rates of evacuation were higher among deployers who were in the Army (23.5 per 1,000 dp-yrs), senior officer rank (19.0 per 1,000 dp-yrs), and in combat-specific occupations (23.3 per 1,000 dp-yrs).

Most medical evacuations (83.7%) were characterized as having routine precedence. The remainder had priority (14.1%) or urgent (2.2%) precedence. All but six (1.0%) of the total medical evacuations were accomplished through military transport **(Table 2)**.

Most frequent specific diagnoses

Among both males and females, "reaction to severe stress, and adjustment disorders" was the most frequent specific diagnosis (three-digit ICD-10 diagnosis code: F43) during initial medical encounters after evacuations; however, the rates of these adjustment disorder–related evacuations were 79.8% higher among females (3.7 per 1,000 dp-yrs) than males (2.0 per 1,000 dp-yrs) **(Table 3)**. All of the five most common three-digit diagnoses associated with evacuations of males were mental health disorders, musculoskeletal disorders, or injuries **(Table 3)**.

Of the top six diagnoses most frequently associated with evacuations of female service members, two were mental health disorders ("reaction to severe stress, and adjustment disorders" and "major depressive disorder, single episode"); one was a condition that primarily affects women ("unspecified lump in breast"); two were injuries ("fracture at wrist and hand level" and "intracranial injury"); and one was a sign, symptom, and ill-defined condition ("abdominal and pelvic pain") **(Table 3)**. Abdominal and pelvic pain and intracranial injury affected equal numbers of female evacuees. Of note, four of the 10 genitourinary system disorders diagnosed among women were for "unspecified lump in breast" and one was for benign mammary dysplasia, solitary cyst of left breast (**data not shown**).

Disposition

Of the 626 medical evacuations reported in 2017, a total of 219 (35.0%) resulted in inpatient encounters. More than one-half (61.2%) of all service members who were hospitalized after medical evacuations were discharged back to duty. Slightly more than one-third (37.4%) of service members who were hospitalized after medical evacuations were transferred or discharged to other facilities **(Table 4)**.

Return to duty dispositions were much more likely after hospitalizations for non-battle injuries (74.3%) than for battle injuries (11.4%). In addition, the majority (88.6%) of battle injury–related hospitalizations and a little more than one-quarter (25.7%) of non-battle injury–related hospitalizations resulted in transfers/discharges to other facilities **(Table 4)**.

Almost two-thirds (n=407, 65.0%) of the total medical evacuations reported resulted in outpatient encounters only. Of the service members who were treated exclusively in outpatient settings after

TABLE 3. Most frequent three-digit ICD-10 diagnoses from medical evacuations, by sex, U.S. Armed Forces, 2017

Males				Females			
3-digit ICD-10	Description	No.	Rate per 1,000 deployed p-yrs	3-digit ICD-10	Description	No.	Rate per 1,000 deployed p-yrs
F43	Reaction to severe stress, and adjustment disorders	70	2.04	F43	Reaction to severe stress, and adjustment disorders	17	3.67
M54	Dorsalgia	26	0.76	F32	Major depressive disorder, single episode	6	1.30
F32	Major depressive disorder, single episode	20	0.58	N63	Unspecified lump in breast	4	0.86
S06	Intracranial injury	17	0.50	S62	Fracture at wrist and hand level	4	0.86
M25	Other joint disorder, not elsewhere classified	14	0.41	R10	Abdominal and pelvic pain	3	0.65
				S06	Intracranial injury	3	0.65

evacuations, the majority (83.0%) were discharged back to duty without work/duty limitations; 14.0% were released with work/duty limitations; and less than 1% each were admitted/transferred to a civilian hospital, immediately referred, or discharged to "home sick" for recuperation. Service members treated as outpatients after battle injury–related evacuations were more likely to be released without limitations (n=9, 100.0%) than medical evacuees treated as outpatients for non-battle injuries (n=71, 73.2%) **(Table 4)**.

TABLE 4. Dispositions after inpatient or outpatient encounters following medical evacuation, U.S. Armed Forces, 2017

Disposition	Total		Battle injury		Non-battle injury and poisoning	
	No.	%	No.	%	No.	%
Inpatient	219		44		35	
Returned to duty	134	61.2	5	11.4	26	74.3
Transferred/discharged to other facility	82	37.4	39	88.6	9	25.7
Discharged home	0	0.0	0	0.0	0	0.0
Separated	0	0.0	0	0.0	0	0.0
Died	0	0.0	0	0.0	0	0.0
Other/unknown	3	1.4	0	0.0	0	0.0
Outpatient	407		9		97	
Released without limitation	338	83.0	9	100.0	71	73.2
Released with work/duty limitation	57	14.0	0	0.0	23	23.7
Sick at home/quarters	1	0.2	0	0.0	0	0.0
Immediate referral	1	0.2	0	0.0	1	1.0
Admitted/transferred to civilian hospital	1	0.2	0	0.0	1	1.0
Died	0	0.0	0	0.0	0	0.0
Discharged home	0	0.0	0	0.0	0	0.0
Other/unknown	9	2.2	0	0.0	1	1.0

