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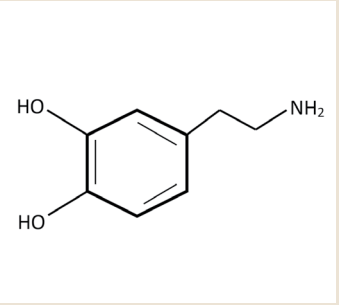
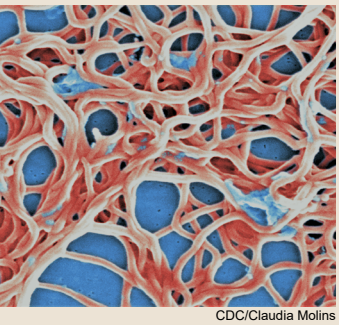




CDC/Claudia Molins

CDC/Gary O. Maupin

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 2014–June 2019

This report provides an update through June 2019 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. From January 2014–June 2019, 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 0.29 per 1,000 tested, respectively). Seroprevalences also peaked in 2015 for active component service members of the Army, Navy, and Air Force and among reservists of the Navy and Marine Corps. Overall (January 2014–June 2019) HIV antibody seroprevalences were highest among Army reservists, Army National Guard members, and Navy reservists. Across active and reserve components of all services, HIV antibody seroprevalences continued to be higher among men than women.

WHAT ARE THE NEW FINDINGS?

Since 2014, prevalences of HIV seropositivity among civilian applicants for service have fluctuated between 24 and 34 per 100,000 applicants tested. Among active component service members, the seroprevalence rate (per 100,000 service members tested) in 2018 was highest in the Navy (22), followed by the Marine Corps (20), the Army (19), and the Air Force (13). Among the reserve components, the seroprevalence was highest in the Army Reserve (37) and lowest in the Air National Guard (7).

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

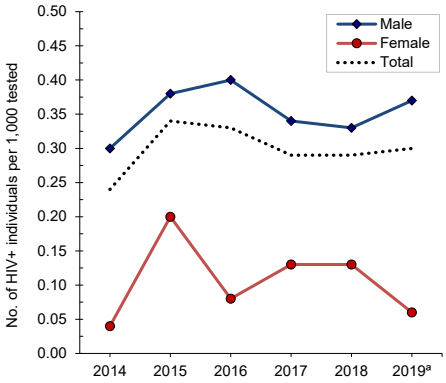
Despite the relatively low rates of new diagnoses observed among U.S. service members, HIV infection has a considerable impact on military mission and troop readiness because of the incurable nature of the disease, the need for lifelong therapy, the high cost of treatment, and the limitations to duty assignments for HIV-infected service members.

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. 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.[4] 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 (DoD) set a standard testing interval of 2 years for all service members.[5,6] All military personnel are periodically screened for HIV infection (at a minimum every 2 years or before deployment, on return from deployment, or after having received a diagnosis of various other conditions, such as a sexually transmitted infection).[6] Routine HIV screenings are usually performed during the periodic health assessment, an annual evaluation of a service member's medical readiness status. Service members who are infected with HIV receive clinical assessments, treatments, and counseling; they may remain in service as long as they are able to fully perform their military duties.[2,3] HIV+ service members continue to be eligible for certain non-combat or non-contingency deployments and, as such, must meet the DoD's retention policy for non-deployable service members. The latest policy on retention determinations for non-deployable service members was implemented in October 2018 and requires service members who are in a non-deployable status for more than 12 consecutive months to be evaluated for a retention determination by their respective military departments or, as appropriate, referred into the Disability Evaluation System or processed for administrative separation from the military.[7]

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. and no instances of HIV-2 infection have thus far been detected in civilian applicants or service members since 2009, HIV-2 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

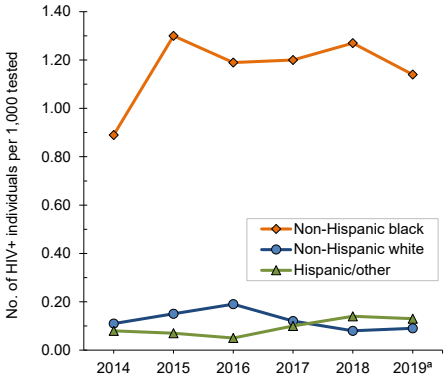
FIGURE 1. HIV seroprevalence rates, by sex, civilian applicants for U.S. military service, January 2014–June 2019



[a]Through 30 June 2019.

HIV, human immunodeficiency virus; No., number.

FIGURE 2. HIV seroprevalence rates, by race/ethnicity, civilian applicants for U.S. military service, January 2014–June 2019



[a]Through 30 June 2019.

HIV, human immunodeficiency virus; No., number.

target of the screening programs as simply "HIV" without specifying 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 2014 through 30 June 2019. 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 2014 through 30 June 2019. 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

TABLE 1. Diagnoses of HIV infections, by sex, civilian applicants for U.S. military service, January 2014–June 2019

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
2014	238,333	232,692	185,314	47,378	**57**	55	2	**0.24**	0.30	0.04
2015	251,438	244,706	193,891	50,815	**83**	73	10	**0.34**	0.38	0.20
2016	252,958	246,815	195,358	51,457	**82**	78	4	**0.33**	0.40	0.08
2017	271,871	265,112	209,729	55,383	**78**	71	7	**0.29**	0.34	0.13
2018	302,976	294,577	230,688	63,889	**85**	77	8	**0.29**	0.33	0.13
2019[a]	213,104	203,096	156,662	46,434	**61**	58	3	**0.30**	0.37	0.06
Total	1,530,680	1,486,998	1,171,642	315,356	**446**	412	34	**0.30**	0.35	0.11

[a]Through 30 June 2019.

HIV, human immunodeficiency virus.

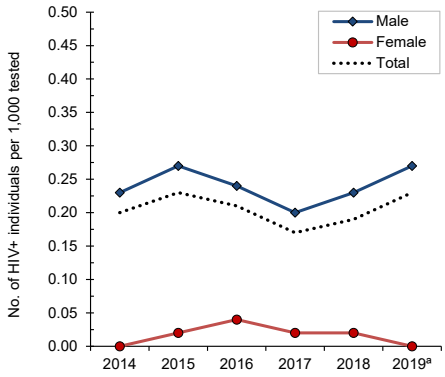
TABLE 2. Diagnoses of HIV infections, by race/ethnicity, civilian applicants for U.S. military service, January 2014–June 2019

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
2014	238,333	232,692	139,256	42,641	50,795	**57**	15	38	4	**0.24**	0.11	0.89	0.08
2015	251,438	244,706	143,633	44,543	56,530	**83**	21	58	4	**0.34**	0.15	1.30	0.07
2016	252,958	246,815	143,170	43,655	59,990	**82**	27	52	3	**0.33**	0.19	1.19	0.05
2017	271,871	265,113	157,964	44,299	62,850	**78**	19	53	6	**0.29**	0.12	1.20	0.10
2018	302,976	294,579	180,529	47,951	66,099	**85**	15	61	9	**0.29**	0.08	1.27	0.14
2019[a]	213,104	203,099	127,299	38,690	37,110	**61**	12	44	5	**0.30**	0.09	1.14	0.13
Total	1,530,680	1,487,004	891,851	261,779	333,374	**446**	109	306	31	**0.30**	0.12	1.17	0.09

[a]Through 30 June 2019.

HIV, human immunodeficiency virus.

FIGURE 3. HIV seroprevalence rates, by sex, active component, U.S. Army, January 2014–June 2019



[a]Through 30 June 2019.
HIV, human immunodeficiency virus; No., number.

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.

An incident case of HIV antibody seropositivity was defined as 2 positive results from serologic testing of 2 different specimens from the same individual or 1 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.

TABLE 3. New diagnoses of HIV infections, by sex, active component, U.S. Army, January 2014–June 2019

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 2019
2014	447,730	361,941	309,983	51,958	**71**	71	0	**0.20**	0.23	0.00	24
2015	426,462	349,811	298,196	51,615	**82**	81	1	**0.23**	0.27	0.02	35
2016	428,275	349,748	297,388	52,360	**72**	70	2	**0.21**	0.24	0.04	47
2017	435,663	351,106	297,031	54,075	**61**	60	1	**0.17**	0.20	0.02	39
2018	450,608	351,344	296,738	54,606	**68**	67	1	**0.19**	0.23	0.02	54
2019[a]	219,537	194,315	162,606	31,709	**44**	44	0	**0.23**	0.27	0.00	43
Total	2,408,275	1,958,265	1,661,942	296,323	**398**	393	5	**0.20**	0.24	0.02	242

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 4. New diagnoses of HIV infections, by sex, U.S. Army National Guard, January 2014–June 2019

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 2019
2014	265,935	239,347	199,832	39,515	**93**	92	1	**0.39**	0.46	0.03	25
2015	205,549	181,785	151,142	30,643	**68**	66	2	**0.37**	0.44	0.07	20
2016	232,930	209,973	174,066	35,907	**80**	78	2	**0.38**	0.45	0.06	37
2017	235,671	205,401	170,170	35,231	**65**	63	2	**0.32**	0.37	0.06	36
2018	235,504	205,454	168,556	36,898	**50**	49	1	**0.24**	0.29	0.03	42
2019[a]	123,710	114,367	93,914	20,426	**34**	34	0	**0.30**	0.36	0.00	34
Total	1,299,299	1,156,327	957,707	198,620	**390**	382	8	**0.34**	0.40	0.04	194

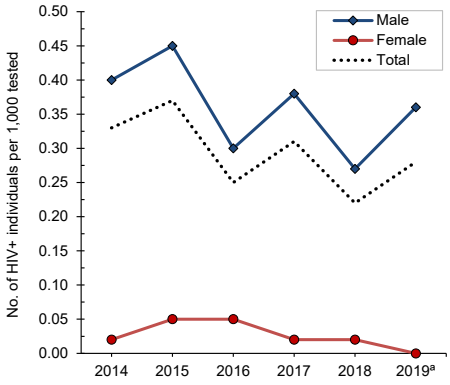
[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 5. New diagnoses of HIV infections, by sex, U.S. Army Reserve, January 2014–June 2019

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 2019
2014	120,292	107,303	81,915	25,388	**47**	44	3	**0.44**	0.54	0.12	16
2015	121,897	110,161	84,778	25,383	**42**	42	0	**0.38**	0.50	0.00	22
2016	121,454	110,370	84,136	26,234	**44**	44	0	**0.40**	0.52	0.00	24
2017	119,373	108,249	82,681	25,568	**41**	40	1	**0.38**	0.48	0.04	31
2018	122,472	106,001	79,878	26,123	**39**	37	2	**0.37**	0.46	0.08	34
2019[a]	62,391	54,581	40,924	13,657	**24**	24	0	**0.44**	0.59	0.00	23
Total	667,879	596,665	454,312	142,353	**237**	231	6	**0.40**	0.51	0.04	150

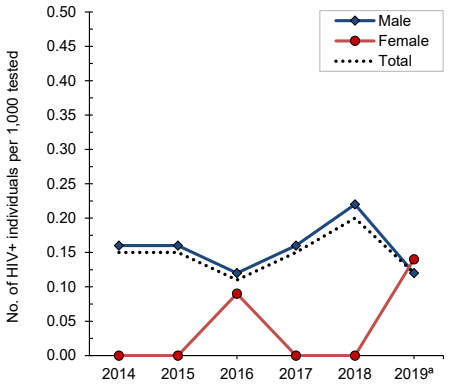
[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

FIGURE 4. HIV seroprevalence rates, by sex, active component, U.S. Navy, January 2014–June 2019



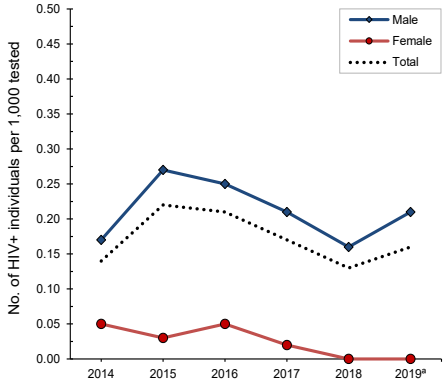
[a]Through 30 June 2019.
HIV, human immunodeficiency virus; No., number.

