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MEDICAL SURVEILLANCE MONTHLY REPORT

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Update: Routine Screening for Antibodies to Human Immunodeficiency Virus, Civilian Applicants for U.S. Military Service and U.S. Armed Forces, Active and Reserve Components, January 2013–June 2018

This report provides an update through June 2018 of the results of routine screening for antibodies to the human immunodeficiency virus (HIV) among civilian applicants for military service and among members of the active and reserve components of the U.S. Armed Forces. During the surveillance period, full-year seroprevalences among applicants for service peaked in 2015 (0.34 per 1,000 tested) and then decreased during the subsequent 2 years (0.33 and 0.26 per 1,000 tested, respectively). Seroprevalences among Army active component service members, Navy active component members, Navy reservists, Marine Corps reservists, and Air National Guard members also peaked in 2015. Overall (1 January 2013 through 30 June 2018) seroprevalences were highest for Army reservists, Army National Guard members, Navy reservists, and Navy active component members. Across active and reserve components of all services, HIV antibody seroprevalences continued to be higher among males than females.

Since acquired immune deficiency syndrome (AIDS) was first recognized as a distinct clinical entity in 1981,[1] its spread has had major impacts on the health of populations and on healthcare systems worldwide. The human immunodeficiency virus type 1 (HIV-1) was identified as the cause of AIDS in 1983. For more than 30 years, the U.S. military has conducted routine screening for antibodies to HIV-1 to enable adequate and timely medical evaluations, treatment, and counseling; to prevent unwitting transmission; and to protect the battlefield blood supply.[2,3]

As part of the U.S. military's total-force HIV screening program, civilian applicants for military service are screened for antibodies to HIV during pre-accession medical examinations. Infection with HIV is medically disqualifying for entry into U.S. military service. Since 1986, all members of the active and reserve components of the U.S. Armed Forces have been periodically screened to detect newly acquired HIV infections. In 2004, the Department of Defense set a standard testing interval of 2 years for all service members.[4,5] All military personnel are periodically screened for HIV infection (at a minimum every 2 years, or on deployment, return from deployment, or after having received a diagnosis of various other conditions such as sexually transmitted infection).[5] Service members who are infected with HIV receive clinical assessments, treatments, and counseling; they may remain in service as long as they are capable of performing their military duties.[2,3]

Before 2009, all of the aforementioned screening programs used laboratory techniques that detected only HIV-1–type infections. Starting in 2009, all programs adopted methods that allowed the detection of antibodies to both major HIV types (i.e., HIV-1 and HIV-2). Although HIV-2 infection is rare in the U.S. itself, and no instances of HIV-2 infection have thus far been detected in civilian applicants or service members since 2009, HIV-2 virus is much more prevalent in other parts of the world where service members may be required to serve. To provide for the change in laboratory methods in the past and for the prospect of future detections of HIV-2 infection in the services' screening programs, this report will hereafter refer to the target of the screening programs as simply "HIV" without specifying either of the types.

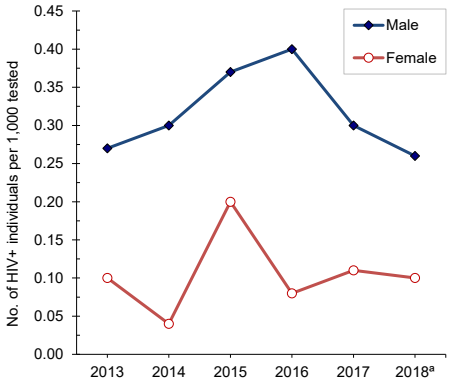
This report summarizes numbers, prevalences, and trends of newly identified HIV antibody positivity among civilian applicants for military service and members of the active and reserve components of the U.S. Armed Forces from 1 January 2013 through 30 June 2018. Summaries of results of routine screening for antibodies to HIV among civilian applicants and active and reserve component members of the U.S. military since 1990 are available at www.health.mil/MSMRArchives.

METHODS

The surveillance period was 1 January 2013 through 30 June 2018. The surveillance population included all civilian applicants for U.S. military service and all individuals who were screened for antibodies to HIV while serving in the active or reserve component of the Army, Navy, Air Force, or Marine Corps during the surveillance period.

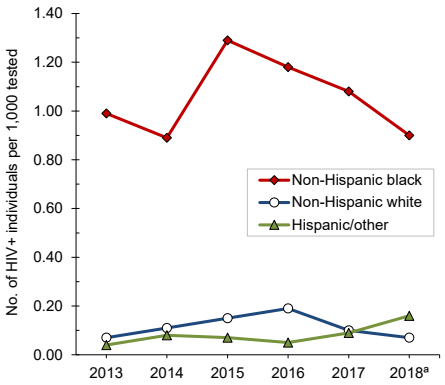
All individuals who were tested and all first-time detections of antibodies to HIV through U.S. military medical testing programs were ascertained by matching specimen numbers and serologic test results to the personal identifiers of providers of the specimens. With the exception of U.S. Air Force members, all results were accessed from records routinely maintained in the Defense Medical Surveillance System (DMSS). The U.S. Air Force provided summarized results of serologic screening for antibodies to HIV among its members.

FIGURE 1. Diagnoses of HIV infections, by sex, civilian applicants for U.S. military service, January 2013–June 2018



[a]Through 30 June 2018

FIGURE 2. Diagnoses of HIV infections, by race/ethnicity, civilian applicants for U.S. military service, January 2013–June 2018



[a]Through 30 June 2018

An incident case of HIV antibody seropositivity was defined as two positive results from serologic testing of two different specimens from the same individual, or one positive result from serologic testing of the most recent specimen provided by an individual.

Annual prevalences of HIV seropositivity among civilian applicants for service were calculated by dividing the number of applicants identified as HIV-antibody seropositive during each calendar year by the number of applicants tested during the corresponding year. For annual summaries of routine screening among U.S. service members, denominators were the numbers of individuals in each component of each service branch who were tested at least once during the relevant calendar year.

RESULTS

Civilian applicants

From January 2017 through June 2018, a total of 484,892 civilian applicants for U.S. military service were tested for antibodies to HIV, and 120 applicants were identified as HIV antibody positive (seroprevalence: 0.25 per 1,000 applicants tested) **(Table 1)**. During the surveillance period, full-year seroprevalences among applicants for service peaked in 2015 (0.34 per 1,000 tested) and then decreased during the subsequent 2 years (0.33 and 0.26 per 1,000 tested, respectively).

TABLE 1. Diagnoses of HIV infections, by sex, civilian applicants for U.S. military service, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total HIV(+)	HIV(+) male	HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested
2013	**274,776**	**266,523**	214,370	52,153	**62**	57	5	**0.23**	0.27	0.10
2014	**239,437**	**233,782**	186,147	47,635	**57**	55	2	**0.24**	0.30	0.04
2015	**252,910**	**246,160**	195,040	51,120	**83**	73	10	**0.34**	0.37	0.20
2016	**255,654**	**249,424**	197,450	51,974	**82**	78	4	**0.33**	0.40	0.08
2017	**306,638**	**299,655**	238,121	61,534	**78**	71	7	**0.26**	0.30	0.11
2018[a]	**196,354**	**185,237**	145,135	40,102	**42**	38	4	**0.23**	0.26	0.10
Total	**1,525,769**	**1,480,781**	1,176,263	304,518	**404**	372	32	**0.27**	0.32	0.11

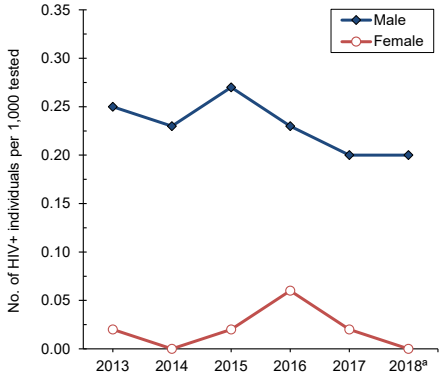
[a]Through 30 June 2018

TABLE 2. Diagnoses of HIV infections, by race/ethnicity, civilian applicants for U.S. military service, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Non-Hispanic white tested	Non-Hispanic black tested	Hispanic/ others tested	Total HIV(+)	Non-Hispanic white HIV(+)	Non-Hispanic black HIV(+)	Hispanic/ others HIV(+)	Overall rate per 1,000 tested	Non-Hispanic white rate per 1,000 tested	Non-Hispanic black rate per 1,000 tested	Hispanic/ others rate per 1,000 tested
2013	**274,776**	**266,523**	161,057	48,524	56,942	**62**	12	48	2	**0.23**	0.07	0.99	0.04
2014	**239,437**	**233,782**	140,059	42,851	50,872	**57**	15	38	4	**0.24**	0.11	0.89	0.08
2015	**252,910**	**246,160**	144,579	44,840	56,741	**83**	21	58	4	**0.34**	0.15	1.29	0.07
2016	**255,654**	**249,424**	145,063	44,122	60,239	**82**	27	52	3	**0.33**	0.19	1.18	0.05
2017	**306,638**	**299,656**	184,843	48,851	65,962	**78**	19	53	6	**0.26**	0.10	1.08	0.09
2018[a]	**196,354**	**185,238**	122,388	31,271	31,579	**42**	9	28	5	**0.23**	0.07	0.90	0.16
Total	**1,525,769**	**1,480,783**	897,989	260,459	322,335	**404**	103	277	24	**0.27**	0.11	1.06	0.07

[a]Through 30 June 2018

FIGURE 3. New diagnoses of HIV infections, by sex, active component, U.S. Army, January 2013–June 2018



[a]Through 30 June 2018

Throughout the surveillance period, HIV antibody seroprevalences among male applicants were consistently higher than among female applicants **(Table 1; Figure 1)**. Seroprevalences were much higher among non-Hispanic blacks, compared with other race/ethnicity groups **(Table 2; Figure 2)**. Between 2017 and 2018, seroprevalences decreased among non-Hispanic white and non-Hispanic black applicants (30.0% and 16.7%, respectively); of note, however, seroprevalences among Hispanic applicants increased markedly during this same period (77.8%). During 2017, on average, one civilian applicant for service was detected with antibodies to HIV per 3,931 screening tests **(Table 1).**

U.S. Army

Active component: From January 2017 through June 2018, a total of 557,319 soldiers in the active component of the U.S. Army were tested for antibodies to HIV, and 95 soldiers were identified as HIV antibody positive (seroprevalence: 0.17 per 1,000 soldiers tested) **(Table 3)**. During the surveillance period, seroprevalences fluctuated between 0.23 per 1,000 tested in 2015

TABLE 3. New diagnoses of HIV infections, by sex, active component, U.S. Army, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	508,965	405,824	349,391	56,433	87	86	1	0.21	0.25	0.02	22
2014	447,730	361,941	309,981	51,960	71	71	0	0.20	0.23	0.00	31
2015	426,462	349,811	298,191	51,620	82	81	1	0.23	0.27	0.02	44
2016	423,262	345,951	294,252	51,699	72	69	3	0.21	0.23	0.06	52
2017	435,656	351,099	297,017	54,082	61	60	1	0.17	0.20	0.02	51
2018[a]	229,625	206,220	174,111	32,109	34	34	0	0.16	0.20	0.00	33
Total	2,471,700	2,020,846	1,722,943	297,903	407	401	6	0.20	0.23	0.02	233

[a]Through 30 June 2018

TABLE 4. New diagnoses of HIV infections, by sex, U.S. Army National Guard, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	173,618	147,729	122,225	25,504	52	51	1	0.35	0.42	0.04	16
2014	265,934	239,346	199,824	39,522	93	92	1	0.39	0.46	0.03	35
2015	205,549	181,785	151,139	30,646	68	66	2	0.37	0.44	0.07	29
2016	230,438	207,561	172,202	35,359	80	78	2	0.39	0.45	0.06	50
2017	235,667	205,398	170,161	35,237	65	63	2	0.32	0.37	0.06	48
2018[a]	123,637	114,507	94,208	20,299	26	25	1	0.23	0.27	0.05	25
Total	1,234,843	1,096,326	909,759	186,567	384	375	9	0.35	0.41	0.05	203

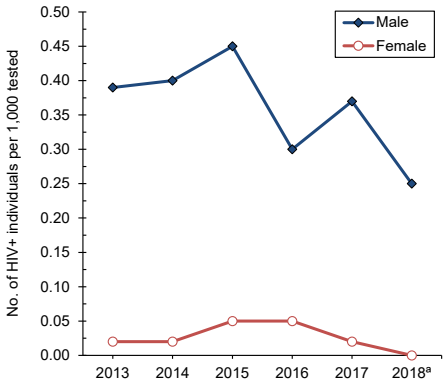
[a]Through 30 June 2018

TABLE 5. New diagnoses of HIV infections, by sex, U.S. Army Reserve, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	127,374	113,176	87,345	25,831	54	50	4	0.48	0.57	0.15	19
2014	120,291	107,303	81,912	25,391	47	44	3	0.44	0.54	0.12	19
2015	121,897	110,161	84,775	25,386	42	42	0	0.38	0.50	0.00	27
2016	120,510	109,467	83,474	25,993	44	44	0	0.40	0.53	0.00	33
2017	119,371	108,247	82,680	25,567	41	40	1	0.38	0.48	0.04	36
2018[a]	63,032	57,443	43,299	14,144	19	17	2	0.33	0.39	0.14	19
Total	672,475	605,797	463,485	142,312	247	237	10	0.41	0.51	0.07	153

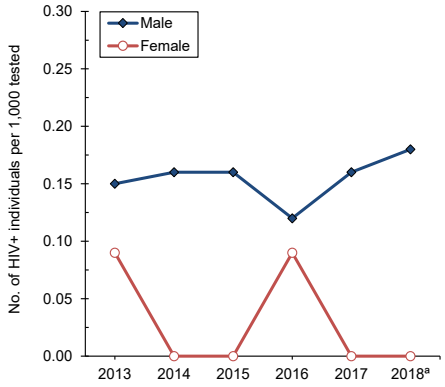
[a]Through 30 June 2018

FIGURE 4. New diagnoses of HIV infections, by sex, active component, U.S. Navy, January 2013–June 2018



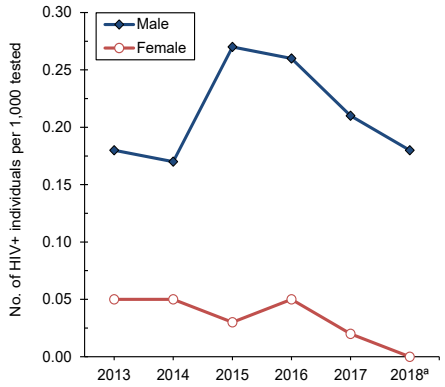
[a]Through 30 June 2018

FIGURE 5. New diagnoses of HIV infections, by sex, active component, U.S. Marine Corps, January 2013–June 2018



[a]Through 30 June 2018

FIGURE 6. New diagnoses of HIV infections, by sex, active component, U.S. Air Force, January 2013–June 2018



[a]Through 30 June 2018

to 0.16 per 1,000 tested in the first 6 months of 2018 (30.4% decrease) **(Table 3)**. Annual seroprevalences for male active component Army members greatly exceeded those of females **(Figure 3)**. During 2017, on average, one new HIV infection was detected among active component Army soldiers per 7,142 screening tests **(Table 3)**. Of the 407 active component soldiers diagnosed with HIV infections since 2013, a total of 233 (57.2%) were still in military service in 2018.