EDITORIAL COMMENT

This report documented that only 8.5% of all medical evacuations during 2017 were associated with battle injuries. Rates of evacuations for battle injuries were considerably lower in 2017 than in 2013, the first year of the surveillance period, which is likely a reflection of both the reduction in troop levels that took place during this period and the change in mission away from direct combat. Most evacuations in 2017 as well as during the overall 2013–2017 surveillance period were attributed to mental health disorders, followed by non-battle injuries, signs and symptoms, and musculoskeletal disorders. Rates of evacuation in 2017 were higher among females than males, as in previous years. Of the major diagnostic categories for which there was more than one medical evacuation for both men and women, only rates of musculoskeletal disorders evacuations were noticeably higher among males compared to females. The majority of service members who were evacuated were returned to normal duty status following their post-evacuation hospitalizations or outpatient encounters, as in previous years. However, only about one-quarter of those evacuated for battle injuries were returned to duty immediately after their initial healthcare encounters.

Overall, the changes in numbers of medical evacuations over the course of the surveillance period reflect the drawdown of U.S. troops from Afghanistan leading up to the end of Operation Enduring Freedom.[4] As Operation Freedom's Sentinel began, U.S. troop withdrawal slowed and began to level off in 2015.[4] The relatively low rate of medical evacuation (16.1 evacuations per 1,000 dp-yrs in 2017) suggests that most deployers were sufficiently healthy and ready for their deployments, and received the medical care in theater necessary to complete their assignments without having to be evacuated. This level of health is further supported by the generally low rates of medical evacuations for chronic conditions such as hematologic disorders and congenital anomalies. However, deployed service members are not immune to such conditions. For example, there was one medical evacuation for congenital anomalies in 2017 that was due to a congenital renal cyst **(data not shown)**. Because congenital anomalies may not be identified and diagnosed until later in life,[5] such diagnoses should not be ruled out.

The rate of medical evacuations attributed to mental health disorders was similar to the rate reported in an earlier *MSMR* analysis of medical evacuations between 2001 and 2012.[3] Although some studies have indicated improved access to mental health care in deployed settings, the results from the current analysis do not demonstrate an obvious correlation between improved access and the rate of mental health medical evacuations out of CENTCOM deployment operations.[6] This could be due, at least in part, to variations in the availability of mental health care in deployed settings. In these settings, the distribution of providers and clinics that deliver such services is uneven and varies according to factors such as the number of deployed personnel and the assessed needs of the particular unit.[6] In addition, although the number of mental healthcare providers in Afghanistan increased from 2005 through 2010, this number decreased after 2013 as part of the overall drawdown of U.S. troops from the region.[6]

Several important limitations should be considered when interpreting the results of this analysis. Direct comparisons of numbers and rates of medical evacuations by cause, as between males and females, can be misleading. For example, such comparisons do not account for differences between the groups in other characteristics (e.g., age, grade, military occupation, locations and activities while deployed) that are significant determinants of medical evacuation risk. Also, for this report, most "causes" of medical evacuations were estimated from primary (first-listed) diagnoses that were recorded during hospitalizations or initial outpatient encounters after evacuation. In some cases, clinical evaluations in fixed medical treatment facilities after medical evacuations may have "ruled out" serious conditions that were clinically suspected in the theater. For this analysis, the "causes" of such evacuations reflect diagnoses that were determined after evaluations outside of the theater rather than diagnoses—perhaps of severe disease—that were clinically suspected in the theater. To the extent that this occurred, the "causes" of some medical evacuations may seem surprisingly minor.

Overall, results highlight the continued need to tailor force health protection policies, training, supplies, equipment, and practices based on characteristics of the deployed force (e.g., combat vs. support; male vs. female) and the nature of the military operations (e.g., combat vs. humanitarian assistance).

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Food-allergy Anaphylaxis and Epinephrine Autoinjector Prescription Fills, Active Component Service Members, U.S. Armed Forces, 2007–2016

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Food-allergy anaphylaxis is an immunoglobulin E–mediated, systemic reaction that is often unanticipated and can rapidly lead to death. Active duty service members with a history of food-allergy anaphylaxis or a systemic reaction to food do not meet military accession or retention standards. In spite of this, the incidence rate of food-allergy anaphylaxis among active component service members approximates that found in the general population and appears to be increasing. The overall incidence of food-allergy anaphylaxis among active component service members was 39.1 cases per 100,000 person-years (p-yrs) during the 2007–2016 surveillance period. The incidence increased over the surveillance period from 32.0 per 100,000 p-yrs in 2007 to 55.8 per 100,000 p-yrs in 2016. First-line treatment of anaphylaxis includes rapid administration of epinephrine. In this study, 29% and 58% of incident anaphylaxis cases had filled a prescription for an epinephrine autoinjector (EAI) within 18 months before or 3 months after the incident diagnosis, respectively. Increasing awareness of food-allergy anaphylaxis, properly identifying at-risk individuals, and ensuring availability of EAIs have the potential to mitigate the risk associated with anaphylaxis.