FIGURE 5. HIV seroprevalence rates, by sex, active component, U.S. Marine Corps, January 2014–June 2019



[a]Through 30 June 2019.
HIV, human immunodeficiency virus; No., number.

FIGURE 6. HIV seroprevalence rates, by sex, active component, U.S. Air Force, January 2014–June 2019



[a]Through 30 June 2019.
HIV, human immunodeficiency virus; No., number.

RESULTS

Civilian applicants

From January 2018 through June 2019, a total of 497,673 civilian applicants for U.S. military service were tested for antibodies to HIV, and 146 applicants were identified as HIV antibody positive (seroprevalence: 0.29 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 0.29 per 1,000 tested, respectively) **(Table 1, Figure 1)**. In 2018, the seroprevalence remained stable at 0.29 per 1,000 tested.

Throughout the surveillance period, annual 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)**. During 2018, on average, 1 civilian applicant for service was detected with antibodies to HIV per 3,564 screening tests **(Table 1)**.

U.S. Army

Active component: From January 2018 through June 2019, a total of 545,659 soldiers in the active component of the U.S. Army were tested for antibodies to HIV, and 112 soldiers were identified as HIV antibody positive (seroprevalence: 0.21 per 1,000 soldiers tested) **(Table 3)**. During the surveillance period, annual seroprevalences fluctuated between a low of 0.17 per 1,000 tested in 2017 and a high of 0.23 per 1,000 tested in 2015 **(Table 3, Figure 3)**. Annual seroprevalences for male active component Army members were considerably higher than those of females **(Figure 3)**. During 2018, on average, 1 new HIV infection was detected among active component Army soldiers per 6,627 screening tests **(Table 3)**. Of the 398 active component soldiers diagnosed with HIV infections since 2014, a total of 242 (60.8%) were still in military service in 2019.

Army National Guard: From January 2018 through June 2019, a total of 319,821 members of the U.S. Army National Guard were tested for antibodies to HIV, and 84 soldiers were identified as HIV antibody positive (seroprevalence: 0.26 per 1,000 soldiers tested) **(Table 4)**. Among Army National Guard soldiers, annual seroprevalences decreased markedly from 2016 through 2018 (seroprevalences: 0.38 and 0.24 per 1,000 soldiers tested, respectively) and then increased slightly in the first 6 months of 2019. On average, during 2018, 1 new HIV infection was detected among Army National Guard soldiers per 4,710 screening tests. Of the 390 National Guard soldiers who tested positive for HIV since 2014, a total of 194 (49.7%) were still in military service in 2019.

Army Reserve: From January 2018 through June 2019, a total of 160,582 members of the U.S. Army Reserve were tested for antibodies to HIV, and 63 soldiers were identified as HIV antibody positive (seroprevalence: 0.39 per 1,000 soldiers tested) **(Table 5)**. Among Army reservists, the seroprevalence was highest in 2014 at 0.44 per 1,000 tested and reached a nadir of 0.37 per 1,000 tested in 2018. The seroprevlance then increased slightly to 0.44 per 1,000 soldiers tested in the first 6 months of 2019. During 2018, on average, 1 new HIV infection was detected among Army reservists per 3,140 screening tests **(Table 5)**. Of the 237 Army reservists diagnosed with HIV infections since 2014, a total of 150 (63.3%) were still in military service in 2019.

U.S. Navy

Active component: From January 2018 through June 2019, a total of 341,259 active component members of the U.S. Navy were tested for antibodies to HIV, and 82 sailors were identified as HIV antibody positive (seroprevalence: 0.24 per 1,000 sailors tested) **(Table 6)**. Among tested male active component sailors, full-year annual HIV antibody seroprevalences decreased 40.0% between 2015 and 2018 **(Figure 4)**. During 2018, on average, 1 new HIV infection was detected among active component sailors

TABLE 6. New diagnoses of HIV infections, by sex, active component, U.S. Navy, January 2014–June 2019

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 2019
2014	250,386	222,117	180,803	41,314	**73**	72	1	**0.33**	0.40	0.02	39
2015	241,711	214,218	172,624	41,594	**79**	77	2	**0.37**	0.45	0.05	41
2016	241,585	214,825	173,080	41,745	**54**	52	2	**0.25**	0.30	0.05	39
2017	249,270	219,408	174,717	44,691	**67**	66	1	**0.31**	0.38	0.02	48
2018	252,551	216,850	172,714	44,136	**47**	46	1	**0.22**	0.27	0.02	44
2019[a]	134,372	124,409	97,688	26,721	**35**	35	0	**0.28**	0.36	0.00	34
Total	1,369,875	1,211,827	971,626	240,201	**355**	348	7	**0.29**	0.36	0.03	245

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 7. New diagnoses of HIV infections, by sex, U.S. Navy Reserve, January 2014–June 2019

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 2019
2014	42,807	37,608	29,909	7,699	**17**	17	0	**0.45**	0.57	0.00	8
2015	39,028	34,625	27,327	7,298	**16**	16	0	**0.46**	0.59	0.00	10
2016	41,693	35,990	28,169	7,821	**8**	8	0	**0.22**	0.28	0.00	7
2017	40,532	34,769	27,262	7,507	**8**	8	0	**0.23**	0.29	0.00	5
2018	37,855	33,385	25,749	7,636	**10**	10	0	**0.30**	0.39	0.00	10
2019[a]	21,162	19,584	15,126	4,458	**5**	5	0	**0.26**	0.33	0.00	5
Total	223,077	195,961	153,542	42,419	**64**	64	0	**0.33**	0.42	0.00	45

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 8. New diagnoses of HIV infections, by sex, active component, U.S. Marine Corps, January 2014–June 2019

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 2019
2014	173,351	146,849	135,140	11,709	**22**	22	0	**0.15**	0.16	0.00	8
2015	162,065	140,440	129,492	10,948	**21**	21	0	**0.15**	0.16	0.00	5
2016	159,466	139,677	128,116	11,561	**16**	15	1	**0.11**	0.12	0.09	7
2017	164,599	140,973	129,132	11,841	**21**	21	0	**0.15**	0.16	0.00	12
2018	157,613	135,989	123,696	12,293	**27**	27	0	**0.20**	0.22	0.00	22
2019[a]	82,654	76,458	69,311	7,147	**9**	8	1	**0.12**	0.12	0.14	8
Total	899,748	780,386	714,887	65,499	**116**	114	2	**0.15**	0.16	0.03	62

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 9. New diagnoses of HIV infections, by sex, U.S. Marine Corps Reserve, January 2014–June 2019

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 2019
2014	27,337	24,389	23,454	935	**7**	7	0	**0.29**	0.30	0.00	3
2015	26,809	24,018	23,141	877	**11**	10	1	**0.46**	0.43	1.14	4
2016	26,760	23,505	22,652	853	**6**	6	0	**0.26**	0.26	0.00	1
2017	28,809	25,364	24,470	894	**8**	8	0	**0.32**	0.33	0.00	1
2018	27,009	22,987	22,215	772	**4**	4	0	**0.17**	0.18	0.00	3
2019[a]	15,580	14,536	13,988	548	**2**	2	0	**0.14**	0.14	0.00	2
Total	152,304	134,799	129,920	4,879	**38**	37	1	**0.28**	0.29	0.21	14

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 10. New diagnoses of HIV infections, by sex, active component, U.S. Air Force, January 2014–June 2019

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 2019
2014	243,141	201,184	162,499	38,685	**29**	27	2	**0.14**	0.17	0.05	10
2015	231,752	192,811	155,480	37,331	**43**	42	1	**0.22**	0.27	0.03	24
2016	242,827	196,486	157,833	38,653	**42**	40	2	**0.21**	0.25	0.05	24
2017	254,725	202,787	161,723	41,064	**35**	34	1	**0.17**	0.21	0.02	19
2018	258,664	207,702	164,680	43,022	**27**	27	0	**0.13**	0.16	0.00	21
2019[a]	135,292	121,905	96,083	25,822	**20**	20	0	**0.16**	0.21	0.00	19
Total	1,366,401	1,122,875	898,298	224,577	**196**	190	6	**0.17**	0.21	0.03	117

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 11. New diagnoses of HIV infections, by sex, U.S. Air National Guard, January 2014–June 2019

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 2019
2014	64,167	57,548	46,490	11,058	**2**	2	0	**0.03**	0.04	0.00	0
2015	60,615	53,483	43,097	10,386	**6**	6	0	**0.11**	0.14	0.00	5
2016	70,691	60,709	48,730	11,979	**6**	6	0	**0.10**	0.12	0.00	3
2017	67,843	58,819	46,911	11,908	**5**	5	0	**0.09**	0.11	0.00	5
2018	71,244	61,315	48,881	12,434	**4**	4	0	**0.07**	0.08	0.00	4
2019[a]	35,986	34,237	27,124	7,113	**4**	4	0	**0.12**	0.15	0.00	4
Total	370,546	326,111	261,233	64,878	**27**	27	0	**0.08**	0.10	0.00	21

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

TABLE 12. New diagnoses of HIV infections, by sex, U.S. Air Force Reserve, January 2014–June 2019

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 2019
2014	41,242	36,717	27,447	9,270	**8**	8	0	**0.22**	0.29	0.00	4
2015	36,579	32,681	24,266	8,415	**3**	2	1	**0.09**	0.08	0.12	2
2016	41,176	36,453	26,797	9,656	**10**	10	0	**0.27**	0.37	0.00	8
2017	39,788	35,252	25,968	9,284	**6**	6	0	**0.17**	0.23	0.00	6
2018	41,402	36,816	26,971	9,845	**4**	4	0	**0.11**	0.15	0.00	3
2019[a]	22,690	21,685	15,847	5,838	**4**	4	0	**0.18**	0.25	0.00	4
Total	222,877	199,604	147,296	52,308	**35**	34	1	**0.18**	0.23	0.02	27

[a]Through 30 June 2019.
HIV, human immunodeficiency virus.

per 5,373 screening tests **(Table 6)**. Of the 355 active component sailors who tested positive for HIV since 2014, a total of 245 (69.0%) were still in military service in 2019.

Navy Reserve: From January 2018 through June 2019, a total of 52,969 members of the U.S. Navy Reserve were tested for antibodies to HIV, and 15 sailors were identified as HIV antibody positive (seroprevalence: 0.28 per 1,000 sailors tested) **(Table 7)**. The HIV antibody seroprevalence among Navy reservists in 2015 was more than 2 times that in 2016 (seroprevalences: 0.46 and 0.22 per 1,000 sailors tested, respectively). Since 2007, no female Navy reservist has been detected with antibodies to HIV during routine testing **(data not shown)**. On average, during 2018, 1 new HIV infection was detected among Navy reservists per 3,786 screening tests **(Table 7)**. Of the 64 reserve component sailors diagnosed with HIV infections since 2014, a total of 45 (70.3%) were still in military service in 2019.

U.S. Marine Corps

Active component: From January 2018 through June 2019, a total of 212,447

members of the active component of the U.S. Marine Corps were tested for antibodies to HIV, and 36 Marines were identified as HIV antibody positive (seroprevalence: 0.17 per 1,000 Marines tested) **(Table 8)**. From January 2014 through June 2019, prevalences of antibodies to HIV remained relatively low and stable among routinely tested Marines **(Figure 5)**. During 2018, on average, 1 new HIV infection was detected among active component Marines per 5,838 screening tests **(Table 8)**. Of the 116 active component Marines diagnosed with HIV infections since 2014, a total of 62 (53.4%) were still in military service in 2019.