Army National Guard: From January 2017 through June 2018, a total of 319,905 members of the Army National Guard were tested for antibodies to HIV, and 91 soldiers were identified as HIV antibody positive (seroprevalence: 0.28 per 1,000 soldiers tested) **(Table 4)**. Among Army National Guard soldiers, annual seroprevalences increased from 2013 through 2014 (seroprevalences: 0.35 and 0.39 per 1,000 soldiers tested, respectively), decreased somewhat in 2015 and then increased slightly in 2016. During 2017–2018, the seroprevalences decreased 28.1%. On average, during 2017, one new HIV infection was detected among Army National Guard soldiers per 3,626 screening tests **(Table 4)**. Of the 384 National Guard soldiers who tested positive for HIV since 2013, a total of 203 (52.9%) were still in military service in 2018.

Army Reserve: From January 2017 through June 2018, a total of 165,690 members of the Army Reserve were tested for antibodies to HIV, and 60 soldiers were identified as HIV antibody positive (seroprevalence: 0.36 per 1,000 soldiers tested) **(Table 5)**. Among Army reservists, the seroprevalence in 2013 (0.48 per 1,000 tested) was the highest during the surveillance period. However, the seroprevalence among Army reservists in 2013 represented a 17.2% decrease from that in 2012 **(Table 5; data not shown)**. Between 2013 and 2017, HIV antibody seroprevalences among Army reservists decreased 20.8% **(Table 5)**. During 2017, on average, one new HIV infection was detected among Army reservists per 2,640 screening tests **(Table 5)**. Of the 247 Army reservists diagnosed with HIV infections since 2013, a total of 153 (61.9%) were still in military service in 2018.

U.S. Navy

Active component: From January 2017 through June 2018, a total of 339,926 active component members of the U.S. Navy were tested for antibodies to HIV, and 90 sailors were identified as HIV antibody positive (seroprevalence: 0.26 per 1,000 sailors tested) **(Table 6)**. Among tested male active component sailors, the annual HIV antibody seroprevalence increased each year between 2013 and 2015, declined 32.4% in 2016 and then increased 20.0% in 2017 **(Figure 4)**. During 2017, on average, one new HIV infection was detected among active component sailors per 3,324 screening tests **(Table 6)**. Of the 366 active component sailors who tested positive for HIV since 2013, a total of 240 (65.6%) were still in military service in 2018.

Navy Reserve: From January 2017 through June 2018, a total of 53,410 members of the Navy Reserve were tested for antibodies to HIV, and 12 sailors were identified as HIV antibody positive (seroprevalence: 0.22 per 1,000 sailors tested) **(Table 7)**. The HIV antibody seroprevalence among Navy reservists in 2015 was more than two times that in 2016 (seroprevalences: 0.46 and 0.22 per 1,000 sailors tested, respectively). The seroprevalence in 2018 (through June) was lower than in any full year of routine HIV antibody screening of Navy reservists since 2004 **(data not shown)**. Of note, no antibodies to HIV were detected among female Navy reservists during 2013–2018 **(Table 7)**. On average, during 2017, one new HIV infection was detected among Navy reservists per 5,067 screening tests **(Table 7)**. Of the 65 reserve component sailors diagnosed with HIV infections since 2013, a total of 43 (66.2%) were still in military service in 2018.

U.S. Marine Corps

Active component: From January 2017 through June 2018, a total of 215,119 members of the active component of the U.S. Marine Corps were tested for antibodies to HIV, and 33 Marines were identified as HIV antibody positive (seroprevalence: 0.15 per 1,000 Marines tested) **(Table 8)**. From January 2013 through June 2018, prevalences of antibodies to HIV remained relatively low and stable among routinely tested Marines **(Figure 5)**. During 2017, on average, one new

TABLE 6. New diagnoses of HIV infections, by sex, active component, U.S. Navy, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	248,137	217,548	177,262	40,286	70	69	1	0.32	0.39	0.02	35
2014	250,386	222,117	180,795	41,322	73	72	1	0.33	0.40	0.02	41
2015	241,711	214,218	172,615	41,603	79	77	2	0.37	0.45	0.05	46
2016	239,410	212,818	171,548	41,270	54	52	2	0.25	0.30	0.05	41
2017	249,252	219,395	174,694	44,701	66	65	1	0.30	0.37	0.02	53
2018[a]	131,175	120,531	96,072	24,459	24	24	0	0.20	0.25	0.00	24
Total	1,360,071	1,206,627	972,986	233,641	366	359	7	0.30	0.37	0.03	240

[a]Through 30 June 2018

TABLE 7. New diagnoses of HIV infections, by sex, U.S. Navy Reserve, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	45,173	38,551	30,702	7,849	12	12	0	0.31	0.39	0.00	4
2014	42,807	37,608	29,911	7,697	17	17	0	0.45	0.57	0.00	9
2015	39,028	34,625	27,327	7,298	16	16	0	0.46	0.59	0.00	12
2016	41,292	35,680	27,941	7,739	8	8	0	0.22	0.29	0.00	7
2017	40,532	34,769	27,264	7,505	8	8	0	0.23	0.29	0.00	7
2018[a]	20,205	18,641	14,463	4,178	4	4	0	0.21	0.28	0.00	4
Total	229,037	199,874	157,608	42,266	65	65	0	0.33	0.41	0.00	43

[a]Through 30 June 2018

TABLE 8. New diagnoses of HIV infections, by sex, active component, U.S. Marine Corps, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	180,549	151,897	140,329	11,568	22	21	1	0.14	0.15	0.09	6
2014	173,351	146,849	135,135	11,714	22	22	0	0.15	0.16	0.00	9
2015	162,065	140,440	129,489	10,951	21	21	0	0.15	0.16	0.00	7
2016	157,659	138,112	126,694	11,418	16	15	1	0.12	0.12	0.09	11
2017	164,596	140,972	129,129	11,843	21	21	0	0.15	0.16	0.00	14
2018[a]	80,290	74,147	67,115	7,032	12	12	0	0.16	0.18	0.00	12
Total	918,510	792,417	727,891	64,526	114	112	2	0.14	0.15	0.03	59

[a]Through 30 June 2018

TABLE 9. New diagnoses of HIV infections, by sex, U.S. Marine Corps Reserve, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	27,669	24,171	23,181	990	4	4	0	0.17	0.17	0.00	0
2014	27,337	24,389	23,454	935	7	7	0	0.29	0.30	0.00	4
2015	26,809	24,018	23,141	877	11	10	1	0.46	0.43	1.14	5
2016	26,283	23,140	22,299	841	6	6	0	0.26	0.27	0.00	3
2017	28,806	25,361	24,467	894	8	8	0	0.32	0.33	0.00	4
2018[a]	14,236	12,746	12,290	456	2	2	0	0.16	0.16	0.00	2
Total	151,140	133,825	128,832	4,993	38	37	1	0.28	0.29	0.20	18

[a]Through 30 June 2018

TABLE 10. New diagnoses of HIV infections, by sex, active component, U.S. Air Force, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	255,720	208,558	168,674	39,884	33	31	2	0.16	0.18	0.05	17
2014	243,141	201,184	162,503	38,681	29	27	2	0.14	0.17	0.05	13
2015	231,752	192,811	155,489	37,322	43	42	1	0.22	0.27	0.03	28
2016	239,254	193,941	155,841	38,100	42	40	2	0.22	0.26	0.05	31
2017	254,720	202,783	161,723	41,060	35	34	1	0.17	0.21	0.02	31
2018[a]	131,910	118,813	94,861	23,952	17	17	0	0.14	0.18	0.00	17
Total	1,356,497	1,118,090	899,091	218,999	199	191	8	0.18	0.21	0.04	137

[a]Through 30 June 2018

TABLE 11. New diagnoses of HIV infections, by sex, U.S. Air National Guard, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	39,923	53,947	43,778	10,169	4	4	0	0.07	0.09	0.00	1
2014	41,242	57,548	46,489	11,059	2	2	0	0.03	0.04	0.00	0
2015	36,579	53,483	43,098	10,385	6	6	0	0.11	0.14	0.00	5
2016	40,948	60,470	48,561	11,909	6	6	0	0.10	0.12	0.00	3
2017	39,788	58,819	46,911	11,908	6	6	0	0.10	0.13	0.00	6
2018[a]	21,110	34,331	27,786	6,545	3	3	0	0.09	0.11	0.00	3
Total	219,590	318,598	256,623	61,975	27	27	0	0.08	0.11	0.00	18

[a]Through 30 June 2018

TABLE 12. New diagnoses of HIV infections, by sex, U.S. Air Force Reserve, January 2013–June 2018

Year	Total HIV tests	Total persons tested	Males tested	Females tested	Total new HIV(+)	New HIV(+) male	New HIV(+) female	Overall rate per 1,000 tested	Male rate per 1,000 tested	Female rate per 1,000 tested	HIV(+) still in military service in 2018
2013	39,923	35,234	26,381	8,853	14	14	0	0.40	0.53	0.00	3
2014	41,242	36,717	27,446	9,271	8	8	0	0.22	0.29	0.00	4
2015	36,579	32,681	24,265	8,416	3	2	1	0.09	0.08	0.12	2
2016	40,948	36,227	26,653	9,574	10	10	0	0.28	0.38	0.00	9
2017	39,788	35,252	25,968	9,284	6	6	0	0.17	0.23	0.00	6
2018[a]	21,110	20,086	14,646	5,440	2	2	0	0.10	0.14	0.00	2
Total	219,590	196,197	145,359	50,838	43	42	1	0.22	0.29	0.02	26

[a]Through 30 June 2018

HIV infection was detected among active component Marines per 7,838 screening tests **(Table 8)**. Of the 114 active component Marines diagnosed with HIV infections since 2013, a total of 59 (51.8%) were still in military service in 2018.

Marine Corps Reserve: From January 2017 through June 2018, a total of 38,107 members of the Marine Corps Reserve were tested for antibodies to HIV, and 10 Marine Corps reservists were identified as HIV antibody positive (seroprevalence: 0.26 per 1,000 Marines tested) **(Table 9)**. During the surveillance period, seroprevalences among Marine Corps reservists peaked at 0.46 per 1,000 tested in 2015 and reached a low of 0.16 per 1,000 tested in 2018 (through June). Of note, only one female Marine Corps reservist was detected with antibodies to HIV during routine screening in 2015; none were detected during 1990–2014 or during 2016–2018 (through June) **(data not shown)**. During 2017, on average, one new HIV infection was detected among Marine Corps reservists per 3,601 screening tests **(Table 9)**. Of the 38 Marine Corps reservists diagnosed with HIV infection since 2013, a total of 18 (47.4%) were still in military service in 2018.

U.S. Air Force

Active component: From January 2017 through June 2018, a total of 321,596 active component members of the U.S. Air Force were tested for antibodies to HIV, and 52 airmen were diagnosed with HIV infections (seroprevalence: 0.16 per 1,000 airmen tested) **(Table 10)**. From 2013 through June 2018, seroprevalences ranged from 0.14 per 1,000 tested to 0.22 per 1,000 tested. HIV antibody seroprevalence decreased among tested males after 2015 and remained relatively low and stable among females **(Figure 6)**. During 2017, on average, one new HIV infection was detected among active Air Force members per 7,278 screening tests **(Table 10)**. Of the 199 active component airmen diagnosed with HIV infections since 2013, 137 (68.8%) were still in military service in 2018.

Air National Guard: From January 2017 through June 2018, a total of 93,150 members of the Air National Guard were tested for antibodies to HIV, and nine airmen were diagnosed with HIV infections (seroprevalence: 0.10 per 1,000 airmen tested) **(Table 11)**. Since 2010, no female Air National Guard member has been detected with antibodies to HIV during routine testing **(data not shown)**. During 2017, on average, one new HIV infection was detected among Air National Guard members per 6,631 screening tests **(Table 11)**. Of the 27 Air National Guard members diagnosed with HIV infections since 2013, 18 (66.7%) were still in military service in 2018.

Air Force Reserve: From January 2017 through June 2018, a total of 55,338 members of the Air Force Reserve were tested for antibodies to HIV, and eight airmen were diagnosed with HIV infections (seroprevalence: 0.14 per 1,000 airmen tested) **(Table 12)**. During 2017, on average, one new HIV infection was detected among Air Force reservists per 6,361 screening tests **(Table 12)**. Of the 43 reserve component airmen diagnosed with HIV infections since 2013, 26 (60.5%) were still in military service in 2018.