Food-allergy anaphylaxis is an immunoglobulin E (IgE)-mediated, systemic reaction that is often unanticipated and can rapidly lead to death. Prevention of anaphylaxis includes identification of individuals at risk for anaphylaxis and avoidance of both the offending agent as well as cofactors that have the potential to induce or exacerbate reactions to an otherwise tolerated allergen.[1] The Joint Task Force on Practice Parameters recommends that patients with a history of food-allergy anaphylaxis and those who are at risk for anaphylaxis due to a previous systemic reaction to foods or other factors be prescribed an epinephrine autoinjector (EAI).[2,3] In spite of this recommendation, studies indicate that EAIs are underutilized.[4,5]

Knowledge related to the epidemiology of anaphylaxis in the general population comes from multiple sources, including surveys,[6] medical claims data from hospital admissions,[7,8] emergency room visits,[9] and medically coded encounters from population-based databases **(Table 1)**.[10-18] Incidence rate estimates vary widely due to variable case definitions, populations, data sources, and study design. Among retrospective studies utilizing medically coded encounters, rates range from 6.7 per 100,000 person-years (p-yrs) in the general population[17] to 109.0 per 100,000 p-yrs among asthmatics.[13]. Studies in the U.S. and elsewhere suggest that the incidence of anaphylaxis is increasing **(Table 1)**.[11,14,15,17]

Individuals with a history of anaphylaxis or a systemic reaction to food do not meet military accession standards.[19] Waivers may be granted, however, based on the severity of a reaction, risk of recurrence, occupation, and the needs of the military. Service members with a history of food-allergy anaphylaxis who are not identified at accession, and those who develop food-allergy anaphylaxis while on active duty warrant referral to a medical evaluation board for a fitness for duty determination.

Establishing the incidence of anaphylaxis within the U.S. military and tracking trends over time would increase awareness of the condition, including the risk of potentially devastating outcomes in austere environments. It may also assist with development and implementation of accession and retention standards. Quantifying EAI prescription fill rates could guide prevention and treatment efforts. To date, there are no studies related to the epidemiology of food-allergy anaphylaxis or EAI prescription fill rates among active component service members. The purpose of this study is to determine the incidence of food-allergy anaphylaxis over time, and to describe EAI prescription fill rates.

METHODS

Anaphylaxis incidence

This was a retrospective cohort study. An incident case of food-allergy anaphylaxis was defined as any inpatient, outpatient, or Theater Medical Data Store (TMDS) medical encounter identified using ICD-9 code 995.6* and ICD-10 code T78.0* in any diagnostic position. Service members who had been diagnosed with food-allergy anaphylaxis prior to the surveillance period were excluded from the study population. The surveillance period for an incident case of food-allergy

TABLE 1. Results of similar studies evaluting the incidence of food-allergy anaphylaxis

Author (publication year)	Study period	Location	Data source	Ages studied	Incidence[a]	Time trend in incidence[a]	Food as cause of anaphylaxis	Sex with highest incidence	Age with highest incidence
Bohlke (2004)[10]	1991–1997	WA	Health Maintenance Organization	<18 yrs	10.5 using codes specific for anaphylaxis; 68.4 using non-specific codes	No increase	Most frequent cause	Males (not statistically significant)	15–17 yrs (not statistically significant)
Yocum (1999)[16]	1983–1987	Olmsted County, MN	Rochester Epidemiology Project	All	30	Not reported	Most frequent cause	No difference	Mean age 29 yrs ± 19 yrs
Decker (2008)[11]	1990–2000	Rochester, MN	Rochester Epidemiology Project	All	49.8	Increased from 46.9 to 58.9	Most frequent cause	Not evaluated	29.3 yrs ±18.2 yrs
Lee (2017)[14]	2001–2010	Olmsted County, MN	Rochester Epidemiology Project	All	42	Increased from 36.8 to 46.6	Most frequent cause in 0–9 y/o	Males 10–19 yrs; Females 30–39 yrs; no difference in other age groups	Median age 31 yrs
Yang (2017)[15]	2008–2014	Republic of Korea	Korean National Health Insurance	All	22.01	Increased from 16.0 to 32.2	Second most frequent cause after unspecified	Males	40–69 yrs
Sheikh (2008)[17]	2001–2005	United Kingdom	QRESEARCH	All	6.7–7.9	Increased from 6.7 to 7.9	Not reported	Males <14 yrs; Females >14 yrs	50–65 yrs
Rolla (2013)[18]	2010	Piemonte Region, Italy	Regional Health System	All	9.9 in 18+ yrs; 29.0 in <18 yrs	Not reported	Rates specific for food	Males <18 yrs; Females >18 yrs	<18 yrs
Gonzalez-Perez (2010)[12]	1996–2005	United Kingdom	The Health Improvement Network	10–79 yrs	21.28 in patients without asthma; 50.45 in patients with asthma	Not reported	Most frequent cause in those <40 yrs	Males	20–29 yrs
Iribarren (2010)[13]	1996–2006	CA	Kaiser	All	19.9 in patients without asthma; 109.0 in patients with asthma	Not reported	Second most frequent cause after serum	Females	19–45 yrs