Marine Corps Reserve: From January 2018 through June 2019, a total of 37,523 members of the U.S. Marine Corps Reserve were tested for antibodies to HIV, and 6 Marine Corps reservists were identified as HIV antibody positive (seroprevalence: 0.16 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 0.14 per 1,000 tested in 2019 (through June). Of note, only 1 female Marine Corps reservist was detected with antibodies to HIV during routine screening in 2015; none were detected during 1990–2014 or during 2016–2019 (through June) **(data not shown)**. During 2018, on average, 1 new HIV infection was detected among Marine Corps reservists per 6,752 screening tests **(Table 9)**. Of the 38 Marine Corps reservists diagnosed with HIV infection since 2014, a total of 14 (36.8%) were still in military service in 2019.

U.S. Air Force

Active component: From January 2018 through June 2019, a total of 329,607 active component members of the U.S. Air Force were tested for antibodies to HIV, and 47 airmen were diagnosed with HIV infections (seroprevalence: 0.14 per 1,000 airmen tested) **(Table 10)**. From 2014 through June 2019, seroprevalences ranged from 0.13 per 1,000 tested to 0.22 per 1,000 tested. Between 2015 and 2018, HIV antibody seroprevalences decreased among tested males and then increased slightly in the first 6 months of 2019 **(Figure 6)**. Annual seroprevalences remained relatively low and stable among females during the surveillance period. During 2018, on average, 1 new HIV infection was detected among active Air Force members per 9,580 screening tests **(Table 10)**. Of the 196 active component Air Force members diagnosed with HIV infections since 2014, 117 (59.7%) were still in military service in 2019.

Air National Guard: From January 2018 through June 2019, a total of 95,552 members of the Air National Guard were tested for antibodies to HIV, and 8 airmen were diagnosed with HIV infections (seroprevalence: 0.08 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 2018, on average, 1 new HIV infection was detected among Air National Guard members per 17,811 screening tests **(Table 11)**. Of the 27 Air National Guard members diagnosed with HIV infections since 2014, 21 (77.8%) were still in military service in 2019.

Air Force Reserve: From January 2018 through June 2019, a total of 58,501 members of the Air Force Reserve were tested for antibodies to HIV, and 8 airmen were diagnosed with HIV infections (seroprevalence: 0.14 per 1,000 airmen tested) **(Table 12)**. During 2018, on average, 1 new HIV infection was detected among Air Force reservists per 10,351 screening tests **(Table 12)**. Of the 35 reserve component airmen diagnosed with HIV infections since 2014, 27 (77.1%) were still in military service in 2019.

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.[2,3,5,6] Results of U.S. military HIV antibody testing programs have been summarized in the *MSMR* for more than 2 decades.[8]

This report documents that since 2014, prevalences of HIV seropositivity among civilian applicants for military service have fluctuated between 0.24 and 0.34 per 1,000 applicants tested. During this period, seroprevalences among civilian applicants peaked in 2015 and then decreased to 0.30 per 1,000 applicants in 2019 (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 fluctuated between 0.37 per 1,000 tested (Navy, 2015) and 0.11 per 1,000 tested (Marine Corps, 2016); the greatest variations in seroprevalences during the period were observed among active component Navy members. As was observed for total civilian applicants, annual seroprevalences among Army active component service members, Navy active component service members, Air Force active component service members, Navy reservists, and Marine Corps reservists peaked in 2015. Seroprevalences among the Navy Reserve exhibited a pronounced drop after 2015, while seroprevalences among the Army Reserve were relatively stable during the surveillance period. Total (January 2014–June 2019) HIV antibody seroprevalences were highest among Army reservists, Army National Guard members, and Navy reservists. Across active and reserve components of all services, seroprevalences continued to be higher among males than females.

The results of the current analysis 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.[9] 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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Epidemiology of Impulse Control Disorders and Association With Dopamine Agonist Exposure, Active Component, U.S. Armed Forces, 2014–2018

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Impulse control disorders (ICDs) are a group of behavioral disorders characterized by failure to resist impulsive thoughts and behaviors that can lead to significant adverse social, legal, and financial consequences. ICDs have been associated with previous diagnoses of depression, anxiety, and post-traumatic stress disorder and have been widely recognized as an adverse effect of dopamine agonist (DA) therapy. The epidemiology of these disorders in the U.S. Armed Forces is unknown. The current study evaluated the incidence of ICD diagnoses in the U.S. Armed Forces during 2014–2018. The overall incidence was 13.7 per 10,000 person-years (p-yrs), with the highest rates among females and younger personnel. The current case-control study evaluated the association between DA exposure in the year preceding an incident ICD diagnosis. Although few individuals had received DA therapy in the past year, DA therapy was independently associated with incident ICD diagnosis (adjusted odds ratio [AOR]=2.34; 95% confidence interval [CI]: 1.29–4.24, p<.0001). Previous mental health disorder diagnosis (AOR=12.00; 95% CI: 11.09–12.98, p<.0001) and fibromyalgia (AOR=1.30; 95% CI: 1.14–1.48, p<.0001) were also associated with incident ICD diagnosis. The impact of ICDs on mission readiness, medical evacuation, and deployability should be further evaluated.

WHAT ARE THE NEW FINDINGS?

This is the first *MSMR* report focused on the epidemiology of ICDs in the U.S. Armed Forces. During 2014–2018, there were 8,868 incident cases of ICDs among active component service members, with a crude overall incidence rate of 13.7 cases per 10,000 p-yrs. ICD diagnosis was independently associated with several factors, including any DA prescription, previous mental health disorder diagnosis (depression, anxiety, and/or post-traumatic stress disorder), history of fibromyalgia, junior enlisted military rank/grade, and U.S. Army service.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

There were only 43 ICD cases and 40 controls that had received any DA in the past year, indicating that DA exposure alone does not account for a large number of ICD cases in the military. Given the high prevalence of mental health disorder diagnoses and fibromyalgia among active component service members, it is important that clinicians screen for ICDs during clinical encounters, particularly when considering DA therapy for any diagnosis. Clinicians should also consider regularly screening for development of ICDs after starting DA therapy.

Impulse control disorders (ICDs) are a heterogeneous group of behavioral disorders characterized by the failure to resist impulsive thoughts and behaviors.[1] ICDs are phenotypically diverse and can manifest as pathologic gambling, compulsive shopping, compulsive eating, and compulsive sexual behavior (including compulsive hypersexuality, frotteurism, exhibitionism, voyeurism, and other behaviors). Symptoms typically begin insidiously, and patients and family members often fail to recognize them because patients tend to conceal or deny these behaviors.[2] ICDs have been associated with post-traumatic stress disorder (PTSD), poor sleep, increased depression and anxiety, obsessive-compulsive symptoms, novelty seeking, poor quality of life, and non-suicidal self-injury and can also lead to serious psychological, social, legal, and financial consequences.[3–8]

While ICDs are associated with comorbid psychiatric diagnoses, such as depression, anxiety, and PTSD,[3,9] the use of dopamine agonist (DA) therapy represents a primary risk factor for ICDs. DA-associated ICDs have been most widely recognized in Parkinson disease[1,5,6,10–13] but have also been recognized as a consequence of DA therapy for restless legs syndrome (RLS),[14,15] prolactinoma,[16] fibromyalgia,[17] progressive supranuclear palsy,[18,19] and multiple system atrophy.[20,21]

Conditions associated with the diagnosis of ICDs, including depression, anxiety, and PTSD, are prevalent in the U.S. Armed Forces.[22] In addition, conditions treated with DA therapy, such as fibromyalgia and RLS, are also common (RLS crude incidence=0.96 per 1,000 person-years [p-yrs]; unpublished Defense Medical Epidemiology Database query, March 2019).[23] Because of the potentially serious psychological, social, legal, and financial consequences of ICDs, including interference with combat support through non-deployability, medical evacuation, and suicidality, these disorders represent an important unexplored field of study in military populations.

The epidemiology of ICDs in the U.S. Armed Forces is currently unknown, and the degree to which these disorders are associated with DA exposure is also unknown. The current study assessed the epidemiology of ICDs among active component service members by first describing the incidence rate of ICD diagnosis in

this population between 2014 and 2018 and then by testing for any associations between incident ICD diagnosis and prior exposure to DA therapy.

METHODS

Data were drawn from the Defense Medical Surveillance System (DMSS), which is a relational administrative database of medical events and personal characteristics maintained by the Armed Forces Health Surveillance Branch (AFHSB). The DMSS contains records documenting ambulatory encounters and hospitalizations of active component service members of the U.S. Armed Forces in fixed military and civilian (if reimbursed through the Military Health System [MHS]) treatment facilities worldwide. In-theater diagnoses are also available in the Theater Medical Data Store, which was incorporated into the DMSS in 2008.

A retrospective cohort study was used to assess the incidence of ICD diagnoses among active component service members in the U.S Army, Navy, Air Force, or Marine Corps between 1 January 2014 and 31 December 2018. An incident case of ICD was defined as a single occurrence of any of the qualifying International Classification of Diseases, 9th or 10th revision (ICD-9 or ICD-10) diagnosis codes in any diagnostic position of a record of an encounter in an inpatient, outpatient, or theater setting **(Table 1)**. An individual was counted as an incident case of ICD only once per lifetime, and individuals who met the criteria for an incident case that occurred before the start of the study period were excluded. Person-time was censored at the time of the incident case diagnosis. Crude incidence was calculated as incidence per 10,000 p-yrs and was stratified by sex, age, race/ethnicity, military rank/grade, branch of service, primary occupational category, marital status, and level of education.

The association between DA exposure and incident ICD diagnosis was assessed using a case-control study design. Subjects meeting the case definition of ICDs described above were included in the case cohort. Four age- and sex-matched controls were selected from the study population of active component service members who were in service at the time the case patient was diagnosed with an incident ICD. The date of incident ICD diagnosis was considered the reference date. Age was matched within 1 year based on age at the reference date. Because controls were sampled from the population at risk at the time of the case diagnosis, it was possible for a control to become a case later and to be included in the study as both a case and control. In addition, it was possible to be selected as a control in the study more than once if the control was selected again for another case.

Previous mental health disorder diagnoses known to be associated with ICDs (i.e., depression, anxiety, and/or PTSD) and conditions treated with DA therapy (Parkinson disease, RLS, prolactinoma, and fibromyalgia) were included as covariates. For each case and control, history of prior diagnosis of depression, anxiety, and/or PTSD was ascertained using the standard AFHSB case definition.[24] An individual was defined as having a previous mental health disorder diagnosis if they were diagnosed as an incident case of depression, anxiety, or PTSD at any time before the reference date. In addition, individuals were identified as having a prior diagnosis of Parkinson disease (ICD-9: 332.0; ICD-10: G20), RLS (ICD-9: 333.94; ICD-10: G25.81), prolactinoma (ICD-9: 227.3; ICD-10: D35.2), or fibromyalgia (ICD-9: 729.1; ICD-10: M79.7) if they had a qualifying diagnosis in any inpatient, outpatient, or theater medical encounter at any time before the reference date.

DA exposure was defined as the presence of a prescription for a DA at any point during the 1-year period before the ICD diagnosis. In order to have a complete 1-year observation period, cases and controls were restricted to individuals who had at least 1 year of continuous active duty service before the incident ICD diagnosis. Therefore, cases of ICD were selected between 1 January 2015 and 31 December 2018 to allow for the minimum 1-year observation time.

In order to standardize comparison of DA exposure, DA prescriptions were converted into the levodopa equivalent dose

TABLE 1. Diagnostic codes used in defining cases of ICDs

	ICD-9	ICD-10
ICDs, unspecified	312.3	F63.9
Pathologic gambling	312.31	F63.0
Kleptomania	312.32	F63.2
Pyromania	312.33	F63.1
Intermittent explosive disorder	312.34	F63.81
Trichotillomania	307.9	F63.3
Fetishism	302.81	F65.0
Transvestic fetishism	302.3	F65.1
Exhibitionism	302.4	F65.2
Voyeurism	302.82	F65.3
Frotteurism	302.89	F65.81
Other paraphilias	302.9	F65.89
Paraphilia, unspecified	302.9	F65.9
Other/unspecified eating disorders	307. 50, 307.59	F50.8, F50.81, F50.9
Other impulse disorders	312.39	F63.89
Other conduct disorder	312.89	F91.8
Unspecified disturbance of conduct	312.9	F91.9

ICDs, impulse control disorders; ICD-9/ICD-10, International Classification of Diseases, 9th/10th revision.