EDITORIAL COMMENT

The U.S. military has conducted routine screening for antibodies to HIV among all civilian applicants for service and all active and reserve component members of the services for more than 30 years.[2-5] Results of U.S. military HIV antibody testing programs have been summarized in the *MSMR* for more than two decades.[6]

This report documents that, since 2013, prevalences of HIV seropositivity among civilian applicants for military service have fluctuated between 0.23 and 0.34 per 1,000 applicants tested. During this period, seroprevalences among civilian applicants peaked in 2015 and then decreased to 0.23 per 1,000 applicants in 2018 (through June). It is important to note that, because applicants for military service are not randomly selected from the general population of U.S. young adults, seroprevalences among applicants are not directly indicative of HIV prevalences, infection rates, or trends in the U.S. civilian population. As such, relatively low prevalences of HIV among civilian applicants for military service do not necessarily indicate low prevalences or incidence rates of HIV among young adults in the U.S. in general.

This report also documents that full-year HIV antibody seroprevalences among members of the active components of all of the services were relatively stable during 2013–2017. As was observed for total civilian applicants, annual seroprevalences among Army active component service members, Navy active component members, Navy reservists, Marine Corps reservists, and Air National Guard members peaked in 2015. Seroprevalences among the Army Reserve showed a consistent decrease between 2013 and 2018 (through June) and the Navy Reserve exhibited a pronounced drop in seroprevalences after 2015. Overall (2013–June 2018) HIV antibody seroprevalences were highest among Army reservists, Army National Guard members, Navy reservists, and Navy active component members. Across active and reserve components of all services, seroprevalences continued to be higher among males than females. Again, however, such results should be interpreted with consideration of the limitations of the surveillance data summarized herein. For example, because of the frequency of screening in the military (as an applicant, routinely every 2 years, and before and after overseas deployments), routine screening now detects relatively recently acquired HIV infections (i.e., infections acquired since the most recent negative test of each affected individual). As such, annual HIV-antibody seroprevalences during routine screening of military populations are reflective of, but are not direct unbiased estimates of, incidence rates and trends of acquisitions of HIV infections among military members.

In summary, the U.S. military has conducted comprehensive HIV prevention, education, counseling, and treatment programs for more than 30 years. Since the beginning of these programs, routine screening of all civilian applicants for service and routine periodic testing of all active and reserve component members of the services have been fundamental components of the military's HIV control and clinical management efforts.[7] Summaries of results of screening programs such as those in this report provide insights into the current status and trends of HIV's impacts in various U.S. military populations.

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Human Papillomavirus Vaccine Initiation, Coverage, and Completion Rates Among U.S. Active Component Service Members, 2007–2017

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

Human papillomavirus (HPV) vaccines have been available and licensed for use in the U.S. among women since 2006 and among men since 2010. Currently, HPV is not a mandatory vaccine for U.S. military service; however, it is encouraged and offered to service members. Between 2007 and 2017, a total of 111,546 (26.6%) eligible active component service women aged 17–26 years and 121,657 (5.8%) men initiated the HPV vaccine. Of those service members who initiated vaccination and remained in service for at least 6 months, less than half of women (46.6%) and only slightly more than one-third of men (35.1%) completed three doses. Initiation and completion rates also varied by service branch, with service members in the Air Force generally having higher initiation and completion rates. The median times between the first and second doses and between the first and third doses were 3.8 months and 10.8 months, respectively. The median time in service at initiation dose was 1.1 years. Continued development and implementation of interventions to enhance HPV vaccination initiation among military service members are warranted.

Genital human papillomavirus (HPV) is the most common sexually transmitted infection (STI) in the U.S.[1]; HPV is the second most frequently diagnosed STI in U.S. military service members.[2] Although most HPV infections are asymptomatic and resolve spontaneously, persistent infection with specific HPV types is causally associated with certain cancers (e.g., cervical, anal, penile, oropharyngeal) and anogenital warts.[3,4]

HPV vaccination has been demonstrated to be a safe and effective means of preventing HPV infection.[5-9] Since 2006, three HPV vaccines have become available and are currently licensed in the U.S. The first vaccine introduced, in 2006, for girls and women aged 11–26 years, was a quadrivalent (4-valent) vaccine (Gardasil®), which protects against HPV types 6, 11, 16, and 18. HPV 16 and 18, the two most common "high-risk" oncogenic genotypes, cause an estimated 64% of all HPV-related cancers, including 65% of all cervical cancers. HPV 6 and 11, two "low-risk" genotypes, cause 90% of anogenital warts (condylomata).[10] Gardasil approval was extended to boys aged 11–26 years in 2010. A bivalent (2-valent) vaccine, Cervarix®, which protects against HPV types 16 and 18, was approved in 2010 for use in girls and women aged 9–25 years, but not in boys.[11,12] A 9-valent HPV vaccine, Gardasil®9, was approved in 2014 in the U.S. and protects against the same four HPV types as the quadrivalent vaccine and five additional cancer-causing HPV types (31, 33, 45, 52, and 58).[12]

Currently, the Centers for Disease Control and Prevention (CDC)'s Advisory Committee on Immunization Practices (ACIP) recommends routine HPV vaccination of both girls and boys at age 11 or 12 years. However, although HPV vaccine coverage has steadily improved in U.S. adolescents and young adults, vaccine uptake remains suboptimal.[13] Consequently, many U.S. adults, including new accessions to the military, are candidates for catch-up vaccination. ACIP recommends catch-up vaccination with any of the three currently available HPV vaccines for females aged 11–26 years and males aged 12–21 years, if they have not previously been vaccinated.[11,12] In addition, males between 22 and 26 years of age who are members of certain groups (e.g., men who have sex with men [MSM], immunocompromised men) are also candidates for catch-up vaccination.[11] Although HPV vaccination is not mandatory for active component service members, it is available and encouraged for unvaccinated individuals.[14]

HPV vaccine initiation and completion rates in female military members between 2006 and 2011 were previously published in the *MSMR*. This previous report documented that 22.5% of eligible service women initiated HPV vaccination and 15.1% completed the vaccination series according to ACIP guidelines.[15] The current analysis provides updated counts and rates of vaccine initiation and completion in both male and female active component service members.

METHODS

The surveillance period was 1 January 2007 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 and were aged 26 years or younger. All data used to determine HPV vaccination initiation and coverage rates were derived from records routinely maintained in the Defense Medical Surveillance

TABLE 1. Human papillomavirus (HPV) vaccine initiation, coverage, and completion rates among eligible active component service members, U.S. Armed Forces, 2007–2017

	Service men ♂			Service women ♀		
DoD overall	No. vaccinated	Population	%	No. vaccinated	Population	%
Initiation rates	121,657	2,095,494	5.8	111,546	418,748	26.6
Coverage rates[a]						
1 dose	42,193	105,247	40.1	30,189	102,144	29.6
2 doses	26,098	105,247	24.8	24,347	102,144	23.8
≥ 3 doses	36,956	105,247	35.1	47,608	102,144	46.6
Completion rates[b]						
6 months	840	105,247	0.8	1,171	102,144	1.1
7 months	7,610	102,792	7.4	12,009	100,589	11.9
1 year	16,993	89,158	19.1	25,191	92,339	27.3
Army						
Initiation rates	29,195	816,980	3.6	29,465	152,647	19.3
Coverage rates[a]						
1 dose	11,779	24,147	48.8	9,785	26,685	36.7
2 doses	6,605	24,147	27.4	7,520	26,685	28.2
≥ 3 doses	5,763	24,147	23.9	9,380	26,685	35.2
Completion rates[b]						
6 months	207	24,147	0.9	417	26,685	1.6
7 months	1,330	23,503	5.7	2,585	26,156	9.9
1 year	2,887	19,785	14.6	4,923	23,602	20.9
Marine Corps						
Initiation rates	9,176	441,810	2.1	8,311	39,626	21.0
Coverage rates[a]						
1 dose	3,573	7,698	46.4	2,049	7,528	27.2
2 doses	1,811	7,698	23.5	1,871	7,528	24.9
≥ 3 doses	2,314	7,698	30.1	3,608	7,528	47.9
Completion rates[b]						
6 months	145	7,698	1.9	120	7,528	1.6
7 months	746	7,439	10.0	746	7,418	10.1
1 year	1,368	6,526	21.0	1,993	6,880	29.0
Navy						
Initiation rates	19,116	452,418	4.2	31,295	119,749	26.1
Coverage rates[a]						
1 dose	6,816	16,694	40.8	11,401	28,746	39.7
2 doses	4,339	16,694	26.0	8,220	28,746	28.6
≥3 doses	5,539	16,694	33.2	9,125	28,746	31.7
Completion rates[b]						
6 months	319	16,694	1.9	342	28,746	1.2
7 months	1,792	16,285	11.0	1,979	28,431	7.0
1 year	3,002	13,746	21.8	3,933	26,386	14.9
Air Force						
Initiation rates	64,170	389,320	16.5	42,475	107,073	39.7
Coverage rates[a]						
1 dose	20,025	56,708	35.3	6,954	39,185	17.7
2 doses	13,343	56,708	23.5	6,736	39,185	17.2
≥3 doses	23,340	56,708	41.2	25,495	39,185	65.1
Completion rates[b]						
6 months	169	56,708	0.3	292	39,185	0.7
7 months	3,742	55,565	6.7	6,699	38,584	17.4
1 year	9,736	49,101	19.8	14,342	35,471	40.4

[a]Coverage rates are measured as the percentage of service members who received 1, 2, or ≥3 doses by the end of the surveillance period, among those who initiated the vaccine.

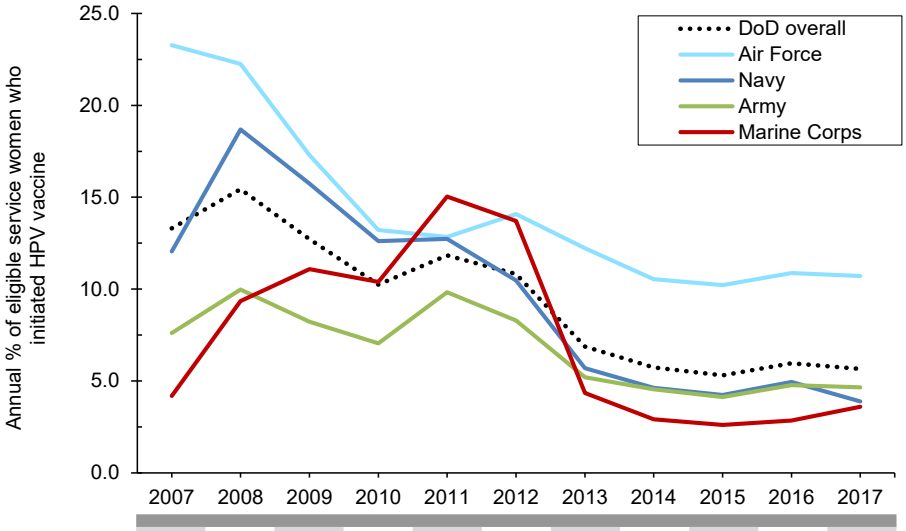
[b]Completion rates are measured as the percentage of service members who received ≥3 doses within 6 months (182 days), 7 months (213 days), or 1 year (365 days) following the first dose, among those who initiated the vaccine.

System (DMSS). In particular, immunization records maintained in DMSS are received from the immunization database of the Defense Enrollment Eligibility Reporting System (DEERS).

HPV vaccination initiation was defined by having a first-ever vaccination recorded in DMSS during the surveillance period. The initiation rate was calculated by dividing the number of service members who initiated in a given year, or during the overall 2007–2017 surveillance period, by the number of service members aged 26 years or younger who had no prior record of HPV vaccination administered while in military service. HPV vaccination records prior to military service were unavailable. Coverage rates for one, two, or three or more doses were also calculated. The denominator for the coverage rates was the number of service members who initiated the vaccine before the last 6 months of the surveillance period and remained in the active component for at least 6 months following their initiation dose. The numerators for the coverage rates were the numbers of service members who completed up to one, two, or three or more doses during the surveillance period. Next, completion rates were calculated. The denominator for the 6-month completion rate was the number of service members who were followed up for a period of at least 6 months after the initiation dose. The numerator for the 6-month completion rate was the number of service members who completed three doses within 6 months following the initiation dose. Completion rates by 7 and 12 months were calculated in a similar manner, among the population of service members who were followed up for 7 and 12 months after the initiation dose, respectively. Similarly, the numerator was the number of service members who completed three doses within 7 and 12 months, respectively.

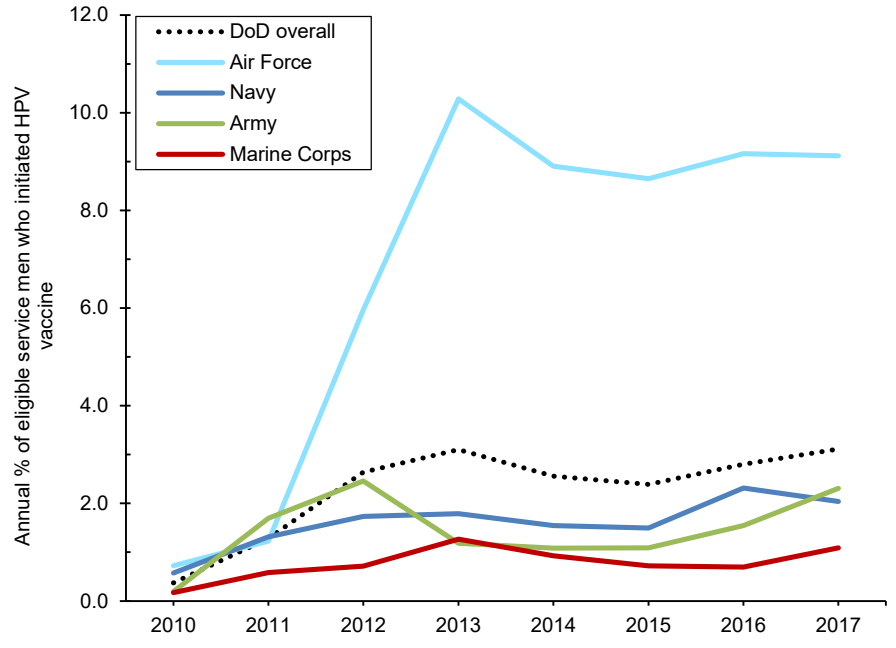
Service members were counted as having an HPV dose if they had immunization records for HPV4, HPV2, HPV9, or an unspecified HPV vaccine. However, HPV2 was counted only for female service members. For all service members, the second dose was not counted unless it was at least 28 days after the initiation dose, and the third dose was not counted unless it was

FIGURE 1. Annual percentage of eligible active component service women who initiated human papillomavirus (HPV) vaccine, U.S. Armed Forces, 2007–2017



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
DoD overall	13.3	15.4	12.7	10.3	11.8	10.8	6.9	5.7	5.3	6.0	5.7
Air Force	23.3	22.3	17.3	13.2	12.8	14.1	12.2	10.5	10.2	10.9	10.7
Navy	12.1	18.7	15.7	12.6	12.7	10.5	5.7	4.6	4.2	5.0	3.9
Army	7.6	10.0	8.2	7.1	9.8	8.3	5.2	4.6	4.1	4.8	4.7
Marine Corps	4.2	9.4	11.1	10.4	15.0	13.7	4.4	2.9	2.6	2.9	3.6

FIGURE 2. Percentage of eligible active component service men who initiated human papillomavirus (HPV) vaccine, U.S. Armed Forces, 2010–2017



	2010	2011	2012	2013	2014	2015	2016	2017
DoD overall	0.4	1.3	2.6	3.1	2.6	2.4	2.8	3.1
Air Force	0.7	1.2	6.0	10.3	8.9	8.7	9.2	9.1
Navy	0.6	1.3	1.7	1.8	1.5	1.5	2.3	2.0
Army	0.2	1.7	2.5	1.2	1.1	1.1	1.5	2.3
Marine Corps	0.2	0.6	0.7	1.3	0.9	0.7	0.7	1.1

at least 84 days after the second dose. Age, sex, service branch, and year were referenced at the time of the initiation dose.