[a]Rate per 100,000 person-years

anaphylaxis was 1 January 2007 through 31 December 2016. The surveillance population included all individuals, deployed and non-deployed, who served in the active component of the Army, Navy, Air Force, or Marine Corps at any time during the surveillance period.

All data used to determine incident food-allergy anaphylaxis were derived from records routinely maintained in the Defense Medical Surveillance System (DMSS). These records document both ambulatory encounters and hospitalizations of active component members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System) treatment facilities.

EAI prescription fill rates

Individuals with an incident case of food-allergy anaphylaxis or an incident diagnosis of food allergy from 30 June 2008 through 30 September 2016 were considered candidates for an EAI prescription. An incident diagnosis of food allergy was defined by having a first-ever inpatient, outpatient, or TMDS medical encounter with ICD-9 codes V15.01–V15.05 and ICD-10 codes Z91.010–Z91.013 or Z91.018 in any diagnostic position during the surveillance period. Individuals were considered candidates for an EAI prescription fill for 18 months prior to and 3 months after a diagnosis of food allergy or food-allergy anaphylaxis.

Prescription information was obtained from the Pharmacy Data Transaction Service, a central data repository that contains medication records for all TRICARE beneficiaries, regardless of point of service (i.e., military, retail, and mail-order pharmacies). Descriptive statistics were used to describe the number of EAI prescriptions dispensed to those identified as candidates for an EAI based on a prior diagnosis of food allergy or food-allergy anaphylaxis.

RESULTS

During 2007–2016, the crude overall incidence of food-allergy anaphylaxis among active component service members was 39.1 cases per 100,000 p-yrs **(Table 2)**. The crude annual incidence increased during the surveillance period from 32.0 per 100,000 p-yrs in 2007 to 55.8 per 100,000 p-yrs in 2016 **(Figure 1)**. The incidence of food-allergy anaphylaxis among females was almost three times that of males (85.4 and 31.1 cases per 100,000 p-yrs, respectively) and this was consistent across much of the surveillance period **(Table 2, Figure 2)**. Across race/ethnicity groups, the highest overall incidence of food-allergy anaphylaxis was found among non-Hispanic blacks (72.6 cases per 100,000 p-yrs), followed by service members in the "other/unknown" category (47.0 cases per 100,000 p-yrs). Non-Hispanic blacks had the highest annual incidence rates throughout the entire surveillance period **(Figure 3)**. The lowest overall incidence was found among non-Hispanic whites (28.8 cases per 100,000 p-yrs) **(Table 2)**. Across the age groups, the overall incidence of food-allergy anaphylaxis was lowest among those aged 20–24 years and highest among those aged 30–34 years (34.9 cases per 100,000 p-yrs and 43.1 cases per 100,000 p-yrs, respectively). During the surveillance period, annual rates increased in all age groups **(data not shown)**.

More than 10% of food-allergic individuals filled a prescription for an EAI within the 18 months prior to their food allergy diagnosis, and more than 28% of individuals with a diagnosis of food-allergy anaphylaxis filled a prescription for an EAI within the 18 months prior to being diagnosed with food-allergy anaphylaxis **(Figure 4)**. There were 26,085 incident cases of food allergy during the surveillance period; of these, 23.2% (6,054) filled a prescription for EAI within the 3 months following the diagnosis. There were 4,475 incident cases of food-allergy anaphylaxis; of these, 58.4% (2,612) filled a prescription for EAI within the 3 months following the diagnosis.

EDITORIAL COMMENT

Few studies specifically evaluate the incidence of food-allergy anaphylaxis, and comparison between studies is difficult given variable study design and populations. Still, comparison of incidence rates between military service members and the general U.S. population is informative. Given that food allergies and the risk for anaphylaxis are often identified during childhood, and that anaphylaxis medically disqualifies an individual from military service, the incidence of anaphylaxis in the military was expected to be lower than that in the general population. This expectation was tempered somewhat by generous waiver approval rates among military applicants with a history of anaphylaxis, which ranged from 54% among Air Force applicants to 91% among Navy applicants between 2008 and 2013.[20] The current study found that the incidence of food-allergy anaphylaxis among active component service members approximated that found in previous large, population-based studies performed in the U.S.[11,14,16] and was higher than that found in comparable studies performed overseas.[15,17,18] Clearly, accession standards and the medical board process do not completely address the issue of anaphylaxis in the military. Military healthcare providers, including those providing care in operational environments, must be prepared to manage at-risk and affected service members. This is especially true given that the incidence of food-allergy anaphylaxis appears to be increasing.