(LED) using conversion factors previously described by Tomlinson and colleagues.[25] LED was calculated as follows, and the conversion factor for each DA is shown in **Table 2.**

$$Rx_{quantity}(number\ of\ tablets) \times dose\ (mg) \times Cf(DA) = Total\ LED\ (mg/100mg\ levodopa)$$

Total LEDs were summed for the 1-year observation period to compare degree of DA exposure.

Adjusted odds ratios (AORs) and 95% confidence intervals (CIs) were calculated using a conditional multivariable logistic regression model to compare the relationship between DA exposure and incident diagnosis of ICDs. The Wald chi-square test was applied using conditional crude logistic regression models for bivariate analyses. Covariates for the multivariable model included sex, age, race/ethnicity, military rank/grade, service, primary occupational category, marital status, and level of education. Because of the large sample size, a p value of .01 was selected as the threshold for statistical significance.

TABLE 2. Conversion factors used in calculation of LED

Dopamine agonist	Conversion factor
Apomorphine	10
Bromocriptine	10
Cabergoline	67
Pramipexole	100
Ropinirole	20
Rotigotine	30

LED, levodopa equivalent dose.

RESULTS

Incidence of ICDs

During 2014–2018, there were 8,868 incident cases of ICDs among active component service members, with a crude overall incidence rate of 13.7 cases per 10,000 p-yrs. The most common ICDs were eating disorders (2,472 cases), followed by other/unspecified conduct disorder (1,911 cases), and other/unspecified impulse disorder (1,677 cases). The frequencies of ICDs by diagnosis are shown in **Table 3**. Crude stratified incidence rates for selected covariates are shown in **Table 4**. During the 5-year surveillance period, the crude overall incidence rate was highest in 2015 (15.5 per 10,000 p-yrs) and lowest in 2017 (11.7 per 10,000 p-yrs) **(Figure)**. The crude overall incidence rate among females was 2.4 times the rate among males (26.7 vs 11.3 per 10,000 p-yrs). The highest overall rates were seen among service members in the youngest age groups (less than 20 years old, 15.6 per 10,000 p-yrs; 20–24 years old, 15.9 per 10,000 p-yrs), and the lowest overall rates were seen among service members in the oldest age groups (40–44 years old and 45+: 10.5 cases per 10,000 p-yrs). Rates were highest among non-Hispanic blacks (16.1 per 10,000 p-yrs) and lowest among Asian/Pacific Islanders (11.8 per 10,000 p-yrs) **(Table 4)**.

Compared to other service branches, overall rates of incident ICD diagnoses were highest among those in the Army (17.5 per 10,000 p-yrs) and lowest among those in the Air Force (11.0 per 10,000 p-yrs).

TABLE 3. Numbers of individuals diagnosed with ICDs, by type, active component service members, 2014–2018

Diagnosis	Frequency	% of total
Other/unspecified eating disorders	2,472	27.88
Other/unspecified conduct disorder	1,911	21.55
Other/unspecified impulse disorder	1,677	18.91
Intermittent explosive disorder	967	10.90
Trichotillomania	905	10.21
Other/unspecified paraphilias	415	4.68
Pathologic gambling	347	3.91
Frotteurism	70	0.79
Fetishism	45	0.51
Voyeurism	24	0.27
Exhibitionism	15	0.17
Kleptomania	15	0.17
Pyromania	5	0.06
Total	8,868	100.00

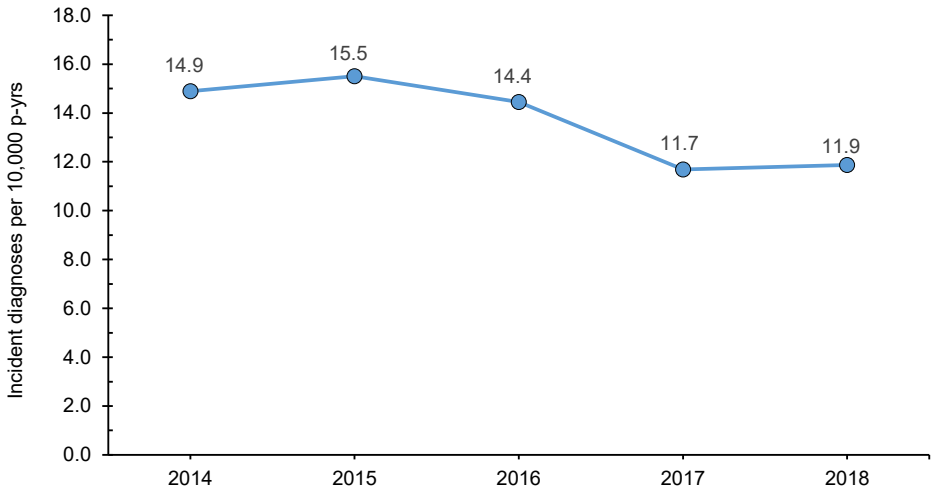
ICDs, impulse control disorders.

TABLE 4. Incident diagnoses and incidence rates[a] of ICD, by demographic and military characteristics, active component, U.S. Armed Forces, 2014–2018

	Total (2014–2018)	
	n	Rate[a]
Total	8,868	13.7
Sex		
Male	6,157	11.3
Female	2,711	26.7
Age group (years)		
<20	1,331	15.6
20–24	2,639	15.9
25–29	2,034	13.4
30–34	1,278	12.2
35–39	891	12.1
40–44	433	10.5
45+	262	10.5
Race/ethnicity		
Non-Hispanic white	4,975	13.3
Non-Hispanic black	1,695	16.1
Hispanic	1,280	13.4
Asian/Pacific Islander	305	11.8
Other/unknown	613	12.9
Rank		
Junior enlisted (E1–E4)	4,864	17.3
Senior enlisted (E5–E9)	3,220	12.8
Junior officer (O1–O3)	458	7.1
Senior officer (O4–O10)	250	6.0
Warrant officer (W1–W5)	76	8.2
Service		
Army	4,166	17.5
Navy	1,902	11.9
Air Force	1,723	11.0
Marine Corps	1,077	11.7
Military occupation		
Combat-specific[b]	1,195	13.2
Motor transport	314	16.8
Pilot/air crew	76	3.1
Repair/engineering	2,255	11.8
Communications/intelligence	2,230	16.0
Healthcare	1,102	19.1
Other/unknown	1,696	13.6
Marital status		
Married	4,598	13.2
Single, never married	3,748	13.8
Other	519	18.3
Unknown	3	7.1
Education level		
High school or less	6,406	15.5
Some college	1,183	14.5
College or more	1,153	8.3
Unknown	126	8.7

[a]Rate per 10,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
ICD, impulse control disorder.

FIGURE. Annual rates of incident ICD diagnoses, active component, U.S. Armed Forces, 2014–2018



ICD, impulse control disorder; p-yrs, person-years.

Rates among Navy and Marine Corps service members were similar (11.9 vs 11.7 per 10,000 p-yrs, respectively). Rates were higher among enlisted personnel compared to officers, with the highest rates among junior enlisted (17.3 per 10,000 p-yrs) and the lowest among senior officers (6.0 per 10,000 p-yrs). With regards to primary occupational category, healthcare workers had over 6 times the overall rate of incident ICD diagnoses compared to those working as pilots/air crew (19.1 vs 3.1 per 10,000 p-yrs). Overall incidence rates of ICD diagnoses were higher among service members with "other" marital status (which includes divorced and widowed) compared to those who were married or those who were single and never married. Finally, higher overall rates were seen among those with lower levels of education compared to those with higher levels of education (15.5 per 10,000 p-yrs among those with high school or less compared to 8.3 among those with college education or more).

Association with DA exposure

A total of 6,373 cases and 25,492 controls were included in the case-control analysis **(Table 5)**. Overall, a higher proportion of cases had histories of mental health disorder diagnoses known to be associated with ICDs compared to controls (p<.0001). There was a higher proportion of cases with a history of RLS compared to controls (p<.0001), and the same was true for fibromyalgia (p<.0001).

Of the 6,373 impulse disorder cases, 43 had received DA therapy prescriptions within the past year. Of the 25,492 controls, 40 had received DA therapy prescriptions within the past year. Cases had a higher percentage of DA therapy prescriptions compared to controls (0.67% vs 0.16%, respectively, p<.0001). Compared to controls, those who received DAs had a significantly higher frequency of prescriptions for pramipexole (20/6,373 compared to 18/25,492, respectively, p<.0001) and ropinirole (19/6,373 compared to 16/25,492, respectively, p<.0001) **(Table 5)**. Among those prescribed DA therapy within the last year, the frequency distributions of total LED were similar among cases and controls.

Multivariable logistic regression analysis revealed significant associations between ICD diagnosis and previous mental health disorder diagnosis (AOR=12.00; 95% CI, 11.09–12.98; p<.0001) as well as between ICD diagnosis and previous diagnosis of fibromyalgia (AOR=1.30; 95% CI, 1.14–1.48; p<.0001) **(Table 6)**. After controlling for covariates, the association between previous diagnosis of RLS and subsequent ICD diagnosis was not statistically significant (AOR=1.18; 95% CI, 0.85–1.65; p=.326). Finally, analysis revealed that any DA use was significantly associated with an ICD diagnosis after controlling for covariates (AOR=2.34; 95% CI: 1.29–4.24). Parkinson disease and prolactinoma were not included in the multivariate logistic regression model because of a limited number of cases and lack of statistical significance in the bivariate analyses.

EDITORIAL COMMENT

Many studies have evaluated the prevalence of ICDs among patients with certain conditions such as Parkinson disease. The prevalence of ICDs in Parkinson disease has been observed to be between 2–39% and is highest among patients taking DAs.[10] In the general adult population, ICD prevalence is estimated to be between 2–8%.[26] However, incidence of ICDs in the U.S. military has not been previously described.

Compared to other mental health disorders among active component service members, the overall incidence of ICDs (13.7 per 10,000 p-yrs) is similar to that of bipolar disorder (15.9 per 10,000 p-yrs).[22] By contrast, ICDs occur less frequently than adjustment disorders (420.1 per 10,000 p-yrs), depressive disorders (242.5 per 10,000 p-yrs), and anxiety disorders (212.0 per 10,000 p-yrs) but more frequently than psychotic disorders (9.3 per 10,000 p-yrs) and schizophrenia (2.3 per 10,000 p-yrs).[22]

Similar to previous studies, this analysis of U.S. military personnel demonstrates that diagnosis of ICDs tends to occur among younger individuals. The highest overall incidence of ICD diagnoses occurred among service members in the Army, which is similar to what has been observed with respect to the overall incidence of many mental health disorders.[22] However, it is unclear the degree to which other factors, such as deployment history (which has been shown to be highly associated with mental health disorders, including depression, anxiety, and PTSD) may confound this observation.[22]

Where previous studies have observed a male predominance of ICD diagnosis, particularly in Parkinson disease,[1] this study demonstrated a female predominance among ICD cases. This finding may

TABLE 5. Demographic and military characteristics of ICD cases and matched controls, 2015–2018