The median number of months between doses, as well as the median number of years in service at the time of HPV vaccine initiation were calculated overall and by sex and service branch.

RESULTS

From January 2007 through December 2017, a total of 111,546 (26.6%) service women and 121,657 (5.8%) service men initiated the HPV vaccine **(Table 1)**. Among both men and women, the initiation rate varied by service branch, with 39.7% of Air Force, 26.1% of Navy, 21.0% of Marine Corps, and 19.3% of Army service women initiating during the surveillance period. Similarly, 16.5% of Air Force, 4.2% of Navy, 3.6% of Army, and 2.1% of Marine Corps service men initiated during the surveillance period. Initiation rates decreased from 2007 to 2017 among service women in all service branches **(Figure 1)**. In contrast, initiation rates among service men increased from 2010 through 2012 among all service branches **(Figure 2)**. Notably, rates of initiation among service men in the Air Force increased dramatically from 1.2% in 2011 to 6.0% in 2012 to 10.3% in 2013 and remained at around 9.0% for the remainder of the surveillance period **(Figure 2)**.

Among the 418,748 service women aged 17–26 years without prior HPV vaccination history in their military service records, 47,608 (11.4%) completed three doses during the surveillance period **(Table 1)**. Of the 102,144 women who initiated the HPV vaccine during the surveillance period and remained in the active component for 6 months or more following their first dose, 30,189 (29.6%) received only one dose, 24,347 (23.8%) received only two doses, and 47,608 (46.6%) completed the recommended three doses. Among the 2,095,494 service men aged 17–26 years without prior HPV vaccination history in their military service records, 36,956 (1.8%) completed three HPV doses during the 2007–2017 surveillance period. Of the 105,247 men who initiated the HPV

FIGURE 3. Three-dose completion rates, by service and completion time, active component service women who initiated human papillomavirus (HPV) vaccine, U.S. Armed Forces, 2007–2017

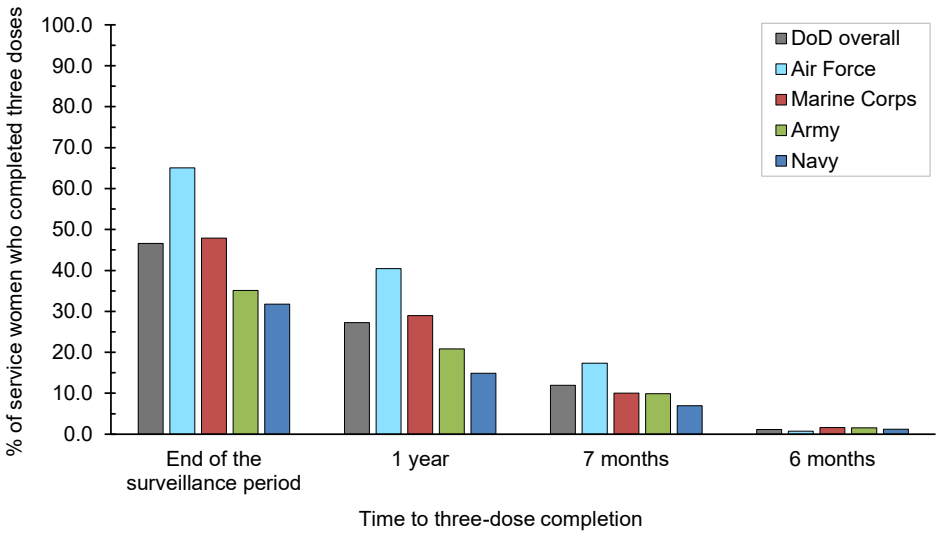
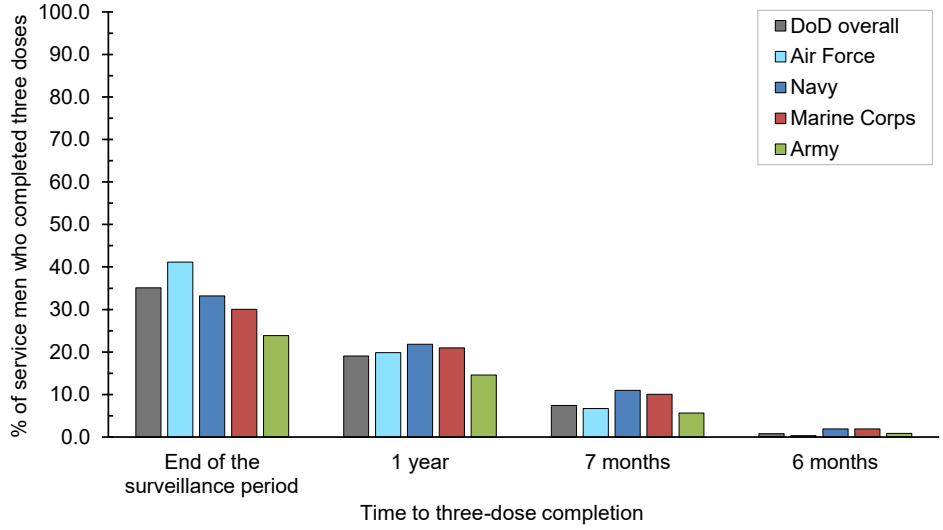


FIGURE 4. Three-dose completion rates, by service and completion time, active component service men who initiated human papillomavirus (HPV) vaccine, U.S. Armed Forces, 2010–2017



vaccine during the surveillance period and remained in the active component for 6 months or more following their first dose, 42,193 (40.1%) received only one dose, 26,098 (24.8%) received only two doses, and 36,956 (35.1%) completed three doses.

Among service women who initiated the HPV vaccine, 1.5% completed three doses within 6 months of initiation, 11.9% within 7 months of initiation, and 27.3% within 1 year of initiation **(Table 1)**. Similarly, among men who initiated the HPV vaccine, 0.8% completed three doses within 6 months following initiation, 7.4% within 7 months after initiation, and 19.1% within 1 year following initiation.

Completion rates also varied by sex and service branch. In particular, service women in the Air Force who initiated HPV vaccine had higher three-dose completion rates by 7 months, 1 year, and by the end of the surveillance period, compared with women in other service branches **(Figure 3)**. However, the completion rate by 6 months was similarly low across all the service branches. Service men in the Air Force who initiated HPV vaccine also had higher completion rates by the end of the surveillance period, compared with men in other service branches **(Figure 4)**. However, men in either the Navy or Marine Corps had higher completion rates within 6 months, 7 months, and 1 year following initiation.

Overall, the median time between the first and second doses was 3.8 months and the median time was 10.8 months between the first and third doses **(Table 2)**. Women had somewhat less time between doses, compared with men (3.5 vs. 4.2 months between first and second doses, and 10.4 vs. 11.4 months between first and third doses). Overall, Marine Corps members had the shortest time between doses, compared with other service branches (2.9 months between first and second doses and 9.5 months between first and third doses). However, among service women, those in the Air Force had shorter times between doses, compared with other service branches (3.1 months between first and second doses and 9.9 months between first and third doses).

The median time in service at initiation dose was 1.1 years overall, with service members in the Navy and Marine Corps tending to initiate a little sooner, at 0.8 and 0.9 years, respectively **(data not shown)**. Women also initiated sooner than men, with the median time in service at initiation dose being 0.8 years among service women and 1.5 years among service men.

EDITORIAL COMMENT

During the 11-year surveillance period covered in this report, more than a quarter (26.6%) of eligible service women and 5.8% of eligible service men initiated HPV vaccination. Initiation rates among service women declined during the period, and overall initiation rates among women during this 11-year period are only slightly higher than the 22.5% rate reported during the 2006–2011 period in a previous *MSMR* report.[15]

To the authors' knowledge, this is the first published summary of population-level HPV vaccination initiation and completion rates in U.S. male service members. Between 2010 and 2017, the percentage of service men initiating vaccination increased almost 8-fold (0.4% in 2010; 3.1% in 2017). This observation mirrors findings in studies of vaccination rates in U.S. civilians which demonstrate that HPV vaccination coverage in males has been steadily increasing in both adolescents and young adults.[13,16]

Active component service men are an important target for catch-up HPV vaccination.[17] High-risk (i.e., oncogenic) HPV prevalence was recently estimated to be 25.1% in U.S. men aged 18–59 years.[18] Possible consequences of HPV infection for men include penile, anal, and oral cancers, including oropharyngeal (i.e., head and neck) squamous cell carcinoma (OPSCC). An estimated 41% of all HPV-related cancers diagnosed between 2008 and 2012 were among men.[19,20] The incidence of OPSCC among men has been increasing steadily over the past several decades and is projected to exceed that of cervical cancer in women.[19,20] Notably, men do not undergo regular screening for these cancers (comparable to Pap screening for cervical cancer in women); thus, prevention via HPV vaccination should be a focus of intervention efforts in service men.

Of service members who initiated HPV vaccination and remained in service for at least 6 months, the three-dose completion rate was suboptimal. Less than half of service women (46.6%) and slightly more than one-third of service men (35.1%) received three doses of vaccine as currently recommended for catch-up HPV vaccination. Similarly, adherence to the recommended dosing schedule (which requires receipt of three doses within 6 months) was poor. This lack of adherence to ACIP schedule and dosing recommendations has been a recurring issue in both civilian and military settings and across adolescent and adult vaccination programs.[21-26]

The comparison of the HPV vaccination initiation rates in this report with comparable civilian rates is difficult because limited data exist for similarly aged, HPV vaccine-naïve civilians and available data are largely based on self-report. In 2016, among a sample of 19- to 26-year-old U.S. women and men with no prior HPV vaccination participating in the National Health Interview Survey, vaccine initiation estimates were 8.6% and 2.7%, respectively.[27] In comparison, the present analysis reported female and male initiation rates in 2016 of 6.0% and 2.8%, respectively, indicating that HPV vaccination initiation rates in active component military members of similar age and without any prior HPV vaccination history are slightly lower than their civilian counterparts in women and slightly higher in men.

A significant limitation to this comparison, however, is that in the current analysis the HPV vaccination history for military service members prior to entering service is unknown. The 2016 National Immunization Survey indicated that 65% of female and 56% of male teenagers aged 13–17 years received one or more HPV vaccine doses, which was an overall increase of 4 percentage points from the previous year.[28] If the proportion of civilian teenagers initiating HPV vaccine is truly increasing, this trend could have decreased the estimated military HPV vaccine initiation rates in this analysis because there would actually be fewer service members eligible to initiate over time. A 2017 *MSMR* analysis documented decreasing incidence of HPV-related genital warts among female active component service members.[2] This finding would support the notion that increasing numbers of service women are protected against HPV, likely as a result of both increased civilian and military vaccination rates.

Rates of initiation and completion of HPV vaccination among both males and females were much higher in Air Force members, compared with members of other services. The reasons for this are unclear. This analysis relies on identification of vaccination status through documentation of vaccine receipt in administrative medical data. Missing or inaccurate documentation of vaccination status would have an adverse impact on the accuracy of reported HPV vaccination and completion. Differences in the completeness and accuracy of data by service could explain these differences if the Air Force has more completely and accurately documented HPV vaccination, compared to other services. In addition, although the Defense Health Agency and each individual service have policies encouraging HPV vaccination, the Air Force's 2007 policy memo included the implementation of electronic prompts to alert providers to unvaccinated females in the Air Force specific immunization tracking systems (i.e., Air Force Complete Immunization Tracking Application, now Aeromedical Services Information Management System).[29] This system of prompts may have positively affected vaccination rates.

Conversely, annual HPV vaccine initiation rates dropped substantially between 2012 and 2013 among service members in the Navy (10.5% to 5.7%) and Marine Corps (13.7% to 4.4%). This corresponds to a Navy Bureau of Medicine and Surgery (BUMED) policy letter that was issued in December 2012, which stated that HPV vaccination "should be offered to both male and female Service members at their first permanent duty station after their accession or training command."[30] This letter likely resulted in the cessation of HPV vaccination at Navy and Marine Corps boot camps, which had previously been offered on a voluntary basis.

Studies in military populations have demonstrated that interventions designed to increase knowledge about HPV infection and its consequences and to provide vaccine recommendations can increase vaccination rates significantly.[24,26] Continued development and implementation of such interventions to enhance HPV vaccination initiation and completion in accordance with ACIP guidelines are warranted.

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CE/CME

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Key points

- The crude annual HPV vaccine initiation rates among active component females declined slightly over the course of the surveillance period; crude initiation rates in active component males increased eightfold during the same surveillance period.
- Among active component service members who initiated the HPV vaccine during the surveillance period and remained in the active component for 6 months or more following their first dose, 46.6% of women and 35.1% of men completed the recommended three doses.
- Compared to their respective counterparts in other services, active component service members in the Air Force had higher rates of HPV vaccination and completion.