Epinephrine injection constitutes first-line treatment of anaphylaxis. U.S. studies of administrative claims data show that 46%–54% of patients being discharged from emergency departments following an episode of anaphylaxis filled a prescription for EAI within 1 year.[5,21] Given that military service members undergo periodic examinations that potentially identify EAI candidates, and the fact that there is no pre-authorization requirement or cost associated with filling a prescription for EAI, it was expected that active component service members would have a higher rate of EAI dispensing than the general population. This expectation was bolstered by the findings of a study of military beneficiaries (including dependents and active

TABLE 2. Incidence rates[a] of food-allergy anaphylaxis, active component, U.S. Armed Forces, 2007–2016

	Total 2007–2016
	Rate
Total	39.1
Service	
Army	41.0
Navy	36.3
Air Force	48.2
Marine Corps	23.1
Sex	
Male	31.1
Female	85.4
Age	
≤19	42.0
20–24	34.9
25–29	40.8
30–34	43.1
35–39	38.6
≥40	40.8
Race/ethnicity	
Non-Hispanic white	28.8
Non-Hispanic black	72.6
Hispanic	42.0
Asian/Pacific Islander	37.5
Other/unknown	47.0
Rank	
Jr. Enlisted (E1–E4)	38.1
Sr. Enlisted (E5–E9)	41.3
Jr. Officer (O1–O3)	37.9
Sr. Officer (O4–O10)	35.5
Warrant Officer (W01–W05)	32.4
Military occupation	
Combat-specific[b]	23.6
Motor transport	30.0
Pilot/air crew	21.3
Repair/engineer	32.1
Communications/intelligence	47.1
Health care	69.8
Other	43.2

[a]Number of cases per 100,000 person-years
[b]Infantry/artillery/combat engineering/armor

FIGURE 1. Annual incidence rates of food-allergy anaphylaxis, active component, U.S. Armed Forces, 2007–2016

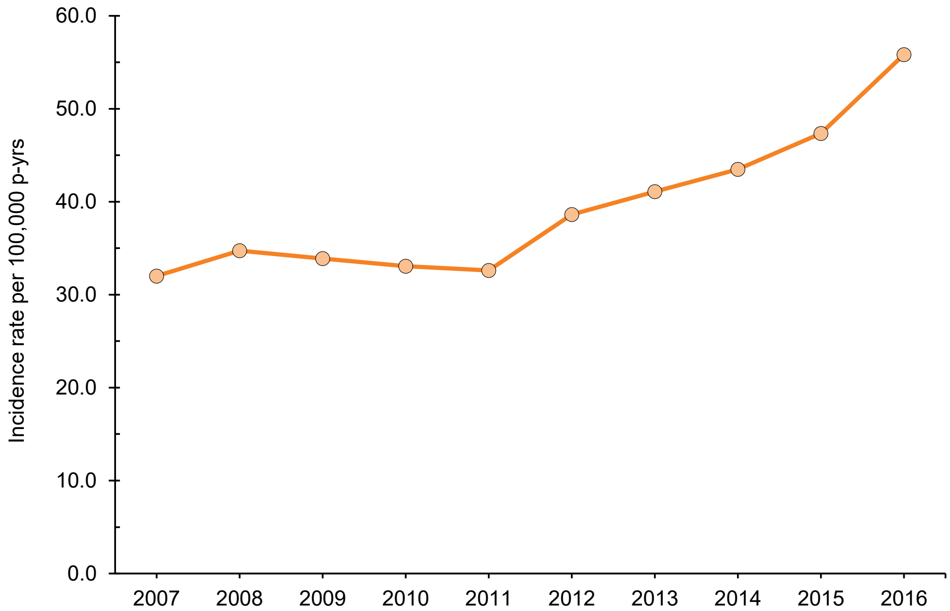
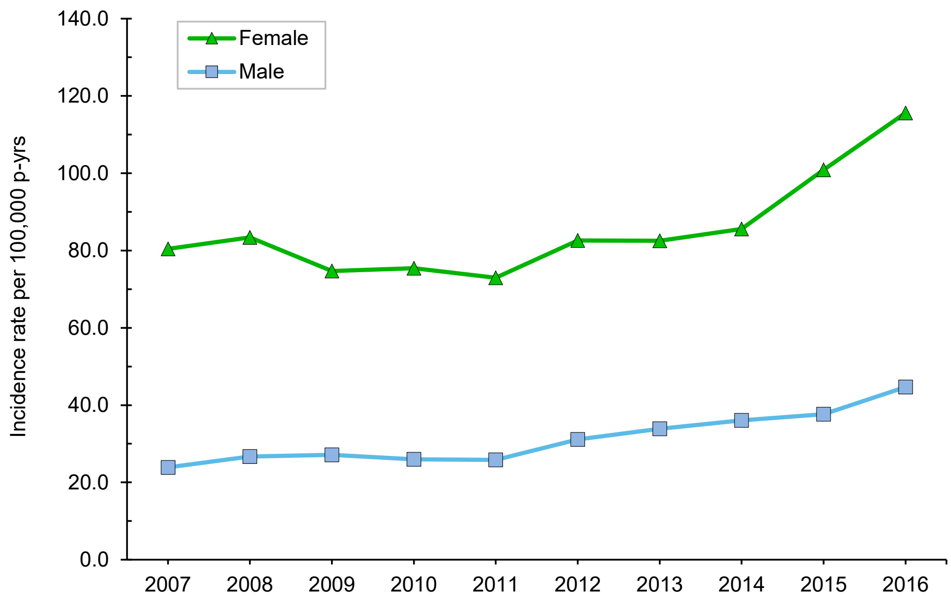