	Case		Control		Total		p-value[a]
	n	%	n	%	n	%	
Total	6,373	100.0	25,492	100.0	31,865	100.0	
Sex							NA
Male	4,358	68.4	17,432	68.4	21,790	68.4	
Female	2,015	31.6	8,060	31.6	10,075	31.6	
Age group (years)							NA
<20	760	11.9	3,017	11.8	3,777	11.9	
20–24	1,909	30.0	7,642	30.0	9,551	30.0	
25–29	1,519	23.8	6,053	23.7	7,572	23.8	
30–34	958	15.0	3,910	15.3	4,868	15.3	
35–39	701	11.0	2,779	10.9	3,480	10.9	
40–44	327	5.1	1,300	5.1	1,627	5.1	
45+	199	3.1	791	3.1	990	3.1	
Race/ethnicity							<.0001
Non-Hispanic white	3,493	54.8	14,008	55.0	17,501	54.9	
Non-Hispanic black	1,280	20.1	4,542	17.8	5,822	18.3	
Hispanic	950	14.9	3,914	15.4	4,864	15.3	
Asian/Pacific Islander	232	3.6	1,009	4.0	1,241	3.9	
Other/unknown	418	6.6	2,019	7.9	2,437	7.6	
Rank							<.0001
Junior enlisted (E1–E4)	3,329	52.2	11,593	45.5	14,922	46.8	
Senior enlisted (E5–E9)	2,459	38.6	9,706	38.1	12,165	38.2	
Junior officer (O1–O3)	345	5.4	2,480	9.7	2,825	8.9	
Senior officer (O4–O10)	185	2.9	1,423	5.6	1,608	5.0	
Warrant officer (W1–W5)	55	0.9	290	1.1	345	1.1	
Service							<.0001
Army	3,068	48.1	8,934	35.0	12,002	37.7	
Navy	1,288	20.2	6,530	25.6	7,818	24.5	
Air Force	1,271	19.9	6,584	25.8	7,855	24.7	
Marine Corps	746	11.7	3,444	13.5	4,190	13.1	
Military occupation							<.0001
Combat-specific[b]	830	13.0	3,081	12.1	3,911	12.3	
Motor transport	217	3.4	764	3.0	981	3.1	
Pilot/air crew	56	0.9	812	3.2	868	2.7	
Repair/engineering	1,687	26.5	7,513	29.5	9,200	28.9	
Communications/intelligence	1,674	26.3	6,232	24.4	7,906	24.8	
Healthcare	845	13.3	2,711	10.6	3,556	11.2	
Other/unknown	1,064	16.7	4,379	17.2	5,443	17.1	
Marital status							<.0001
Married	3,452	54.2	13,481	52.9	16,933	53.1	
Single, never married	2,510	39.4	10,766	42.2	13,276	41.7	
Other/unknown	411	6.4	1,245	4.9	1,656	5.2	
Education level							<.0001
High school or less	4,476	70.2	16,435	64.5	20,911	65.6	
Some college	918	14.4	3,332	13.1	4,250	13.3	
College or more	901	14.1	5,255	20.6	6,156	19.3	
Unknown	78	1.2	470	1.8	548	1.7	
Previous mental health disorder diagnosis[c]							<.0001
Yes	3,741	58.7	3,023	11.9	6,764	21.2	
No	2,632	41.3	22,469	88.1	25,101	78.8	
Previous indicator disease diagnosis							
Parkinson disease	1	0.02	0	0.0	1	0.00	---
Restless legs syndome	105	1.6	159	0.62	264	0.83	<.0001
Prolactinoma	13	0.20	25	0.10	38	0.12	---
Fibromyalgia	595	9.3	1,384	5.43	1,979	6.2	<.0001
Any DA use							<.0001
Yes	43	0.67	40	0.16	83	0.26	
No	6,330	99.3	25,452	99.8	31,782	99.7	
DA type							
Apomorphine	0	0.0	0	0.0	0	0.0	---
Bromocriptine	3	0.05	2	0.01	5	0.02	---
Cabergoline	2	0.03	8	0.03	10	0.03	---
Pramipexole	20	0.31	18	0.07	38	0.12	<.0001
Ropinirole	19	0.30	16	0.06	35	0.11	<.0001
Rotigotine	0	0.0	0	0.0	0	0.0	---
Total LED among those with DA use (mg/100 mg levodopa)							---[d]
>0–750 mg	14	32.6	14	35.0	28	33.7	
>750–6,725 mg	19	44.2	19	47.5	38	45.8	
>6,725 mg	10	23.3	7	17.5	17	20.5	

[a]P values <.01 are presented.
[b]Infantry/artillery/combat engineering/armor.
[c]Mental health disorders known to be associated with ICD (i.e., depression, anxiety, and/or PTSD).
[d]P value could not be calculated because of the high correlation of total LED with the matching factors age and sex.
ICD, impulse control disorder; DA, dopamine agonist; LED, levodopa equivalent dose.

be accounted for by the high number of eating disorder cases among female active component service members.[27]

The association between DA exposure and ICD diagnosis has been widely studied in patients with Parkinson disease and other conditions, such as prolactinoma, fibromyalgia, progressive supranuclear palsy, and multiple system atrophy. However, this study examined the relationship between DA exposure and incident ICD diagnosis independently of the condition for which DA therapy was prescribed. DA use was independently associated with ICD diagnosis, even after controlling for other factors in the model (AOR=2.34; 95% CI: 1.29–4.24). However, there were only 43 cases and 40 controls that had received any DA in the past year, indicating that DA exposure alone does not account for a large number of ICD cases in the military.

Similar to previous studies, this report demonstrated a higher association of ICDs with pramipexole and ropinirole therapy compared to other DAs. This may be due to the D3-preferring receptor binding profile of these agents compared to other DAs, which has been suggested from previous studies.[12] Larger sample sizes may help to further elucidate this relationship.

The strongest independent association with ICD diagnosis was with previous mental health disorder diagnosis. This suggests that among active component service members, ICDs are more likely to occur in association with previous mental health disorder diagnosis than with DA therapy. Fibromyalgia was also independently associated with ICD diagnosis in the current study. These findings are particularly important for the U.S. military population, in which these disorders are common. Future studies may be helpful in further elucidating the relationship between specific mental health disorder diagnoses and the diagnosis of ICDs.

Finally, the degree to which RLS represents an independent risk factor for ICD diagnosis is a topic of ongoing study in the field of neurology. While the current analysis revealed a statistically significant bivariate association between RLS and ICD diagnosis, this finding did not remain after adjustment for covariates, suggesting that RLS may not be an independent risk factor for ICD diagnosis.

TABLE 6. Adjusted odds ratios for incident ICD, 2015–2018

	AOR	95% CI LL	95% CI UL	p-value
Race/ethnicity				
Non-Hispanic white	ref	.	.	.
Non-Hispanic black	1.11	1.01	1.21	.030
Hispanic	0.97	0.88	1.07	.577
Asian/Pacific Islander	1.10	0.92	1.31	.311
Other/unknown	0.92	0.81	1.05	.222
Rank				
Junior enlisted (E1–E4)	ref	.	.	.
Senior enlisted (E5–E9)	0.58	0.52	0.64	<.0001
Junior officer (O1–O3)	0.62	0.51	0.75	<.0001
Senior officer (O4–O10)	0.46	0.36	0.59	<.0001
Warrant officer (W1–W5)	0.44	0.30	0.64	<.0001
Service				
Army	ref	.	.	.
Navy	0.66	0.60	0.72	<.0001
Air Force	0.70	0.64	0.77	<.0001
Marine Corps	0.77	0.70	0.86	<.0001
Military occupation				
Combat-specific[a]	ref	.	.	.
Motor transport	1.06	0.86	1.30	.594
Pilot/air crew	0.64	0.46	0.88	.006
Repair/engineering	0.98	0.88	1.11	.790
Communications/intelligence	1.06	0.94	1.20	.321
Healthcare	1.05	0.91	1.20	.543
Other/unknown	1.08	0.95	1.22	.269
Marital status				
Married	ref	.	.	.
Single, never married	1.00	0.92	1.08	.934
Other/unknown	0.95	0.82	1.10	.500
Education level				
High school or less	ref	.	.	.
Some college	0.94	0.84	1.04	.228
College or more	0.84	0.73	0.97	.019
Unknown	0.92	0.67	1.24	.572
Previous mental health disorder diagnosis[b]				
Yes	12.00	11.09	12.98	<.0001
No	ref	.	.	.
Previous diagnosis of RLS				
Yes	1.18	0.85	1.65	.326
No	ref	.	.	.
Previous diagnosis of fibromyalgia				
Yes	1.30	1.14	1.48	<.0001
No	ref	.	.	.
Any DA use				
Yes	2.34	1.29	4.24	.005
No	ref	.	.	.

[a]Infantry/artillery/combat engineering/armor.
[b]Mental health disorders known to be associated with ICD (i.e., depression, anxiety, and/or PTSD).
ICD, impulse control disorder; AOR, adjusted odds ratio; CI, confidence interval; LL, lower limit; UL, upper limit; RLS, restless legs syndrome; DA, dopamine agonist; PTSD, post-traumatic stress disorder.

There are several limitations to this study. First, because ICDs are likely underrecognized and underdiagnosed, the incidence data reported here are likely an underestimate of the true burden of these conditions. Moreover, this lack of recognition of patients' ICDs represents a potential source of outcome misclassification bias in this study, as patients who had unrecognized ICDs may have been classified as controls or not included in the case cohort. In addition, retrospective analysis using diagnostic codes limits the ability to detect certain subtypes of mild ICDs, such as punding, hypercreativity, or excessive hobbyism, which are commonly recognized DA-associated ICDs. Similar to other studies involving database queries, provider miscoding is a potential source of misclassification bias.

Retrospective data analysis also limits adequate assessment of cumulative DA exposure before the study period, as prescription data were only available in the DMSS beginning in 2014. Calculation of LED was performed in order to standardize the assessment of DA exposure during the year before ICD diagnosis. However, degree of medication compliance and prescription discontinuation are not known and therefore not represented in the present analysis. Finally, although many potential confounders were adjusted for, uncontrolled confounding cannot be ruled out, specifically with regards to other mental health disorder diagnoses.

ICD diagnosis was independently associated with several factors in this study, including any DA prescription, previous mental health disorder diagnosis (depression, anxiety, and/or PTSD), history of fibromyalgia, junior enlisted military rank/grade, and U.S. Army service. Given the high prevalence of mental health disorder diagnosis and fibromyalgia among active component service members,[22,23] it is important that clinicians screen for ICDs during clinical encounters, particularly when considering DA therapy for any diagnosis. Clinicians should also consider regularly screening for development of ICDs after starting DA therapy, as has been previously suggested.[28] Additional research exploring the impact of these conditions on medical readiness, medical evacuation, deployability, and mission accomplishment is warranted.

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Commentary

Gaps in Reportable Medical Event Surveillance Across the Department of the Army and Recommended Training Tools to Improve Surveillance Practices

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Department of Defense Directive (DoDD) 6490.02E stipulates that health surveillance is essential to the evaluation, planning, and implementation of public health practice.[1] A reliable system for capturing and communicating the occurrence of reportable medical events (RMEs) is a critical component of health surveillance within the DoD. Since its implementation in 2010, the Disease Reporting System internet (DRSi) has improved the timeliness of reporting and disease capture rates of RME surveillance for the DoD. However, numerous surveillance gaps still remain, in part, because many military treatment facilities (MTFs) lack written procedures for ensuring disease capture or DRSi utilization. Furthermore, the public health personnel of many MTFs need more knowledge of and training on the proper utilization of the RME case definitions and the submission of complete reports through the DRSi. These shortcomings limit the sensitivity and specificity of the passive surveillance system. While these gaps are not the only constraints identified by DRSi users, each significantly impacts surveillance for the DoD overall. This article will attempt to describe some of the deficiencies observed by experienced users of the DRSi and will elaborate on some tools developed by the Army Public Health Center (APHC) to improve RME surveillance, including a communicable disease toolkit.

Current practices for RMEs

Before 2010, the RME system used by the Army was only available for 35 locations. In an effort to improve surveillance of RMEs in the Army population, U.S. Army Medical Command (MEDCOM) adopted the Navy's DRSi in 2010.[2] The internet-based interface allows more users and installations, including those located outside the continental U.S., to access the system. In addition, data submitted to the system are immediately available for review and analysis.