Learning objectives

1. The reader will interpret data related to the initiation rates of HPV vaccination among active component service members.
2. The reader will explain how the HPV vaccination initiation rates among active component service members compares to that in the general population and how initiation rates have changed over time.
3. The reader will interpret data related to completion rates of HPV vaccination among active component service members.

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Update: Accidental Drownings and Near Drownings, Active Component, U.S. Armed Forces, 2013–2017

Valerie F. Williams, MA, MS; Gi-Taik Oh, MS; Shauna Stahlman, PhD, MPH

Service members are at risk for unintentional drownings or near drownings during training, occupational activities, and off-duty recreation. During 2013–2017, there were 359 incident accidental drowning episodes (includes drownings and near drownings) for a crude rate of 5.7 cases per 100,000 person-years. Compared with their respective counterparts, the overall incidence rates of drowning episodes were highest among males, those aged 29 years or younger, those who were unmarried, and enlisted service members. Across the services, crude overall rates were highest among Marine Corps and Navy members and lowest among Air Force members. Overall rates of drowning episodes were highest among those working in motor transport and lowest among those in repair/engineering or communications/intelligence occupations. The overall rate of drowning episodes among service members with any history of alcohol-related disorder was nearly twice that of those without any history of alcohol-related disorder. Between 2015 and 2017, annual rates of drowning episodes decreased in each service, with the greatest decline observed among Navy and Marine Corps members. The results of this report may be useful to increase awareness regarding the ongoing risks and effects of drowning episodes among U.S. service members.

In the U.S., unintentional drowning ranks as the sixth leading cause of unintentional injury death and accounted for an average of 3,558 deaths (non-boating related) annually between 2007 and 2016.[1] Males and members of racial/ethnic minorities were overrepresented among fatal unintentional drowning victims during this period.[1] Among adolescents and adults, alcohol use was involved in up to 70% of fatalities during recreational aquatic activities and close to one-quarter of all emergency department visits for drowning.[2-4] Inability to swim and failure to wear life jackets are also key risk factors for drowning among adults.[5,6]

Many military occupational activities, particularly of the Navy and Marine Corps, occur on or near water. The accidental drowning deaths of two Navy SEALs at the Combat Swimmer Training Facility at Joint Expeditionary Base Little Creek, VA, in 2015 show that even the most highly trained and fit personnel can be at risk of accidental fatal drowning during training and diving operations.[7] Recreational aquatic activities also can be dangerous and are commonly associated with drowning, particularly for non-swimmers and weak swimmers, in hazardous conditions and settings (e.g., storms, currents, riptides), and when safety measures are not observed.[8]

In the U.S., the risk factors for drowning are well established. Bell and colleagues reviewed 352 fatal drownings of male U.S. Army soldiers during 1980–1997.[9] Their analysis revealed elevated risk among male soldiers who were aged 25 years or younger, black, and unmarried.[9] Most deaths occurred during off-duty activities; alcohol use was involved in approximately one-third of the cases. A June 2015 *MSMR* report documented an average of 119 accidental drowning episodes (includes drownings and near drownings) and 16 deaths per year among active component service members during 2005–2014.[10] Results of the 2015 analysis showed that overall incidence rates of accidental drownings were highest among service members aged 30 years or younger, males, those who were unmarried, Navy or Marine Corps members, and those in combat-specific occupations.[10] Compared with their respective counterparts, overall rates of drowning episodes were lowest among non-Hispanic black service members; however, the case fatality percentage among non-Hispanic blacks was the highest among all race/ethnicity groups.[10]

The current analysis extends and updates the findings of the June 2015 *MSMR* article.[10] Specifically, the current report summarizes counts, rates, and correlates of risk of medical encounters related to drowning episodes (drownings and near drownings) among U.S. military members during 2013–2017.

METHODS

The surveillance period was 1 January 2013 through 31 December 2017. The surveillance population consisted of active component service members of the U.S. Army, Navy, Air Force, or Marine Corps who served at any time during the surveillance period. Diagnoses were ascertained from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System or civilian facilities in the purchased care system. These data are maintained in the electronic database of the Defense Medical Surveillance System (DMSS).

Electronic records of all active component service members were searched to identify hospitalizations and ambulatory

encounters that included diagnosis codes indicative of injuries associated with "drowning-related episodes." For surveillance purposes, the term "drowning-related episode" included fatal drownings and nonfatal submersions, and was defined by a qualifying ICD-9 or ICD-10 diagnosis code (in any diagnostic position), ICD-9 or ICD-10 external cause of injury code, or a NATO standardization agreement (STANAG) cause of injury code that indicated a drowning or submersion injury that was not intentionally inflicted **(Table 1)**. Fatal drowning episodes were not distinguished from nonfatal episodes because data on underlying cause of death were not available for the current analysis. Healthcare encounters that occurred during deployment were excluded from the analysis. Medical encounters with the following codes in any diagnostic position were excluded from consideration as cases: ICD-9 E964 "assault by submersion (drowning)"; ICD-9 E954 "suicide and self-inflicted injury by submersion (drowning)"; ICD-10 X92* "assault by drowning and submersion"; ICD-10 X71* "intentional self-harm by drowning and submersion"; and NATO STANAG "general class of trauma" codes 3 ("assault, or intentionally inflicted by another person") and 4 ("intentionally self-inflicted") **(Table 1)**.

If a service member had case-defining inpatient and outpatient records in the same calendar year, information from the hospitalization record was used for the analysis. Individuals could be counted as cases once per calendar year. Incidence rates were calculated using non-deployed person-time in the denominator and as the number of cases per 100,000 person-years (p-yrs).

History of an alcohol-related disorder was defined by one hospitalization with a qualifying ICD-9 or ICD-10 diagnosis code in the 1st or 2nd diagnostic position;[12] *or* two outpatient encounters within 180 days of each other with a qualifying diagnosis code in the 1st or 2nd diagnostic position; or one outpatient encounter with Medical Expense and Performance Reporting System (MEPRS) code "BF", indicating psychiatric and/or mental health care and a qualifying diagnosis code in the 1st or 2nd diagnostic position. Qualifying ICD diagnoses could occur prior to or during the surveillance period.

RESULTS

During the 5-year surveillance period, there were 359 incident accidental drowning episodes (includes drownings and near drownings) among active component service members, for a crude overall incidence rate of 5.7 cases per 100,000 p-yrs **(Table 2)**. Compared with their respective counterparts, the overall

TABLE 1. ICD-9 and ICD-10 diagnosis/external cause of injury codes and STANAG[a] injury codes used to define drowning episodes[b]

ICD-9	Description	ICD-10	Description
994.1	Drowning and nonfatal submersion	T75.1*	Unspecified effects of drowning and nonfatal submersion
E830*	Accident to watercraft causing submersion	V9089X*	Drowning and submersion due to other accident to unspecified watercraft
E832*	Other accidental submersion/drowning in water transport accident	V9209X*	Drowning and submersion due to fall off unspecified watercraft
E910*	Accidental drowning and submersion	W69XXX*	Accidental drowning and submersion while in natural water
		W65XXX*	Accidental drowning and submersion while in bathtub
		W67XXX*	Accidental drowning and submersion while in swimming pool
E984	Submersion (drowning), undetermined whether accidentally or purposely inflicted	W74XXX*	Unspecified cause of accidental drowning and submersion
STANAG[a]	Description		
150	Water transport accident, involving submersion in boarding and alighting		
151	Water transport accident, involving submersion of occupant of small boat		
159	Water transport accident, involving submersion, other		
860–869	Drowning or submersion, not elsewhere classified		
Exclusions			
X92*	Assault by drowning and submersion	E964	Assault by submersion (drowning)
X71*	Intentional-self harm by drowning and submersion	E954	Suicide and self-inflicted injury by submersion (drowning)
STANAG inpatient trauma code 3 "assault or intentionally inflicted by another person"			
STANAG inpatient trauma code 4 "intentionally self-inflicted"			

[a]NATO standardization agreement cause of injury code
[b]The term "drowning episode" refers to any accidental submersion event that resulted in death or injury.
*Any digit/character

TABLE 2. Incident cases and incidence rates of drowning episodes[a], active component, U.S. Armed Forces, 2013–2017

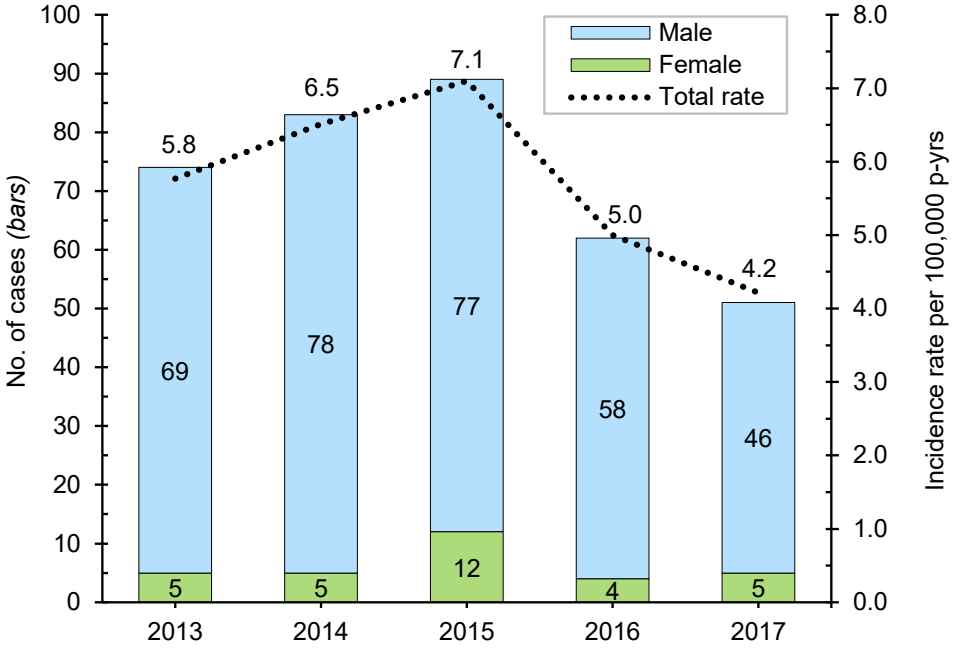
	Total	
	No.	Rate[b]
Total	359	5.7
Sex		
Male	328	6.2
Female	31	3.2
Age group		
<20	30	6.9
20–24	145	7.4
25–29	96	6.5
30–34	44	4.3
35–39	23	3.2
40+	21	3.2
Race/ethnicity		
Non-Hispanic white	221	6.0
Non-Hispanic black	46	4.5
Hispanic	52	5.9
Asian/Pacific Islander	14	5.8
Other/unknown	26	5.7
Marital status		
Married	160	4.7
Unmarried	188	7.3
Other/unknown	11	4.0
Service		
Army	125	5.3
Navy	95	6.3
Air Force	63	4.2
Marine Corps	76	8.4
Rank		
Recruit	1	0.7
Enlisted (excluding recruits)	308	6.1
Officer	50	4.5
Military occupation		
Combat-specific[c]	63	7.2
Motor transport	35	19.5
Pilot/air crew	16	6.9
Repair/engineering	83	4.5
Communications/intelligence	62	4.6
Health care	33	5.8
Other/unknown	67	5.6
Geographic region of military assignment[d]		
Northeast	4	2.1
Midwest	15	3.7
South	148	5.0
West	119	7.1
Overseas	32	4.3
Unknown/missing	41	16.1
History of alcohol-related disorder		
Yes	25	10.0
No	334	5.6

[a]The term "drowning episode" refers to any accidental submersion event that resulted in death or injury.
[b]Rate per 100,000 person-years
[c]Infantry/artillery/combat engineering/armor
[d]Within the U.S., categorization was based on U.S. Census Bureau regions (www.census.gov/geo/reference/webatlas/regions.html).

incidence rates of accidental drowning were highest among males, those aged 29 years or younger, those who were unmarried, and enlisted service members. Across the services, crude overall incidence rates were highest among Marine Corps members and Navy members (8.4 and 6.3 per 100,000 p-yrs, respectively) and lowest among Air Force members (4.2 per 100,000 p-yrs). Stratification by military occupation revealed that crude overall rates of drowning episodes were highest among those working in motor transport (19.5 per 100,000 p-yrs) and lowest among those in repair/engineering or communications/intelligence occupations (4.5 and 4.6 per 100,000 p-yrs, respectively) **(Table 2)**. Of active component service members with known locations of military assignment, overall incidence of drowning episodes was highest among those stationed in the Western region of the U.S. (7.1 per 100,000 p-yrs) and lowest among those stationed in the Northeast (2.1 per 100,000 p-yrs). However, the overall incidence rate among service members with unknown/missing locations of military assignment was more than 3 and 2 times the rates of service members with military assignments in the Southern and Western regions of the U.S., respectively. Of note, the overall rate of drowning episodes among service members with any history of alcohol-related disorder (10.0 per 100,000 p-yrs) was nearly twice that of those without any history of alcohol-related disorder (5.6 per 100,000 p-yrs) **(Table 2)**. Among all service members with a history of an alcohol-related disorder and a subsequent incident drowning episode, for more half of them (52.0%; n=13), more than a year had passed between the last alcohol-related diagnosis and the incident date of the drowning event; for nearly three-eighths (36.0%; n=9) of service members with both diagnoses, 30 or fewer days had passed between the last alcohol-related disorder diagnosis and the date of the incident drowning episode **(data not shown)**.