FIGURE 2. Annual incidence rates of food-allergy anaphylaxis, by sex, active component, U.S. Armed Forces, 2007–2016



component service members) in which 82% of individuals prescribed an EAI filled their prescriptions within 1 year.[22] The current study found that only 58.4% filled their prescriptions for EAI within 3 months of incident anaphylaxis. It is unclear whether the 58.4% fill rate found in the current study is due to failure to prescribe, failure to fill, or the relatively short window used to evaluate prescription fill rates. Regardless of the reason, there is room for improvement. Pharmacist-led interventions have been found to improve medication management and may play a role in improving fill rates among those who are prescribed an EAI.[23]

Approximately 28% of service members with food-allergy anaphylaxis filled prescriptions for an EAI within the 18 months prior to being diagnosed. This observation may reflect recognition of the service member's risk for anaphylaxis based on a previous, less severe food reaction, or the existence of another allergy warranting an EAI prescription. More worrisome is the potential for this to reflect a failure to identify at-risk individuals and appropriately document the condition in the member's medical record as may be seen when avoidance of a medical board and potential separation from the military is desired.

Current guidelines recommend that all patients experiencing food-allergy anaphylaxis be prescribed an EAI. Other patients for whom an EAI is indicated include patients with a history of a prior systemic allergic reaction; patients with food allergy and asthma; and patients with a known food allergy to peanut, tree nuts, fish, and crustacean shellfish (i.e., allergens known to be associated with more fatal and near-fatal allergic reactions).[3]

Given difficulties associated with identifying food-allergic individuals who are at risk for anaphylaxis, as well as difficulties predicting the severity of future IgE-mediated reactions, guidelines also recommend that providers consider prescribing an EAI to all patients with IgE-mediated food reactions.[3,24]

It is important to note that the current study did not differentiate between food-allergic individuals who met the above criteria from those who did not. As a result, it is difficult to interpret EAI fill rates among those diagnosed with food allergy. What is notable is that at least 23% of individuals with a documented history of food allergy were considered to be at risk for anaphylaxis and candidates for an EAI by their treating provider.

Future efforts should ensure that medical and emergency personnel are made aware of the notable number of individuals who serve in the military who have experienced or at risk for food-allergy anaphylaxis. Healthcare professionals need to properly identify, document, and code for

FIGURE 3. Annual incidence rates of food-allergy anaphylaxis, by race/ethnicity, active component, U.S. Armed Forces, 2007–2016