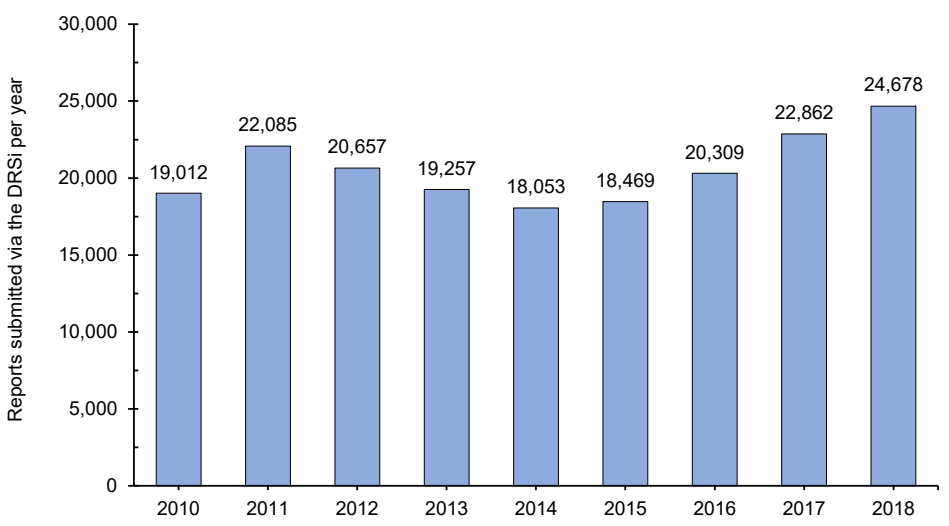
Overall usage of the DRSi in the Army increased by 30% from 2010 through 2018 in terms of the number of reports entered into the system **(Figure 1)**.[3] The most commonly reported RMEs from Army MTFs during this period were sexually transmitted infections (STIs), with STI reports accounting for 83% of all RMEs. Heat- and cold-related illnesses accounted for 5% of all reports, and gastrointestinal RMEs accounted for approximately 4% of all reports (APHC, unpublished data, 2019).

Cases may be entered into the DRSi by public health professionals at the local MTF on a daily basis, but the responsibilities of RME surveillance encompass several positions at the MTF. To start, the local public health professional should verify the patient's diagnosis using laboratory records and electronic medical records and then report that case into the DRSi within 2 business days of the diagnosis.[3,4] If confirmatory laboratory data are still pending, the case must be reported as a preliminary case but then updated as new information becomes available. All required data elements outlined in the RME guidelines must be included in the medical event report in the DRSi.[5] The case classification (i.e., suspected, probable, or confirmed) selected for that medical event report should conform to the current version of the Armed Forces RME Guidelines and Case Definitions.[5]

Cases reported to the DRSi from Army MTFs are reviewed and verified by epidemiologists at the APHC for accuracy and completeness on a daily basis. Information entered into the medical event report is checked against the RME guidelines. If the information meets the required criteria, the case is accepted without revisions. If necessary information is missing or the case classification does not match the information entered, the APHC contacts the original recorder of that report for clarification and additional information. This quality control measure ensures that the medical event reports entered in the DRSi database are reliable and standardized across all Army MTFs. The details of this secondary review process currently vary among the services, thus diminishing the validity of service-to-service comparisons when examining RME trends.

In their surveillance of notifiable diseases, the Centers for Disease Control and Prevention (CDC) and state and local health departments face challenges similar to those faced by the DoD.[6–9] RME reporting in the civilian public health sector is based on passive surveillance through internet-based surveillance systems. Data on RMEs are captured through emergency room logs, laboratory results, infection control practitioners, and/or astute physicians or nurses at local clinics and are reported through the National Notifiable Disease Surveillance System. However, unlike the model used in the DoD, civilian public health professionals are required to document the disease follow-up for each RME.[10] Standardized reporting and case investigation forms created and disseminated by the state or local health department are used to guide the investigations. Military installations are required to report notifiable conditions to the local and state health departments in parallel with DoD reporting through the DRSi. Since standardized investigation forms and processes for follow-up specific to the military are not available, investigations by DoD public

FIGURE 1. Total number of reports submitted per year in the DRSi, 2010–2018



DRSi, Disease Reporting System internet.

health entities differ between installations, as they do between states.

Case follow-up is a critical step in surveillance of RMEs and includes activities such as verification of the diagnosis, determination of whether other individuals may be at risk of the same condition, post-exposure screening and prophylaxis, and other actions that protect and assure public health. Case follow-up augments a purely passive surveillance system with an active primary prevention component. In the DoD, thorough case follow-up occurs most consistently for STIs, as when public health nurses seek to identify and notify sexual contacts about exposure to a patient with an STI.[11] This contact tracing is tracked through risk surveys, which are available through the DRSi and linked to each STI medical event report. Standardized questions on sexual behaviors are asked of each STI case. In the Army, the percentage of total STI reports with completed risk surveys is tracked quarterly for each installation and region. For example, Army MTFs in the Regional Health Command-Atlantic region completed risk surveys for 87% of all chlamydia cases reported from October through December 2018.[11]

Limitations to the current practice across the Army

The known gaps in RME follow-up are multifaceted and not isolated to 1 discrete cause. The gaps discussed in the current article were discovered through discussions with Army Preventive Medicine Chiefs, Army Public Health Nurses, and surveys of Army DRSi users carried out in 2017 and 2018. Challenges in RME follow-up unique to Air Force and Navy installations are not included in the current article. It should be noted that individuals whose public health duties at Army installations include the submission of RME reports through the DRSi are referred to here as "reporters."

Problems at the local level

The DoD struggles with reliable and consistent disease follow-up because of a lack of policy or command emphasis. Current DoD and Army regulations mandate reporting of specific RMEs, yet these same policies do not mandate public health surveillance practices for disease follow-up. However, DoDD 6490.02E does state that the services are to implement early intervention and control strategies using practices consistent across the DoD.[1] As a result, although public health officials and leadership may be made aware of the occurrence of individual cases of specific conditions, there may be no supplemental evidence to suggest that cases are related or that other persons may be at risk. For example, because the performance of contact tracing and the collection and analysis of food histories for non-STI RMEs are not methodically tracked by higher headquarters, it is not known whether or not such surveillance actions are consistently performed at Army MTFs. The only indication that food histories were taken for potential foodborne illnesses may be information in the comments section of the medical event report in the DRSi, but evidence within DRSi reports suggests that such interviews are often incomplete or not performed with scientific rigor. For example, 1 comment associated with a culture-confirmed case of campylobacteriosis stated "consumed leftover turkey legs [and] 4–5 hours later he started to have symptoms."[12] Given the incubation period of 2–5 days for campylobacteriosis, this meal consumed by the patient is not likely to be the source of infection; however, no other information was provided regarding the possible source.

Frequent turnover in the staff who function as DRSi reporters commonly results in the placement of new reporters who need detailed training in the necessary knowledge base and procedures involved in RME reporting. A lack of training for new DRSi reporters is a significant problem that may be partially due to frequent staff turnover. A 2018 survey of Army medical event reporters completed by Battelle found that less than 50% of DRSi-using survey respondents had ever received any DRSi training. Further, approximately 60% of the DRSi-using respondents reported that their initial training for the system was learned on the job, and only 20% reported receiving training from a mentor. Frequent turnover in military health systems is inevitable; however, a lack of standard operating procedures (SOPs) that include guidelines for training exacerbates the negative impact of turnover on reporting compliance and data quality.

Effective, continuous surveillance based upon RME data depends upon DRSi reporters identifying cases of reportable conditions from notifications by healthcare providers or through regular searches of diagnoses recorded in patient records or laboratory results. A recent study by the APHC found that the percentage of diagnoses qualifying as RMEs that were reported as such through the DRSi (i.e., case capture percentage) ranged from 65–95% (mean=91%) (Army Institute of Public

Health, unpublished data, 2013). Even a case capture percentage of 90% represents a concerning reduction in the sensitivity of the surveillance system. Qualitative assessment of this gap has found that case capture is sometimes difficult at the MTF level because local public health personnel lack the knowledge and abilities required to access medical systems of information. The APHC may be unaware of these training gaps unless substantial differences between laboratory and DRSi data are seen. Without evidence of such discrepancies, the APHC relies on reporters and their public health leadership at the local level to identify and communicate case reporting challenges.

Funding and established reporting responsibilities at each MTF vary significantly across the DoD. Some MTFs employ a team of reporters whose sole responsibility is to report diseases, while others assign 1 individual to handle reporting in addition to their other occupational responsibilities. Army regulation requires that all medical events on the current RME list be reported into the DRSi as soon as possible after the diagnosis has been made but no later than 2 business days from the diagnosis date.[3,4] This standard includes case reports from subordinate and satellite clinics. In addition, local and state health departments have their own requirements for RME reporting timeliness. Reporting RMEs to multiple authorities with differing requirements and within a specified timeframe poses a significant burden to disease reporters. This burden becomes more substantial with fewer available reporters and can lead to a delay in the timeliness of reporting associated with the entire MTF. In addition, as military installations send more patients to civilian MTFs, barriers to communication may develop between civilian health agencies and military public health personnel.

Disease reporting as a challenging job duty

DRSi reporters have described difficulties interpreting specific case criteria and classifications for RMEs as presented in the RME guidelines. Some diseases have simple, laboratory-based definitions (e.g., "positive culture from any clinical specimen") and others are more complex, requiring interpretation of multiple laboratory results (e.g., "at least a 4-fold increase of antibody titer between acute and convalescent sera separated by 6–8 weeks").[5] Sickbert-Bennett et al. found that, in civilian public sector surveillance systems, diseases with fewer clinical criteria and laboratory-based case definitions tend to have higher completeness of reporting.[9] This tendency underestimates the true burden of diseases with more clinical criteria and no laboratory-based case definitions. A similar gap likely exists within the DoD surveillance system; however, no studies comparing the DoD and civilian systems have been performed.

Historically, outbreak reporting in the Army has been inadequate because of a lack of clear understanding of what constitutes an outbreak. Moreover, what information to include in an RME outbreak report varies considerably between reporters. After action reports from outbreaks such as the *Legionella* outbreak in Selfridge, MI, and the atypical pneumonia outbreak at Fort Leonard Wood specifically noted this gap.[13–15] Often, these reports contain insufficient information to answer basic public health-related questions. Since 2010, 104 outbreak reports have been submitted to the DRSi from 30 Army MTFs. Of the 104 outbreak reports, 30 (29%) did not specify the number of laboratory-confirmed cases and 60 (58%) were incomplete.[16] Annual training has been provided by the services on how to identify outbreaks, strategies for investigating outbreaks, and how to report outbreaks in the DRSi; however, not all outbreaks are being reported and the APHC often learns of these outbreaks from situational reports, media, or personal contacts throughout the DoD.[16]

In summary, the gaps in RME-based surveillance described above pertain to the need for 1) detailed follow-up investigation of cases to identify contacts and possible risk to others; 2) training of public health investigators and DRSi reporters to allow more efficient execution of their duties; 3) improvement in the completeness of identification of cases that warrant DRSi reporting; and 4) enhancements in the recognition and investigation of outbreaks and the quality of outbreak reports. In order to reduce these gaps found in disease surveillance across the DoD, the following strategies for improving RME surveillance are recommended.

Tools needed to improve RME surveillance

Fundamental guidelines for reporting

Each DoD public health professional must be very familiar with the current list of conditions required to be reported by DoD policy and by their state and/or local public health authorities.[5] Each MTF's public health team should ensure that lists of the reportable conditions are on display throughout the MTF so that healthcare providers who make diagnoses of such conditions are continuously reminded of the need to notify public health professionals when appropriate. The effort to display these lists throughout the MTF requires initiative and planning on the part of leadership and the staff. The current DoD list includes 68 RMEs, some of which are reportable only by DoD policy and not by state laws. The lists should be clearly visible throughout the MTF and regularly reviewed and updated when changes are made to the RME guidelines.

A copy of the RME guidelines[5] must be available to all staff responsible for routine RME reporting. Each RME has specific clinical, laboratory, and exposure criteria that constitute a case definition. Although the case definitions were intended to correspond with those written by the CDC, there are some important differences. Therefore, it is crucial that staff review RME case definitions while entering cases into the DRSi to ensure they are completely and accurately reporting case information. Failure to refer to the case definition will result in incorrect medical event reports and a delay in timely notification of RMEs.