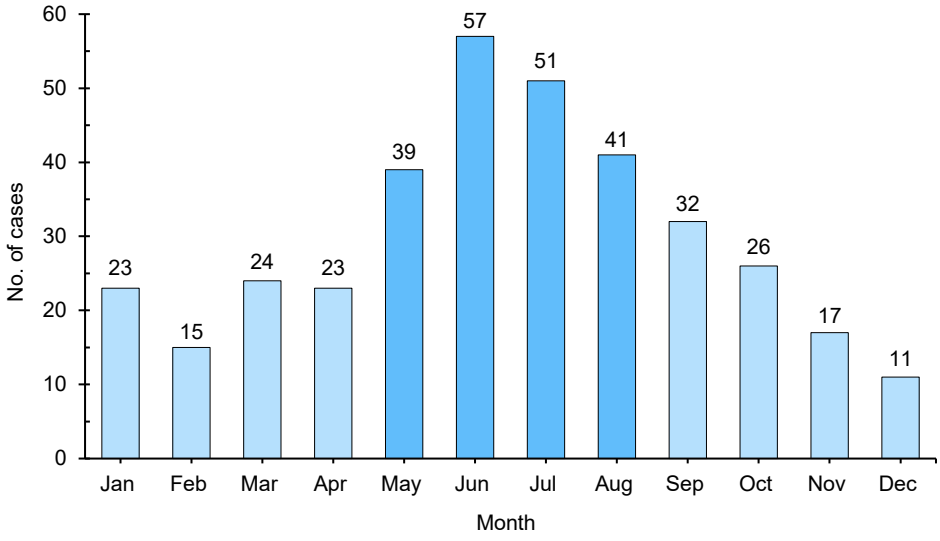
During 2013–2017, the fewest incident drowning episodes occurred in 2017 (n=51) and 2016 (n=62) **(Figure 1)**. Crude annual incidence rates of drowning episodes increased from 5.8 cases per 100,000

FIGURE 1. Numbers of cases and incidence rates of drowning episodes,[a] by year, active component, U.S. Armed Forces, 2013–2017



[a]The term "drowning episode" refers to any accidental submersion event that resulted in death or injury.

FIGURE 2. Cumulative numbers of drowning episodes, by month of occurrence, active component, U.S. Armed Forces, 2013–2017



p-yrs in 2013 to 7.1 cases per 100,000 p-yrs in 2015, after which rates decreased by 40.6% to a low of 4.2 cases per 100,000 p-yrs in 2017 **(Figure 1)**. Between 2015 and 2017, annual rates of drowning episodes decreased in each service with the greatest decline observed among Navy and Marine Corps members (48.3% and 29.0%, respectively) **(data not shown)**.

During the 5-year surveillance period, more incident drowning episodes occurred in June (n=57) than in any other month; slightly more than one-half (52.4%) of all drowning episodes occurred from May through August **(Figure 2)**.

EDITORIAL COMMENT

This report documents an average of 72 accidental drowning episodes per year among active component members of the U.S. Armed Forces. Consistent with the findings of earlier *MSMR* analyses of accidental drowning episodes among active component military members as well as Bell and colleagues' study of fatal drownings among U.S. soldiers, the current analysis found relatively high crude overall incidence rates of drowning episodes among service members who were male, young, unmarried, and in combat occupations.[9,10,12] As in the previous *MSMR* studies, the overall incidence rate of drowning episodes among non-Hispanic white service members was higher than that among non-Hispanic black service members. However, the difference between the rates among service members in these two race/ethnicity groups in the current analysis is much smaller than that reported from earlier *MSMR* analyses (2015 analysis: non-Hispanic white, 10.8 cases per 100,000 p-yrs; non-Hispanic black, 5.8 cases per 100,000 p-yrs; 2018 analysis: non-Hispanic white, 6.0 cases per 100,000 p-yrs; non-Hispanic black, 4.5 cases per 100,000 p-yrs) **(data not shown)**.[10,12]

In the current analysis, the highest overall rates of drowning episodes affected members of the Marine Corps and Navy—perhaps due to geographic proximity to, more frequent and/or more prolonged exposures to, potentially dangerous water environments (on and off duty). Of interest, in the Navy and Marine Corps, swimming and water survival proficiencies are required for graduation from recruit training. In Army and Air Force recruit training, swimming proficiency is not required and water survival training is not routinely conducted.

During 2015–2017, annual counts and rates of incident accidental drowning episodes decreased in all services but were most pronounced among Marine Corps

and Navy members. This decrease may be due, at least in part, to improvements in safety and training that were made during this period. For example, new safety guidelines were put into place after the shallow-water blackout–related deaths of two Navy Seals in 2015. Shallow-water blackout occurs when a swimmer tries to stay underwater for a long period of time, typically to build endurance. Some swimmers purposely hyperventilate before going underwater as a way to prolong their submersion time; by so doing, they reduce their blood carbon dioxide levels. Once underwater, carbon dioxide levels fail to rise quickly enough to trigger the urge to breathe. However, the rapid fall in blood oxygen levels can lead to cerebral hypoxia, seizures, loss of consciousness, and ultimately drowning. The U.S. Navy Diving Manual Revision 7 was updated in December 2016 to include additional guidance on breath-hold diving and the risk of loss of unconsciousness.[13]

Current findings must be considered in light of some important limitations. For example, drowning and near drowning–related medical encounters were identified from drowning and nonfatal submersion-specific diagnosis and cause-of-injury codes that were reported on standardized electronic medical records. The completeness and accuracy of case ascertainment by these methods are not known; it is possible that many medical encounters for conditions related to water submersion ("near drowning") were not documented with the case indicator codes used for this report. Moreover, drowning episodes that were not associated with inpatient or outpatient encounters were not included in this analysis. Another limitation of the current analysis is related to the implementation of MHS GENESIS, the new electronic health record for the Military Health System. During 2017, medical data from sites that were 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 the analysis.

This analysis summarized drowning episodes in relation to demographic and military characteristics. As such, the findings do not account for factors such as swimming ability, nature and setting of the drowning episode, frequency and duration of exposure to drowning risk, or adherence to routine safety measures. Absent information related to these factors, novel specific recommendations aimed at prevention are not appropriate. However, the results of this report may be useful to increase awareness regarding the ongoing risks and effects of drowning-related episodes among U.S. service members.

More information about water safety is available from these online resources:

American Red Cross
www.redcross.org/services/hss/tips/healthtips/safetywater.html

Army
https://safety.army.mil/safetycity/pages/water/watersafety.aspx

Navy
www.public.navy.mil/NAVSAFECEN/Pages/shore/off-duty_rec/off_duty_rec.aspx

Air Force
www.safety.af.mil/Divisions/Occupational-Safety-Division/Summer-Safety/Water-Safety/

National Safety Council
www.nsc.org/home-safety/tools-resources/seasonal-safety/drowning

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Update: Lightning Strike Injuries, Active Component, U.S. Armed Forces, 2008–2017

Valerie F. Williams, MA, MS; Alexis A. Oetting, MPH; Shauna Stahlman, PhD, MPH

During 2008–2017, a total of 241 service members had incident lightning-related medical encounters with ICD-9 or ICD-10 codes that documented specific lightning-associated injuries or illnesses. The crude overall incidence rate of lightning strike injury during the surveillance period was 1.9 cases per 100,000 person-years. Compared to their respective counterparts, overall rates of lightning strike injury were higher among males, those aged 20–29 years, non-Hispanic whites, Army members, enlisted service members, those in combat-specific occupations, and those stationed in the Southern region of the U.S. During the surveillance period, there was a peak in incidence of lightning strike injury during 2015, as well as two smaller peaks in 2011 and 2013. "Disturbance of skin sensation," headache, limb pain, and burns were the four most frequent diagnoses during medical encounters for incident lightning strike injuries. The largest numbers of incident lightning strike injuries occurred in June, July, August, and September. Service members who routinely train and work outdoors should be vigilant about the dangers of lightning, especially in field settings during summer months.

According to the National Weather Service, nearly 2,000 people were reported as injured by lightning in the U.S. between 2006 and 2017.[1] A total of 376 people were killed by lightning during this period.[2] However, research suggests that up to 50% of lightning strike injuries go unreported.[3,4]

For more than a century, lightning injuries had ranked among the top five most common causes of weather-related death in the U.S.[5,6] However, in 2017, lightning killed fewer Americans (n=16) than in any year on record,[1,2] with lightning injuries ranking as the eighth most common cause of weather-related fatalities behind floods, heat, rip currents, wind, hurricanes, tornadoes, and cold.[7] This record low marks a steady downward trend that has been attributed to urbanization, better lightning-proof construction, heightened lightning safety awareness (through educational outreach and public awareness campaigns), and improved medical treatments (e.g., cardiopulmonary resuscitation, automated external defibrillators).[6,8]

In the U.S. civilian population, lightning injuries most often occur during summer months among people who are outdoors between noon and early evening (1200–1800 local time).[9] This temporal association is related not only to when thunderstorms generally occur, but also to when people are most likely to be engaging in outdoor activities.[2] Activities most frequently associated with lightning injuries include camping, hiking, jogging, water-related activities (e.g., swimming, fishing, boating), golfing, working on construction or electrical equipment, and using landline telephones.[2,8] Less than one-third of lightning injuries in the U.S. civilian population are work-related and, in approximately one-fifth of lightning injury events, there are two or more victims.[2,8,10]

Lightning-related injuries result from the effect of electrical current, heat, and/or concussive force (e.g., muscle contraction, complication of a fall, impact of falling heavy objects)[11,12] and are usually neurological in nature with manifestations ranging from temporary confusion to cardiopulmonary arrest.[13] Sleep disturbances, neurocognitive deficits, and chronic pain syndromes are commonly reported sequelae of lightning injuries.[14,15]

Military personnel are at risk for lightning injury due to the nature of their training and operational activities. Many of those activities take place outdoors in all types of weather conditions and often in geographic regions of the U.S. associated with higher cloud-to-ground lightning strike densities (e.g., southern and eastern coastal areas).[16]

The current analysis updates the findings of previous *MSMR* articles on lightning strike injuries among active component service members.[17,18] Specifically, the current report summarizes the counts, rates, and correlates of risk of lightning injuries among U.S. military members during 2008–2017.

METHODS

The surveillance period was 1 January 2008 through 31 December 2017. The surveillance population included all active component service members who served in the Army, Navy, Air Force, or Marine Corps of the U.S. Armed Forces at any time during the surveillance period. Diagnoses were ascertained from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System or civilian facilities in the purchased care system. These data are maintained in the electronic database of the Defense Medical Surveillance System (DMSS).

Electronic records of all active component service members were searched to identify hospitalizations and ambulatory encounters that included diagnosis codes (in any diagnostic position) indicative of lightning injuries: "effects of lightning" (ICD-9: 994.0; ICD-10: T75.0*) or

"accident due to lightning" (ICD-9: E907). For analysis purposes, cases of "lightning-associated injuries/illnesses" were defined by medical encounters that included a diagnosis code indicative of a lightning injury *plus* one or more injury- or illness-specific diagnosis codes, excluding "mental disorders." More specifically, medical encounters were not case defining as "lightning-associated injuries/illnesses" if the primary (first-listed) diagnosis was an ICD-9 V-/E-code or an ICD-10 V- through Z-code (i.e., the primary reason for the encounter was not a current illness or injury); or there were no diagnostic codes for specific illnesses or injuries, ICD-9 V- or E-codes, ICD-10 V- through Z-codes, mental disorders (ICD-9: 290–319; ICD-10: F01–F99) or "other effects of external causes" (ICD-9: 994.9; ICD-10: T75.89*).

If an individual had both case-defining inpatient and outpatient records during the surveillance period, information from the hospitalization record was used for the analysis. Each individual was included as a case only once during the surveillance period. Service members with case-defining diagnoses before the start of the surveillance period were excluded from the analysis. Incidence rates were calculated using non-deployed person-time in the denominator and as the number of cases per 100,000 person-years (p-yrs).

Finally, cases were ascertained from medical records of deployed service members whose healthcare encounters were documented in the Theater Medical Data Store (TMDS). These cases were analyzed separately because of the differences in coding practices in theater (e.g., secondary diagnoses are not common). A service member was considered a case of lightning strike in theater if he or she had a diagnosis for "effects of lightning" (ICD-9: 994.0; ICD-10: T75.0*) or "accident due to lightning" (ICD-9: E907).

RESULTS

Between 2008 and 2017, a total of 375 non-deployed service members had incident lightning-related medical encounters. Of these service members, 241 (64.3%) had encounters that included ICD-9 or ICD-10 codes documenting specific injuries or illnesses **(Table 1)**. Subsequent analysis using these 241 cases yielded a crude overall incidence rate of lightning strike injury of 1.9 cases per 100,000 p-yrs. The crude overall rate of lightning strike injury among males (2.1 per 100,000 p-yrs) was more than twice that among females (1.0 per 100,000 p-yrs) **(Table 1)**. Compared to their respective counterparts, rates of lightning strike injury also were higher among service members aged 20–29 years (20–24 years: 2.7 per 100,000 p-yrs; 25–29 years: 2.3 per 100,000 p-yrs), non-Hispanic whites (2.2 per 100,000 p-yrs), enlisted service members (2.1 per 100,000 p-yrs), those in combat-specific occupations (4.4 per 100,000 p-yrs), and those stationed in the Southern region of the U.S. (2.8 per 100,000 p-yrs). Of note, the overall rate among service members in combat-specific occupations was more than twice that of those in the other occupational groups **(Table 1)**. Across the services, Army members had the highest crude overall rate of lightning strike injuries (3.8 per 100,000 p-yrs) and Navy members had the lowest (0.7 per 100,000 p-yrs). Between 2008 and 2017, there were no lightning strike injuries identified among recruit trainees.

A total of 18 active component service members were affected by lightning-associated injuries/illnesses in theater during 2008–2017. Deployed cases were most frequently male (88.9%), aged 20–24 years (61.1%), non-Hispanic white (66.7%), enlisted (excluding recruits, 100%), and in the Army (61.1%) **(data not shown)**.

During the 10-year surveillance period, there was a peak in incidence of lightning strike injury during 2015 (5.2 per 100,000 p-yrs), as well as two smaller peaks in 2011 (2.8 per 100,000 p-yrs) and 2013 (2.2 per 100,000 p-yrs) **(Figure 1)**. In general, however, overall numbers and rates varied from year to year with no apparent trend. The largest numbers of incident injuries occurred during the summer months of June (n=51; 21.2%), July (n=48; 19.9%), August (n=77; 32.0%), and September (n=32; 13.3%), together accounting for 86.3% of the total number of incident lightning strike injuries **(Figure 2)**. Between 2008 and 2017, the largest number of incident cases were diagnosed during two consecutive weeks in August 2015 (n=54) **(data not shown)**.