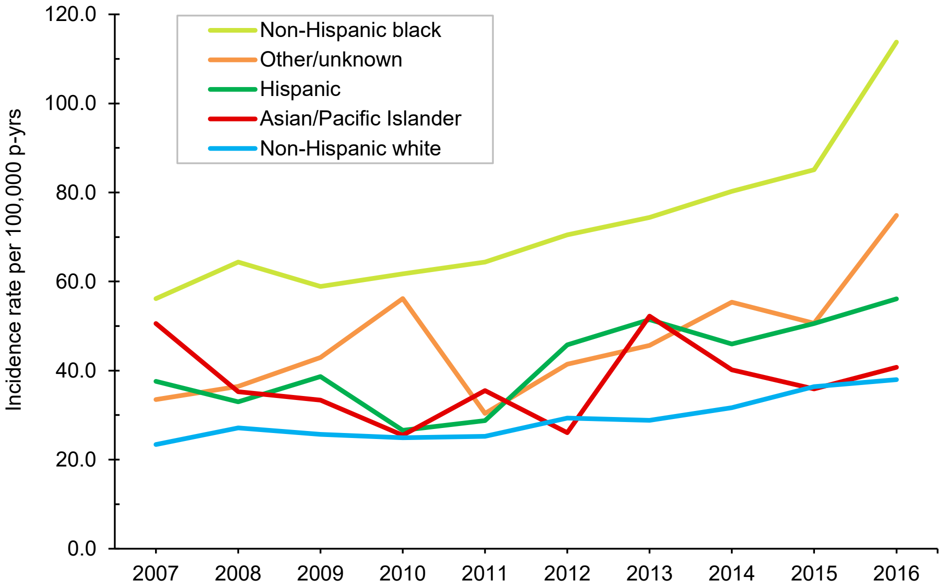
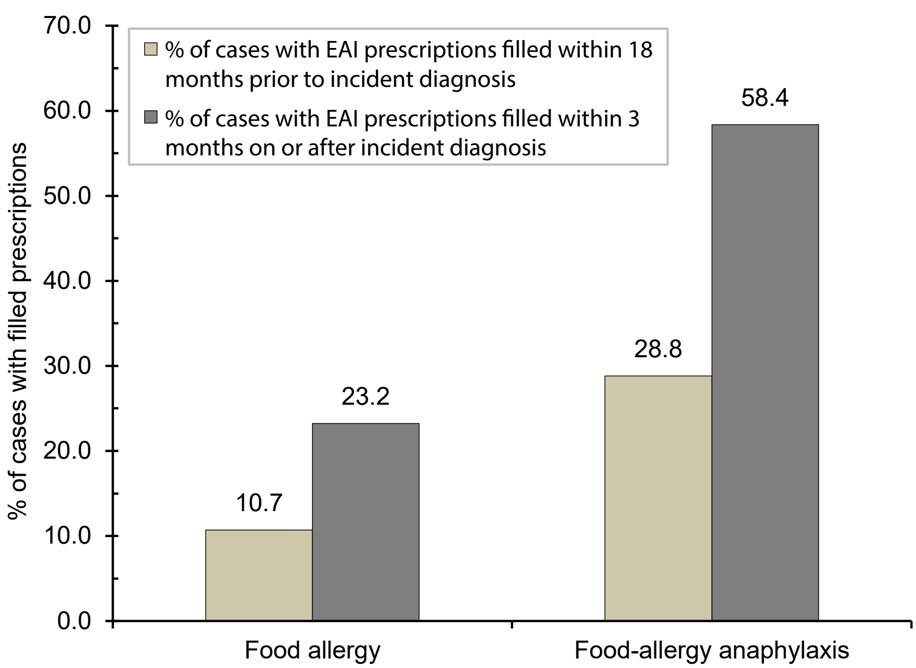


FIGURE 4. Percentages of incident cases of food allergy and food-allergy anaphylaxis with epinephrine autoinjector (EAI) prescriptions filled during specified time frames, active component, U.S. Armed Forces, 30 June 2008 through 30 September 2016



anaphylaxis so that appropriate prevention and treatment are made available.

Although this study did not formally address risk factors for anaphylaxis, it notes that the incidence of food-allergy anaphylaxis was higher among those aged 30–34 years, compared to other age groups; females compared to males; and non-Hispanic blacks, compared to other races/ethnicities. These findings are generally consistent with previous studies **(Table 1)**. Other studies involving civilian populations have explored risk factors for severe anaphylaxis (e.g., asthma[12,13,25] and vitamin D deficiency[26]), biomarkers,[27] and cofactors that induce or exacerbate reactions that might not otherwise occur (e.g., exercise, nonsteroidal anti-inflammatory drugs, and alcohol[1]). Future studies aimed at identifying factors associated with severe, life-threatening anaphylaxis in the military could help stratify risk and further inform accession standards, fitness for duty determinations, and prevention and treatment efforts.

This study has several limitations. Notably, not all cases of anaphylaxis come to medical attention and the true incidence of food-allergy anaphylaxis is likely underestimated here. In addition, this study relied on medically coded encounters that were not validated by chart review or a criteria-based approach to diagnosis; this may further contribute to underestimation of the true incidence of food-allergy anaphylaxis. Of note, a study utilizing the National Electronic Injury Surveillance System found that 57% of patients presenting to an emergency department with a likely case of anaphylaxis did not receive a diagnosis of anaphylaxis.[9] Finally, it is not clear whether the increasing incidence of food-allergy anaphylaxis reported here reflects an increase in the true incidence of anaphylaxis or increased awareness of the condition.

With regard to food allergies, it is likely that some individuals with food allergies were missed due to the failure to report, diagnose, or document their condition. In addition, the ICD-9/ICD-10 codes used to identify individuals with food allergies did not include nonspecific codes such as ICD-9: 693.1 ("Dermatitis due to food taken internally"), ICD-10: L27.2 ("Dermatitis due to ingested food"), and ICD-9: 995.7 and ICD-10: T78.1* ("Other adverse food reactions, not elsewhere classified"); this further contributes to potential underestimation of the condition.