Having SOPs for the public health/preventive medicine staffs of the MTFs is an important option to promote improved reporting and surveillance of RMEs. SOPs offer a method to standardize case capture procedures and to provide installations with consistency over time. Staff turnover, lack of resources, and change of leadership all contribute to a work environment that is not conducive to accurate and reliable data reporting. These SOPs should provide location-specific guidance and outline how to perform RME follow-up, train new staff to ensure consistent disease surveillance, and conduct an outbreak investigation. For a

more detailed example, readers are advised to see the epidemiological training session provided by the services in January 2019 that discussed the importance of implementing an SOP and provided templates for MTFs to develop their own.[17]

Communicable disease toolkit

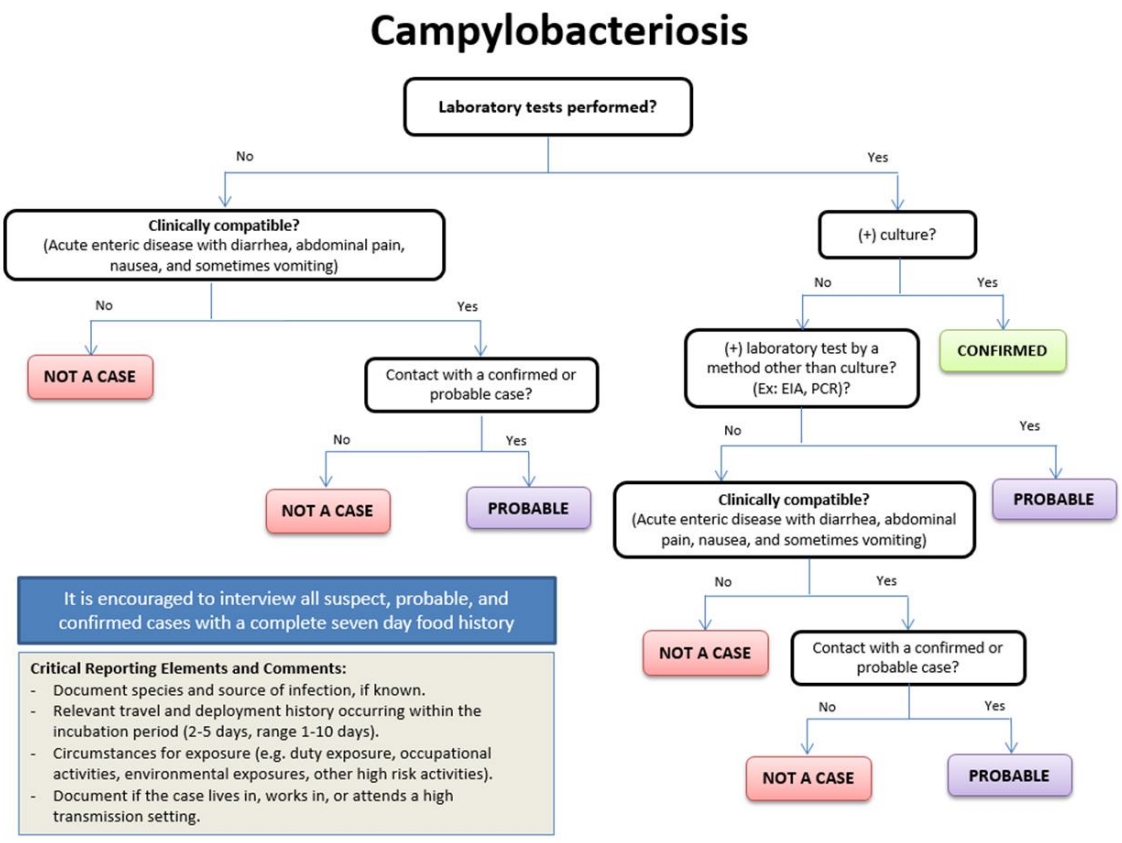
To help standardize the investigation process in response to outbreaks and RME surveillance in the DoD, a communicable disease toolkit was developed, and a first draft is currently undergoing technical and editorial review. The initial release will include factsheets, flow charts of the case definition **(Figure 2)**, and standardized investigation forms for every RME. Future iterations of the toolkit will include template SOPs with guidance for documenting case findings, conducting outbreak investigations, managing disease follow-up, and carrying out epidemiologic analyses. Electronic copies of the toolkit will be available for download and will serve as a standardized resource for all MTFs to aid in disease reporting and surveillance according to DoD policy.

Once the communicable disease toolkit is available, significant marketing and training for all DoD MTFs will be required to encourage the actual use of the resources available to avoid the creation of MTF-specific toolkits. The aforementioned survey found that less than 55% of respondents used case definitions while entering cases in the DRSi. Furthermore, only 45% said that they referenced the RME guidelines for medical event reporting. It is unknown what guidelines the remaining 55% are using while reporting RMEs. These observations highlight the possibility that MTFs are implementing their own policies or lack an understanding of RME reporting. Training and marketing to MTFs to use the toolkit as well as the RME guidelines in their follow-up and disease reporting in the DRSi must be an ongoing process to ensure that new and existing staff are trained and aware of this important resource. In addition, DoD and service policy changes to mandate RME follow-up to improve surveillance and early outbreak detection should be considered.

Recommendations

Army RME practices present several opportunities for improvement. With ongoing support from leadership, implementing the recommendations of this proposal will result in improved RME surveillance, which will then result in improved public health response and thus increased force health protection and readiness. Adherence to case definitions results in data consistency, which then allows for meaningful comparisons and analyses for future studies. Questions such as, "Are these cases related?" cannot be reliably or consistently answered in the current system without significant additional investigation by the

FIGURE 2. Case definition for campylobacteriosis per the 2017 Armed Forces RME Guidelines and Case Definitions



RME, reportable medical event; EIA, enzyme-linked immunosorbent assay; PCR, polymerase chain reaction.

service public health centers with support from the MTFs.

The communicable disease toolkit contains resources that both simplify and standardize the reporting process across the DoD. The simplification of the reporting process will reduce the time burden on our public health professionals and encourage quality improvement on overall public health tasks. Outbreak identification would similarly be improved, which could enable a faster public health response. Similar toolkits have been made available by state and local public health departments, but a standardized resource for the DoD MTFs has been lacking for many years.

There are several opportunities to enhance disease reporting in the DoD, and ideally the recommendations discussed in this article can translate to other disciplines within the DoD public health realm. The end result may be a more efficient surveillance system for assessing the health status of the population it serves. Use of this system will result in clearer understanding, communication, and education on the importance of RME surveillance. Addressing the surveillance gaps discussed in this paper is an important first step to establish the foundation for public health intervention and impact. Additional interventions to improve surveillance include periodic surveillance evaluation studies, informatics solutions, new policies, better integration with CDC and civilian surveillance systems, and increased accountability measures.

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Evaluation of Serological Testing for Lyme Disease in Military Health System Beneficiaries in Germany, 2013–2017

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Lyme disease diagnostic workups conducted on active and retired U.S. service members and their dependents at U.S. Air Force military treatment facilities (MTFs) in Germany between 2013 and 2017 were assessed to determine the appropriateness of laboratory testing and antibiotic prescriptions. Of the 1,176 first-tier immunoassays, 1,114 (94.7%) were negative, and of the 285 immunoglobulin M (IgM) immunoblots, 242 (84.9%) followed a negative first-tier assay or were performed without an antecedent first-tier assay. Eighty-three positive IgM immunoblot tests were adjudicated using modified published criteria, of which 40 (48.2%) were deemed false positives. Thirty-two patients with false-positive tests were treated with an antibiotic. Additionally, 30 patients with uncomplicated erythema migrans could have been treated without laboratory confirmation. Understanding the use and limitations of 2-tier diagnostic criteria, as well as the common pitfalls in diagnosing Lyme disease, may help prevent overdiagnosis, reduce unnecessary testing, and promote antibiotic stewardship.

WHAT ARE THE NEW FINDINGS?

Of the 83 positive Lyme disease IgM immunoblots conducted at U.S. Air Force MTF laboratories in Germany between 2013 and 2017, 40 (48.2%) were deemed false positives after standardized chart review, and 32 of these patients were prescribed antibiotics. Thirty patients with true-positive IgM immunoblots could have been diagnosed and treated without laboratory testing.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Lyme disease is the most commonly diagnosed vector-borne illness in the U.S. military. Early diagnosis and treatment are essential to prevent complications from disseminated disease. Overreliance on serologic testing, given its low positive predictive value in certain contexts, can lead to misdiagnosis, wasted expenditure, and antibiotic misuse.

Lyme disease, known commonly outside the U.S. as Lyme borreliosis, is caused by infection with tick-borne spirochetes of the *Borrelia burgdorferi* sensu lato complex.[1] Clinicians trained in the U.S. who practice internationally or who commonly treat international travelers should understand the universal commonalities and region-specific differences in the microbiology, presentation, and diagnosis of Lyme disease.

In North America, the vast majority of Lyme disease is caused by *B. burgdorferi* sensu stricto,[1] although other presumably pathogenic genospecies have been isolated.[2–5] Pathogen diversity is greater in Europe, where *B. burgdorferi* sensu stricto, *B. afzelii*, *B. garinii, B. bavariensis*, and *B. spielmanii* are established contributors to the burden of human disease. Regardless of the infecting genospecies, Lyme disease can be classified into 3 stages: 1) early localized disease, which occurs days to weeks after the vector tick bite and is often characterized by erythema migrans (i.e., an expanding erythematous skin lesion that may develop central clearing); 2) early disseminated disease, which can follow weeks to months after untreated infection and may present as multiple erythema migrans, Lyme carditis, or neuroborreliosis; and 3) late disease, which may follow months or years after untreated infection and may include arthritis and other dermatologic and neurologic manifestations.[1] Although erythema migrans is a frequent manifestation of Lyme disease worldwide, less common clinical syndromes are geographically heterogeneous. Lyme neuroborreliosis, acrodermatitis chronica atrophicans, and borrelial lymphocytoma, for example, are mostly restricted to Europe.[1,6]

This pattern of universal commonality and regional disparity also applies to the diagnostic workup. Irrespective of location, laboratory testing should be reserved for patients with an intermediate pre-test probability of disease.[6–8] Testing parameters, however, should follow local guidelines. While 2-tier serologic testing for Lyme disease is the standard of care in the U.S.,[7] Germany,[9] and some other parts of Europe,[6,8,10] immunoblot band interpretation differs between North America[11] and Europe because of variable surface protein expression among the genospecies.[12,13] Two-tier testing is usually conducted in a "reflex" manner such that positive or equivocal results on a first-tier immunoassay are followed by the automatic performance of a Western immunoblot to test for immunoglobulin M (IgM) and immunoglobulin G (IgG) antibodies.[7]

As in the U.S., Lyme disease has attracted much attention in Europe, where guidelines warn of public misconceptions[6] and unwarranted testing.[8] The extent of overdiagnosis in the U.S. has been documented in endemic areas[14–16] and in a

military population spanning endemic and non-endemic areas,[17] but similar estimates are not available internationally. This study sought to assess the appropriateness of diagnostic workups and treatments of current and retired U.S. service members and their dependents accessing healthcare services in Germany. The location was chosen because of its high reported incidence of Lyme disease and its sizable population of U.S. military personnel and beneficiaries.[1,18,19]

METHODS

All Lyme disease serologic tests ordered on U.S. service members, military retirees, and their dependent relatives at U.S. Air Force military treatment facilities (MTFs) between 1 January 2013 and 31 December 2017 were retrieved by querying the Composite Health Care System for the key words "Lyme disease" or "*B. burgdorferi*." Molecular and C6 peptide tests, as well as tests of non-serum samples (e.g., of cerebral spinal fluid), were excluded. The Defense Medical Information System identifier was used to restrict to tests ordered in Germany. Serologic tests were stratified as either first-tier immunoassays (enzyme immunoassays and indirect immunofluorescence assays, which are indistinguishable in the database) or second-tier Western immunoblots. Immunoblots were further classified as IgM or IgG.