Approximately 13.3% (n=32) of all incident lightning injuries resulted in hospitalizations **(data not shown)**. "Disturbance of skin sensation" was the most frequent diagnosis during medical encounters for incident lightning strike injuries (n=62). Headache (n=25), limb pain (n=31), burns (n=17), cardiac dysrhythmias and conduction disorders (n=15), neck/back pain (n=11), and chest symptoms (n=11)

TABLE 1. Incident cases and incidence rates of lightning strike injuries, active component, U.S. Armed Forces, 2008–2017

	Total	
	No.	Rate[a]
Total	241	1.93
Sex		
Male	222	2.10
Female	19	1.00
Age group		
<20	8	0.95
20–24	105	2.67
25–29	68	2.30
30–34	29	1.49
35–39	17	1.18
40+	14	1.04
Race/ethnicity		
Non-Hispanic white	168	2.24
Non-Hispanic black	34	1.69
Hispanic	26	1.61
Other/unknown	13	0.97
Rank		
Recruit	0	0.00
Enlisted (excluding recruits)	207	2.06
Officer	34	1.58
Service		
Army	173	3.75
Navy	21	0.70
Air Force	27	0.88
Marine Corps	20	1.11
Military occupation		
Combat-specific[b]	76	4.35
Motor transport	2	0.56
Health care	9	0.81
Other/unknown	154	1.67
Geographic region of military assignment[c]		
Northeast	4	1.03
Midwest	6	0.74
South	171	2.82
West	47	1.39
Overseas	10	0.65
Unknown/missing	3	1.08

[a]Rate per 100,000 person-years
[b]Infantry/artillery/combat engineering/armor
[c]Within the U.S., categorization based on U.S. Census Bureau regions (www.census.gov/geo/reference/webatlas/regions.html)

FIGURE 1. Numbers of cases and incidence rates of lightning strike injuries, active component, U.S. Armed Forces, 2008–2017

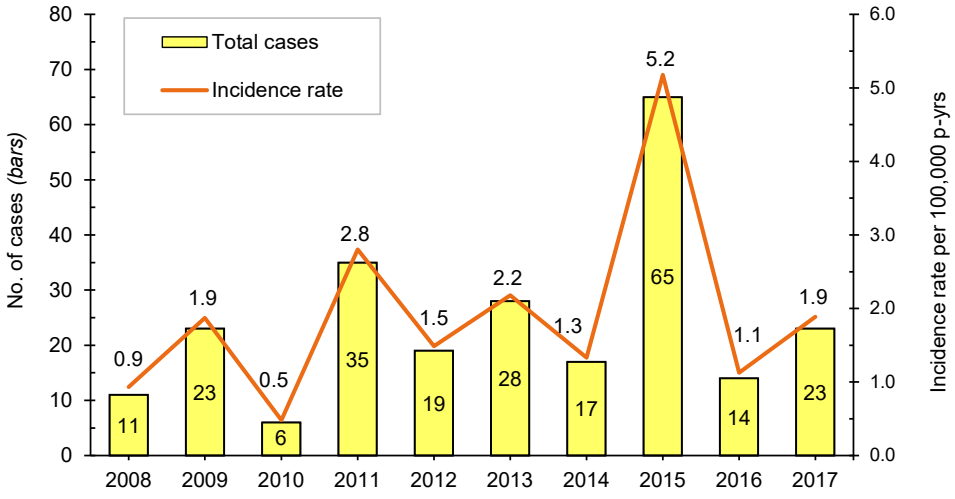
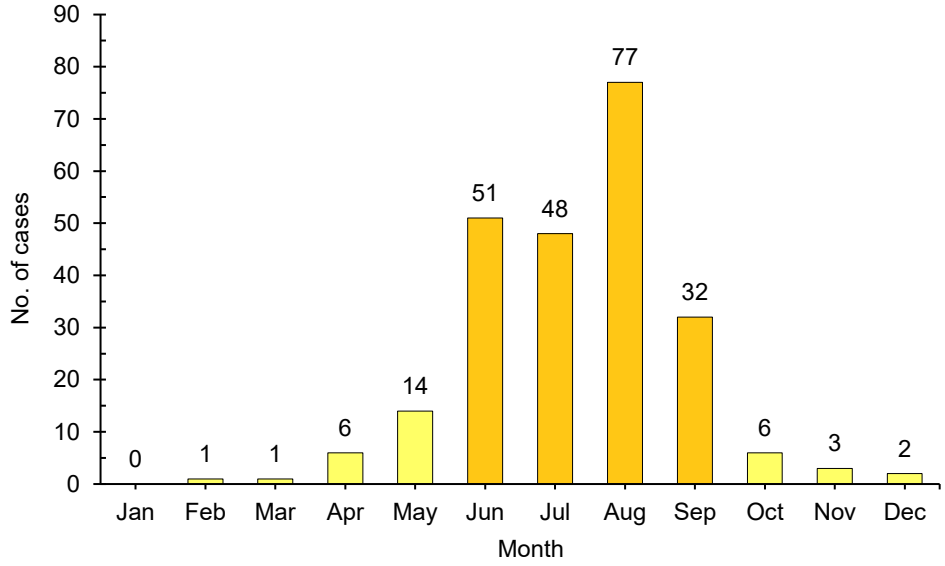


FIGURE 2. Incident cases of lightning strike injuries, by month, active component, U.S. Armed Forces, 2008–2017



were the next six most frequent diagnoses among cases of lightning-associated injuries/illnesses **(data not shown)**.

Incident lightning strike injuries were diagnosed at more than 60 U.S. military installations worldwide. However, six installations together accounted for more than half (57.7%) of all incident diagnoses **(Table 2)**. These installations were Eglin Air Force Base, FL (n=39; 16.2%), Fort Bragg, NC (n=27; 11.2%), Fort Stewart, GA (n=26; 10.8%), Fort Carson, CO (n=19; 7.9%), Fort Benning, GA (n=17; 7.1%), and Marine Corps Base Camp Lejeune, NC (n=11; 4.6%) **(Table 2, Figure 3)**. Lightning strike injuries occurred more often in the Southern U.S. in Georgia (n=50), Florida (n=46), North Carolina (n=40), and Texas (n=14).

Several spatial-temporal clusters of injuries (two or more service members being treated for lightning strike injuries on the same day at the same location) were identified during the surveillance period **(data not shown)**. Clusters affected two to 36 service members each and 125 service members overall. All of the clusters occurred between May and September. The largest cluster occurred at Eglin Air Force Base, FL, in August 2015, when 36 service members were diagnosed with lightning strike injuries on the same day. The next largest cluster occurred at Fort Stewart, GA, in September 2011 when 21 service members were diagnosed with lightning strike injuries on the same day. Large clusters also occurred at Fort Carson, CO, in July 2013 and at Fort Bragg, NC, in August 2015; 10 service members were diagnosed on the same day at each installation **(data not shown)**.

EDITORIAL COMMENT

The current findings by demographic and military characteristics mirror the results of the 2009 *MSMR* analysis.[17] Most notably, service members in combat-specific occupations (generally associated with increased outdoor exposure) had substantially higher lightning strike injury rates than those in other military occupations. Taken together, these results suggest that lightning injury risk is determined primarily by the timing, frequency, duration, location, and type of outdoor exposure to thunderstorms. Thus, specific demographic and military characteristics likely are associated with risk of lightning injury only to the degree they are related to the primary risk determinant.[19]

As the results of the current study show, lightning-related injuries in the military often involve a single lightning strike that injures multiple personnel. At Eglin Air Force Base, FL, on 12 August 2015, a lightning bolt hit a tree and the electrical current side-splashed (i.e., current jumped from a tree to other objects) throughout a wooded area; 44 Ranger School participants (students and instructors) were injured.[20] Of those who were injured, 20 were hospitalized. One patient had cardiac arrest and was admitted to an intensive care unit; 17 other patients were admitted for observation for rhabdomyolysis and/or cardiac arrhythmias.[20] The day after the lightning strike, all patients were released without restrictions and returned to duty with increased medical monitoring.[17]

At Fort Bragg, NC, on 19 August 2015, two simultaneous lightning strikes

TABLE 2. Incident cases of lightning strike injuries, by installation, active component, U.S. Armed Forces, 2008–2017

Installation	No. of cases	%
Eglin Air Force Base, FL	39	16.2
Fort Bragg, NC	27	11.2
Fort Stewart, GA	26	10.8
Fort Carson, CO	19	7.9
Fort Benning, GA	17	7.1
Marine Corps Base Camp Lejeune, NC	11	4.6
Fort Hood, TX	7	2.9
Naval Hospital Jacksonville, FL	5	2.1
Joint Base Lewis-McChord, WA	5	2.1
Other known locations	84	34.9
Unknown locations	1	0.4
Total	241	100.0

occurred; 18 soldiers from a cavalry scout platoon were injured.[21,22] The strikes occurred at opposite ends of camp during a training exercise and resulted in injuries via ground current.[21] All injured soldiers were admitted for evaluation and observation. All but one of the injured soldiers were released within the 48 hours following the lightning strikes; one patient remained hospitalized for a longer period for cardiac monitoring. Several symptoms were consistent among the patients, including lower extremity paresthesia, headache, tinnitus, brief loss of consciousness, and slightly elevated creatine kinase levels.[21]

In both civilian and military populations, most lightning injuries occur during the summer. Among active component U.S. military members during 2008–2017, more than two-thirds (70.1%) of the total lightning strike injuries occurred at installations in Georgia, Florida, North Carolina, or Texas; however, the risk is ubiquitous. In the past 10 years, lightning injuries have occurred among active component service members at more than 40 installations worldwide. The geographic distribution of lightning strike injuries presented here, and that presented in the previous *MSMR* report, reflect the geographic distribution of military service members across the U.S.; a disproportionate number of service members are stationed in rural areas and in southern and eastern coastal states.

The results of the current study should be interpreted in the context of several important limitations. First, because medical encounters with only nonspecific diagnoses (e.g., "effects of lightning) were excluded from the analysis, the total number of cases of lightning strike injury presented here is an incomplete ascertainment of the total number of service members with any effects of lightning (regardless of how mild or transient). Also, the analysis did not capture service members with lightning-associated injuries who did not seek medical care or who sought medical care outside the Military Health System (MHS) or purchased care system, but both groups are anticipated to be small. Another limitation of the current analysis is related to the implementation of MHS GENESIS, the new electronic health record for the MHS. During 2017, medical data from sites that were using MHS GENESIS were 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 the analysis.

No single action eliminates the risk of lightning injury to an individual, but risk can be reduced by following simple measures such as avoiding working and training outside during thunderstorms and seeking appropriate shelter when storms are imminent. The dangers of lightning are not always apparent to ground observers. Lightning may strike as far as 10 miles ahead of approaching thunderstorms, before rain starts, and while the sky is still clear.[23]

Even with recommendations such as weather monitors and lightning action/safety plans in place, military training and operations must sometimes continue during thunderstorms. Service members who routinely train and work outdoors (e.g., tactical communications specialists, tactical vehicle and aircraft maintenance crews, ground combat forces, recruit trainees) should be particularly knowledgeable of and vigilant regarding the dangers of lightning, especially in field settings during summer months. In addition, during military training and operational activities, leaders are responsible and accountable for protecting their subordinates from injury. The lightning safety recommendations in **Table 3** may be useful to commanders, training staffs, and supervisors at all levels to reduce lightning injury risk.[24-26]

FIGURE 3. Locations of installations with five or more incident cases of lightning strike injuries, active component, U.S. Armed Forces, 2008–2017

TABLE 3. Lightning safety precautions[a]

Prepare for lightning by checking weather forecasts and watching for signs of approaching storms. Most lightning strikes occur during June–August between 1200 and 1800 hours local time.
When thunder is first heard, lightning seen, or dark threatening clouds observed, cease all outdoor training. Resume activities only when there has been no lightning or thunder for 30 minutes.
Move personnel into an enclosed structure, if possible. Tents and open shelters are not safe.
If no building is available, move personnel into a closed, metal-topped vehicle or boat cabin; dense woods; a low area, ditch or ravine; or the foot of a hill or cliff. When inside an enclosed vehicle, close windows and keep hands on lap.
If unable to take shelter and caught in the open or in a forested area, personnel should disperse to minimize the possibility of multiple injuries from a single lightning strike.
Avoid high places, hilltops, isolated trees, flagpoles, open spaces, lakes or deep standing water, tents, small, unprotected buildings in the open and canvas topped vehicles.
Keep personnel away from fences, electrical wiring, vehicles, heavy equipment or other possible conductors of electricity. Move a safe distance away (approximately 100 feet) from metal machinery.
When marching in formation, increase the minimum distance and interval to twice that normally maintained.
Do not use radios or associated equipment; move away from TV antennas, relay antennas, or vehicles with whip antennas.
Weapons should be stacked at least 50 meters away from personnel. Multiple integrated laser engagement system (MILES) gear and other metal conductors should be removed.
When indoors, stay away from possible conductors of electricity such as electrical wiring, plumbing, and landline phones. Cell phones are safe to use. Inner rooms within a building provide the best protection.
Do not handle flammable liquids in open containers.
Do not use personal plug-in appliances such as hair dryers, toothbrushes, or razors.
Do not lie on concrete floors or lean against concrete walls.