With regard to EAI fill rates, significant information is lacking. Namely, prescription rates were not available and thus could not be used as a comparison to fill rates. In addition, EAI prescriptions were not linked to a specific diagnosis or event and prescription fills could potentially be related to another diagnosis such as an allergy to bee stings. Finally, the reasons for fill failures, including the possibility that an EAI was not indicated or was already available to a patient, were not explored.

The incidence of food-allergy anaphylaxis among active component service members approximates that found in the general population and increased steadily over the study period. Medical accession standards and the medical board process do not completely address the issue of food-allergy anaphylaxis in the military. Properly identifying and documenting at-risk individuals, and ensuring availability of EAI have the potential to mitigate the risk of anaphylaxis. Further identifying risk factors for severe anaphylaxis, biomarkers, and cofactors could inform accession and retention standards and prevent life-threatening reactions.

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Surveillance Snapshot: Cardiovascular-related Deaths During Deployment, U.S. Armed Forces, October 2001–December 2012

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In 2013, the *MSMR* summarized cardiovascular-related deaths in U.S. military members overall.[1] This snapshot provides a summary of cardiovascular-related deaths occurring in service members while deployed. The surveillance population included all individuals who served on active duty at any point between 1 October 2001 and 31 December 2012 as a member of the active, reserve, or guard component of the U.S. Army, Navy, Air Force, or Marine Corps. Cardiovascular-related deaths in active duty service members were ascertained as previously described.[1] Deaths were included in this analysis if the date of death occurred during the surveillance period and between the start and end dates of a deployment identified from the Contingency Tracking System from the Defense Manpower Data System. For each death identified, the presence of a cardiovascular risk factor was defined by the documentation of specific ICD-9 codes in any diagnostic position of a hospitalization discharge record or an outpatient medical encounter prior to the start of the deployment during which the death occurred **(Table 1)**.

Between October 2001 and December 2012, there were a total of 62 deaths attributed to cardiovascular causes occurring during deployment. Of these deaths, more than half occurred in reserve or guard members (n=35; 56.5%). The strongest demographic correlates of a cardiovascular-related death was age with the greatest number and percentage of deaths occurring in service members aged 45 years or older. The most frequently diagnosed cardiovascular risk factor was hypertension and approximately one in seven service members had more than one cardiovascular risk factor diagnosed prior to deployment **(Table 2)**.

The relatively few numbers of cardiovascular-related deaths occurring during deployment is likely attributable to multiple factors. Military members who deploy are generally younger and healthier than their civilian counterparts and undergo comprehensive health assessment prior to deployment to identify potential deployment limiting health conditions. However, not all deploying service members undergo specific cardiovascular screening even in the presence of cardiovascular risk factors.[2] Significantly, the deployment of forward-deployed cardiologists with access to first-line cardiovascular diagnostic tools (e.g., echocardiography, stress testing, ambulatory electrocardiography) allows for expert evaluation of cardiac complaints in theater. This capability enables expert risk stratification that provides an effective tool in discriminating life-threatening diagnoses from more benign conditions, and likely enhances the appropriate disposition of cardiac patients.[2-4]

TABLE 1. ICD-9 codes used for identification of cardiovascular risk factors

Risk factors	ICD-9 codes
Essential hypertension	401.*
Hyperlipidemia	272.0–272.4
Obesity	278.00, 278.01, 278.03, V85.3*–V85.4*, V85.54
Abnormal glucose level	790.2*
Diabetes mellitus	250.*

TABLE 2. Demographic characteristics of cardiac deaths during deployment, U.S. Armed Forces, October 2001–December 2012

	Deaths	
	No.	%
Total	62	100.0
Sex		
Male	60	96.8
Female	2	3.2
Age group		
≤19	0	0.0
20–24	6	9.7
25–29	7	11.3
30–34	5	8.1
35–39	9	14.5
40–44	14	22.6
≥45	21	33.9
Race/ethnicity		
Non-Hispanic white	34	54.8
Non-Hispanic black	20	32.3
Hispanic	2	3.2
Other	6	9.7
Grade		
Jr. Enlisted (E1–E4)	10	16
Sr. Enlisted (E5–E9)	37	60
Jr. Officer (O1–O3)	6	10
Sr. Officer (O4–O10)	8	13
Warrant Officer (W1–W5)	1	2
Component		
Active	27	44
Reserve/guard	35	56
Service		
Army	49	79
Navy	6	10
Air Force	5	8
Marine Corps	2	3
Military occupation		
Combat-specific[a]	13	21
Motor transport	3	5
Pilot/air crew	0	0
Repair/engineering	15	24
Communications/intelligence	18	29
Health care	4	6
Other	9	15
With pre-deployment risk factor		
Hypertension	15	24
Hyperlipidemia	11	18
Obesity	5	8
Abnormal glucose level	1	2
Diabetes	1	2
>1 risk factor	9	15

[a]Infantry/artillery/combat engineering/armor

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