[a]Source: U.S. Army Training and Doctrine Command Guide for Lightning Protective Measures for Personnel,[24] National Weather Service lightning safety tips,[25] and the National Athletic Trainers' Association position statement on lightning safety for athletics and recreation.[26]

Although such measures may be critical for the prevention of lightning-related injuries,[27] when injuries do occur, prompt and proper medical management is essential to survival and the reduction of morbidity. Long-term follow-up is also critical to ensure that any sequelae of the lightning strike are managed appropriately.[28]

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Fireworks Injuries, Active Component, U.S. Armed Forces, 2008–2017

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Although fireworks shows are considered patriotic and festive, the use of consumer fireworks also can be dangerous. There were 302 records of fireworks injuries during the 10-year surveillance period (2.4 cases per 100,000 person-years [p-yrs]). During 2008–2017, the lowest crude annual incidence of fireworks injury was reported in 2010 (1.5 per 100,000 p-yrs) and the highest was reported in 2017 (3.4 per 100,000 p-yrs). Compared with their respective counterparts, overall incidence of fireworks injury was higher among males, non-Hispanic whites, Army members, those in an enlisted rank, and those in combat-specific occupations. Of all incident fireworks injuries, the most commonly affected body regions were hand/wrist (45.0%), head/neck (27.8%), and leg (7.9%). The most common types of injuries were burns (57.0%), open wounds (14.6%), and contusion/superficial injuries (13.2%). Although the incidence of fireworks injuries among active component service members was found to be generally low, there is still risk of serious injury if proper safety and handling precautions are not taken.

The use of fireworks to celebrate holidays such as the Fourth of July is a U.S. tradition dating back to the Declaration of Independence.[1] Although fireworks shows are considered patriotic and festive, the use of consumer fireworks also can be dangerous. According to a 2017 U.S. Consumer Product Safety Commission report, there were more non-occupational, emergency department–treated, fireworks-related injuries reported in the U.S. in 2015 than in any surveillance year since 2001.[2] This increase has been correlated with a reduction in state prohibitions against consumer fireworks as well as an increase in the number of fireworks purchased.[3,4]

Consumer fireworks include shells and mortars, Roman candles, rockets, sparklers, firecrackers with a limited amount of powder, and other novelty items such as snakes, ground spinners, and party poppers.[2] Currently, 45 U.S. states allow the sale and/or use of all or some consumer fireworks; in some of these states, laws or regulations at the municipal, city, or county level restrict the sale and/or use of consumer fireworks.[5] Illinois, Ohio, and Vermont allow only wire or wood stick sparklers and certain novelty items.[5] Delaware and Massachusetts are the only states to have banned the sale and use of all consumer fireworks.[5] Consumer fireworks also are prohibited on U.S. government property.[6]

In the U.S., young adults aged 20–24 years have the highest estimated rate of emergency department–treated fireworks injuries compared with other age groups, at 4.9 injuries per 100,000 persons.[2] In addition, males tend to have higher rates than females and experience more severe injuries.[7] However, there are no published data on the incidence of fireworks injuries among U.S. service members. The lack of such data is important because males aged 25 years or younger constitute more than two-fifths of the U.S. active component population.[8] To fill this gap, this report provides information on the frequency, incidence, and trend of fireworks injuries among active component service members during 2008–2017. The frequencies of injury by body region and type of injury are also described.

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. Diagnoses were ascertained from administrative records of all medical encounters of individuals who received care in fixed (i.e., not deployed or at sea) medical facilities of the Military Health System or civilian facilities in the purchased care system. These data are maintained in the electronic database of the Defense Medical Surveillance System (DMSS).

For surveillance purposes, a case of fireworks-associated injury was defined by a record of a hospitalization or outpatient encounter that included a diagnosis for injury in the 1st or 2nd diagnostic position (ICD-9 codes 800–999; ICD-10 codes beginning with "S" or "T"), and an external cause code for "accident caused by fireworks" (ICD-9: E92.30) or "discharge of firework" (ICD-10: W39.*) in any other secondary diagnostic position during the same encounter. Healthcare encounters that occurred during deployment were excluded.

Each individual was included as a case only once per calendar year. If an individual had case-defining inpatient and outpatient records in the same calendar year, information from the hospitalization record was used in the analysis. Incidence rates were calculated using non-deployed person-time in the denominator and as the number of cases per 100,000 person-years (p-yrs).

The *MSMR* burden dictionary was used to assign body region of fireworks-related injury,[9] which was based on the injury diagnosis in the 1st or 2nd diagnostic position of the fireworks-related injury incident encounter. Injuries were categorized by affected anatomic site: head/neck, arm/shoulder, hand/wrist, back/abdomen, knee, leg, and foot/ankle. In addition, the types of injury (e.g., fracture, burn, open wound) were categorized using methods described in a previous report.[10]

RESULTS

There were 302 records of fireworks injuries during the 10-year surveillance period (2.4 cases per 100,000 p-yrs) **(Table 1)**. Of these

injuries, 20 (6.6%) were documented in the records of hospitalizations and 282 (93.4%) were associated with outpatient encounters **(data not shown)**. During 2008–2017, the lowest crude annual incidence of fireworks injury was reported in 2010 (1.5 per 100,000 p-yrs) and the highest was reported in 2017 (3.4 per 100,000 p-yrs). The second-highest peak in incidence was reported in 2015 at 3.1 per 100,000 p-yrs **(Figure 1)**.

Compared with their respective counterparts, overall incidence of fireworks injury was higher among male service members (2.7 per 100,000 p-yrs), non-Hispanic whites (3.0 per 100,000 p-yrs), Army members (3.6 per 100,000 p-yrs), those in an enlisted rank (2.6 per 100,000 p-yrs), and those in combat-specific occupations (4.5 per 100,000 p-yrs) **(Table 1)**. Of note, infantry was the occupation with the single largest number of fireworks injuries (n=50, 16.6%) **(data not shown)**. In addition, incidence of fireworks injury was higher among those aged 20–24 years (3.3 per 100,000 p-yrs), compared with other age groups **(Table 1)**. Of service members with known locations of military assignment, the overall incidence of fireworks injury was highest among those stationed in the Midwest (4.0 per 100,000 p-yrs). However, the highest incidence was reported among those with missing or unknown locations of military assignment, compared with all other geographic regions (4.4 per 100,000 p-yrs).

Of all incident fireworks injuries, the most commonly affected body regions were hand/wrist (45.0%), head/neck (27.8%), and leg (7.9%) **(Table 2)**. The most common types of injuries were burns (57.0%), open wounds (14.6%), and contusion/superficial injuries (13.2%) **(Table 3)**.

Incident cases of fireworks injury occurred most often during July (n=169, 56.0%) and January (n=52; 17.2%) **(Figure 2)**. During the surveillance period, the highest number of incident fireworks injury diagnoses were recorded at Joint Base Lewis-McChord, WA (n=19; 6.3%), Fort Campbell, KY (n=18; 6.0%), Fort Bragg, NC (n=15, 5.0%), and Joint Base San Antonio-Lackland, TX (n=12; 4.0%) **(data not shown)**. All other installations were associated with less than 3% of the total number of cases.

EDITORIAL COMMENT

During 2008–2017, the overall incidence of fireworks injuries among active component service members was 2.4 per 100,000 p-yrs and fluctuated between 1.5 cases and 3.4 cases per 100,000 p-yrs. Similar to the general U.S. population, fireworks injuries are more common among male service members and those aged 20–24 years.[2] Incidence is also higher among Army service members and those in combat-related occupations.

Within the regions of the U.S., incidence of fireworks injuries was lowest in the Northeast, which includes the two states with the most stringent regulations against consumer fireworks.[5] However, this analysis did not examine and cannot make conclusions about the impact of state laws on fireworks injuries. The peaks in the numbers of injuries during January and July suggest that public health campaigns about fireworks safety and injury prevention should target the New Year's and Fourth of July holidays.

Among active component service members, the most commonly affected body

TABLE 1. Incident cases and incidence rates of fireworks injuries, active component, U.S. Armed Forces, 2008–2017

	Total	
	No.	Rate[a]
Total	302	2.4
Sex		
Male	285	2.7
Female	17	0.9
Age group		
<20	23	2.7
20–24	128	3.3
25–29	72	2.4
30–34	46	2.4
35–39	20	1.4
40+	13	1.0
Race/ethnicity		
Non-Hispanic white	225	3.0
Non-Hispanic black	22	1.1
Hispanic	36	2.2
Asian/Pacific Islander	8	1.7
Other/unknown	11	1.3
Marital status		
Married	156	2.3
Unmarried	138	2.8
Other/unknown	8	1.4
Service		
Army	166	3.6
Navy	41	1.4
Air Force	69	2.3
Marine Corps	26	1.4
Rank		
Enlisted	272	2.6
Officer	30	1.4
Military occupation		
Combat-specific[b]	78	4.5
Motor transport	7	1.9
Pilot/air crew	11	2.4
Repair/engineer	94	2.6
Communications/ intelligence	49	1.8
Health care	21	1.9
Other/unknown	42	1.7
Geographic region of military assignment[c]		
Northeast	6	1.6
Midwest	32	4.0
South	143	2.4
West	86	2.6
Overseas	22	1.4
Unknown/missing	13	4.4

[a]Rate per 100,000 person-years

[b]Infantry/artillery/combat engineering/armor

[c]Within the U.S., categorization based on U.S. Census Bureau regions (www.census.gov/geo/reference/webatlas/regions.html)

FIGURE 1. Numbers of cases and incidence rates of fireworks injuries, active component, U.S. Armed Forces, 2008–2017

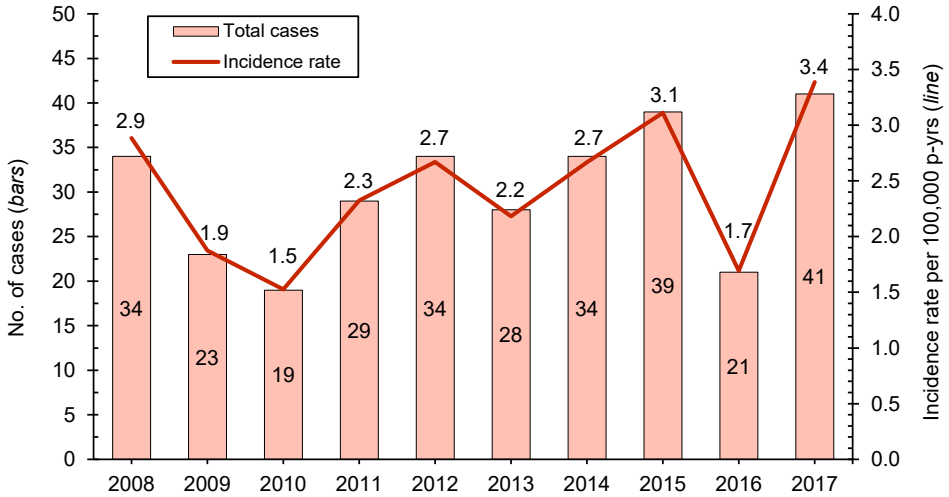


TABLE 2. Body region of incident fireworks injuries, active component, U.S. Armed Forces, 2008–2017

	No.	% of total
Hand/wrist	136	45.0
Head/neck	84	27.8
Leg	24	7.9
Arm/shoulder	15	5.0
Other or unspecified	15	5.0
Foot/ankle	14	4.6
Back/abdomen	13	4.3
Knee	1	0.3

TABLE 3. Incident fireworks injuries, by type, active component, U.S. Armed Forces, 2008–2017

	No.	% of total
Burns	172	57.0
Open wounds	44	14.6
Contusion/superficial injuries	40	13.2
Other or unspecified injuries	19	6.3
Fractures	16	5.3
Dislocations	4	1.3
Sprains and strains	3	1.0
Amputations	2	0.7
Internal injuries	1	0.3
Blood vessel injuries	1	0.3

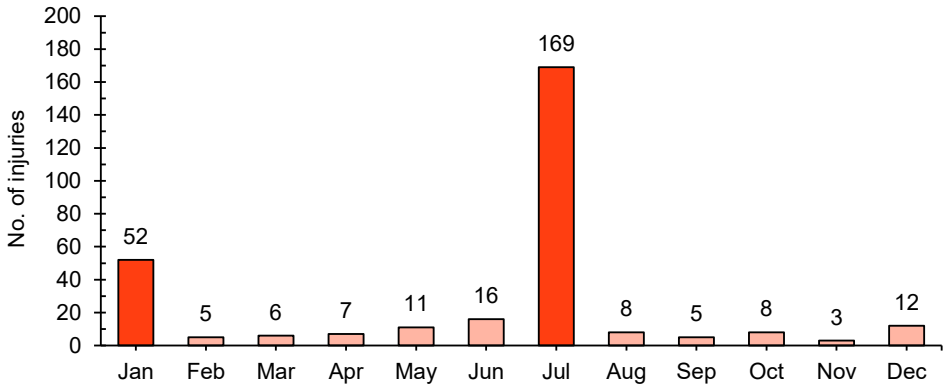
regions were hand/wrist (45.0%) and head/neck (27.8%). Burns were the most common type of injury. These findings mirror patterns observed in the U.S. population, where most injuries tend to be burns to the hands and fingers, or to the head, face, and ears.[2]

Current findings should be interpreted in the context of several limitations. Not all adverse health conditions due to fireworks were captured in this report. During the surveillance period, there were three cases of acoustic trauma or hearing loss, two cases of ocular pain, two cases of both headache and tinnitus, one case of cicatricial entropion of the upper eyelid, one conjunctival hemorrhage, one case of perforation of tympanic membrane, one case of iridocyclitis, and one case of photokeratitis. These 12 cases were not included because they did not meet the case definition requirement of an acute injury diagnosis (ICD-9 codes in the 800–999 range; ICD-10 codes beginning with "S" or "T") in the 1st or 2nd diagnostic position but did have an external cause code for "accident caused by fireworks" (ICD-9: E92.30) or "discharge of firework" (ICD-10: W39.*). In addition, data were not available on the types of fireworks used, which can affect the severity and type of injury. For example, shell/mortar injuries have been found to be particularly devastating, sometimes resulting in permanent impairment from eye and hand injury.[11] Another limitation of the current analysis is related to the implementation of MHS GENESIS, the new electronic health record for the Military Health System. During 2017, medical data from sites that were 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 the analysis.

Although the incidence of fireworks injuries among active component service members was found to be generally low, there is still risk of serious injury if proper safety and handling precautions are not taken. Fireworks are classified as hazardous substances under the Federal Hazardous Substances Act.[12]

More information about the safe handling of fireworks is available at www.military.com/independence-day/firework-safety.html.

FIGURE 2. Number of fireworks injuries, by calendar month, active component, U.S. Armed Forces, 2008–2017



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