For all patients with a positive IgM immunoblot, data were abstracted from the Armed Forces Health Longitudinal Technology Application and the Health Artifact and Image Management Solution by the principal investigator (BJW). All notes within 1 year of the index Lyme disease IgM immunoblot were reviewed to obtain the following information: patient sex and age at presentation; chief complaint or complaints for healthcare seeking; symptom onset date; laboratory sample collection date; documented travel within 30 days of clinical presentation; reported tick bite; antibiotic prescription(s) for an indication of Lyme disease; and the presence or absence of erythema migrans, acute febrile illness, cranial nerve palsy, carditis, and meningitis. Criteria and diagnostic codes associated with these 5 conditions have been published elsewhere.[17] Patients were assumed to have no travel history if none was documented in the chart. Given the potential for prolonged IgM seropositivity,[1] the analysis was restricted to a patient's first positive IgM immunoblot during the study period. Cases with insufficient documentation (i.e., had no clinical notes associated with Lyme disease) or patients with no evidence of residing in or traveling to Germany within 30 days of the test were excluded (this may occur if a specimen is shipped to an MTF laboratory in Germany for testing).

Methodology published by Seriburi and colleagues[14] was modified to adjudicate positive IgM immunoblots as true or false positives. Positive immunoblot tests were considered true positives unless 1 or more of the following criteria applied: 1) a first-tier test had been omitted or was negative or the time since symptom onset exceeded 30 days with a negative IgG immunoblot; 2) the patient was tested between December and March, when incident infection in Germany is exceedingly rare;[19] and/or 3) the patient was asymptomatic or reported only non-specific symptoms. The immunoblot band criterion of Seriburi was not applied because of different banding patterns for pathogenic *B. burgdorferi* sensu lato genospecies in Germany.

The Armed Forces Disease Reporting System internet (DRSi) was queried to determine if the IgM positive cases were reported between 1 January 2013 and 30 September 2018 (to account for delayed reporting up to 9 months). All Lyme disease cases diagnosed at MTFs must be reported electronically to this system.[20] Based on U.S. Council of State and Territorial Epidemiologists definitions, cases are classified by local public health authorities as suspected, probable, or confirmed.[21]

Descriptive statistics and 2-sided Fisher exact tests with 95% confidence intervals (CIs) were used to describe the history and clinical presentation of patients and to compare false-positive proportions by sex and by age (children [aged <18 years] versus adults [aged ≥18 years]). Data were analyzed using SAS/STAT® software, version 9.4 (2014, SAS Institute, Cary, NC). The study was approved by the Air Force Research Laboratory Institutional Review Board.

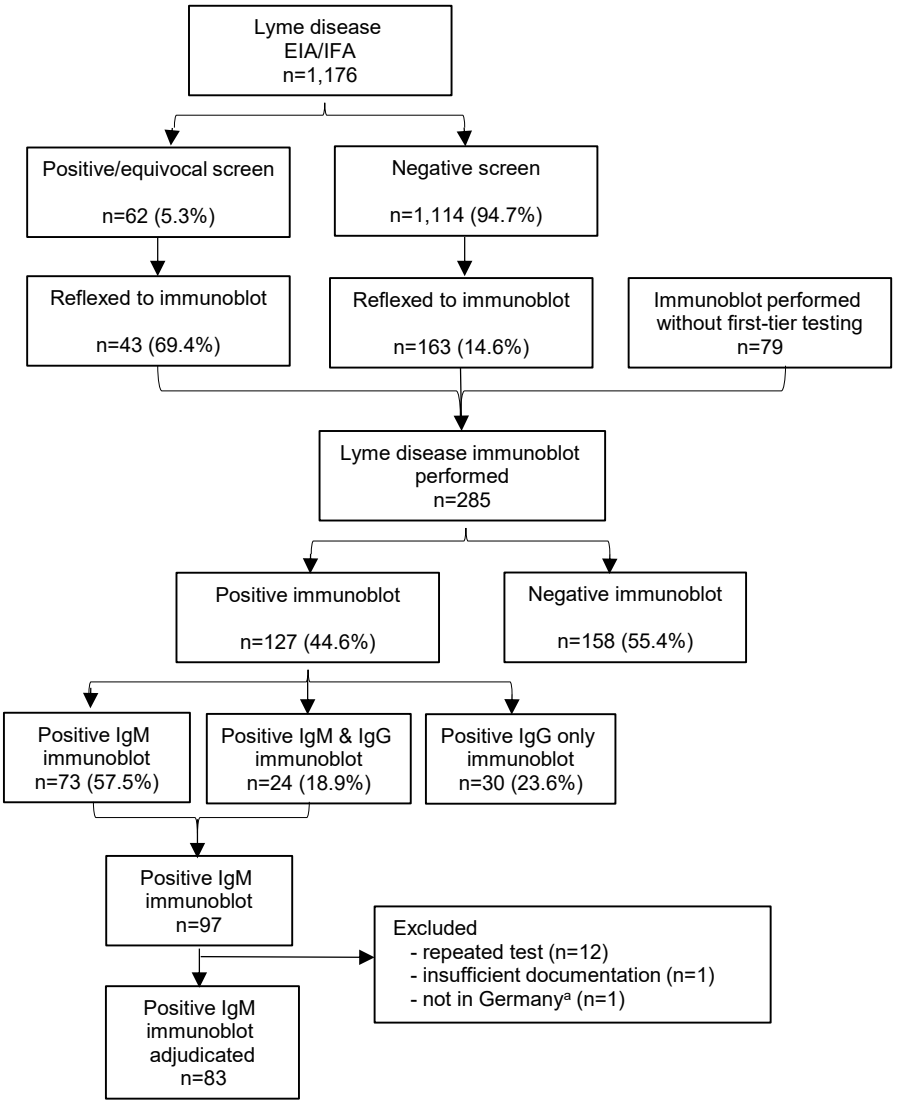
RESULTS

A total of 1,461 serum tests (1,176 immunoassays and 285 immunoblots) were performed on 1,026 unique patients. The mean age of tested patients was 33 years (range: 2 months to 87 years), and 53.8% were female. Of the 1,176 first-tier serologic tests, 62 (5.3%) were positive or equivocal. Of these 62 positive or equivocal first-tier assays, 43 (69.4%) were reflexed to immunoblotting. Seventy-nine additional immunoblots were performed without first-tier testing, and 163 were performed after a negative screen. Of the 285 immunoblots performed, 127 (44.6%) were positive: IgM only (n=73); IgG only (n=30); IgM and IgG (n=24). Fourteen of the 97 positive IgM tests were excluded, leaving 83 cases available for adjudication **(Figure 1)**.

Of the 83 positive IgM immunoblots, 43 (51.8%; 95% CI: 40.6–62.9) were deemed true positives and 40 (48.2%; 95% CI: 37.1–59.4) were deemed false positives. The most common false-positive criterion was asymptomatic or non-specific presentation (n=36), followed by failure to meet seropositivity criteria (n=27). Eleven patients were tested in December through March, but all met at least 1 other false-positive criterion **(Figure 2)**. Among the 83 persons with positive IgM immunoblots, false-positive proportions differed by age (adults [36/63] and children [4/20]; p=.007) and by sex (females [26/40] and males [14/43]; p=.006).

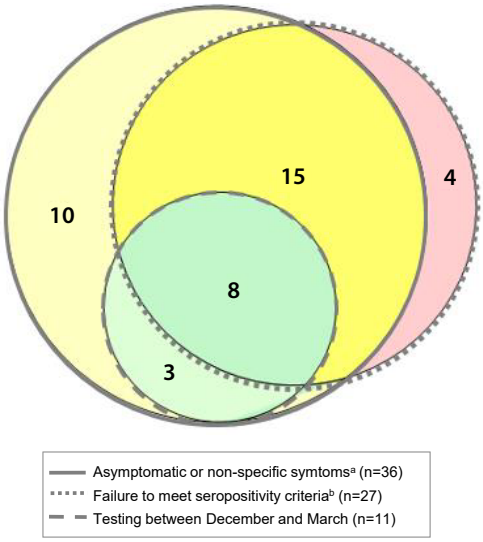
Clinical presentation of the 43 patients with true-positive tests included erythema migrans (n=30), acute febrile illness (n=9), facial palsy (n=2), and carditis (n=2) **(data not shown)**. A tick bite was reported by 19 (44.2%) patients with a true-positive test and 5 (12.5%) patients with a false-positive test. Among the 40 persons who were deemed to have false-positive tests, 1 patient was asymptomatic at presentation, and 35 presented with a variety of chief complaints: arthralgia (n=14), non-erythema migrans skin rash (n=10), headache (n=5), fatigue (n=3), neuropathy (n=3), movement disorder (n=2), myalgia (n=2), abscess (n=1), and cough (n=1); some patients had more than 1 chief complaint **(data not shown)**.

FIGURE 1. Lyme disease serologic tests ordered at U.S. Air Force MTFs in Germany, 1 January 2013–31 December 2017



[a]Test was conducted at an MTF in Germany but patient had no obvious travel to Germany.
MTFs, military treatment facilities; EIA, enzyme immunoassay; IFA, indirect immunofluorescence assay; IgM, immunoglobulin M; IgG, immunoglobulin G.

FIGURE 2. Adjudication findings of false-positive Lyme disease IgM immunoblots (n=40)



[a]Patient was asymptomatic at the time of testing (n=1) or had symptoms non-specific for early Lyme disease (i.e., no documented or described erythema migrans lesion, acute febrile illness, cranial nerve palsy, carditis, or meningitis) (n=35).

[b]First-tier test was omitted (n=5) or negative (n=2) or symptoms were in excess of 30 days with a negative IgG immunoblot (n=22); 2 patients met multiple criteria.

IgM, immunoglobulin M; IgG, immunoglobulin G.

Antibiotics were prescribed for Lyme disease for 41 (95.3%) patients with a true-positive test. This included oral doxycycline (n=27), oral amoxicillin (n=11), intravenous ceftriaxone (n=2), and oral erythromycin (n=1). Thirty-two (80.0%) patients with a false-positive test were prescribed antibiotics: oral doxycycline (n=27), oral amoxicillin (n=4), and oral cefuroxime (n=1) **(data not shown).**

Thirty-six of the 83 positive IgM immunoblot cases were reported as Lyme disease to the DRSi, including 21/43 (48.8%) patients with true-positive tests and 15/40 (37.5%) with false-positive tests. Eighteen patients with true-positive tests were classified as confirmed compared to 13 patients with false-positive tests **(data not shown).**

EDITORIAL COMMENT

Nearly 95% of the 1,176 Lyme disease immunoassays ordered at U.S. Air Force MTFs in Germany were negative. Of the 83 positive IgM immunoblot tests reviewed, 43 were adjudicated as true positives and 40 as false positives. Thirty-two (80.0%) patients with false-positive tests were treated with antibiotics.

These data provide valuable information for military clinicians stationed in Germany. First, this study suggests Lyme disease serologic testing is overutilized at MTFs. Only 5.3% of the first-tier immunoassays performed during the surveillance period were positive or equivocal, well below the 11.9% positivity observed at U.S. commercial laboratories (n=287,595 tests).[22] Therefore, imperfect sensitivity of Lyme disease serology does not fully explain the large number of negative results in this study. A more likely cause is the use of serology in the workup of vague or non-specific symptoms (e.g., arthralgia, headache, or fatigue).[1] While these symptoms may occur during early Lyme disease, they are highly prevalent across the population.[7] In the absence of objective findings, Lyme disease serologic testing in these cases is discouraged.[7,8,23] Subjective arthralgia of early Lyme disease is clinically distinguishable from Lyme arthritis, a potential manifestation of late disease. The latter affects large joints, presents with objective synovitis,

and is almost always pauciarticular (and usually monoarticular). For patients who present with potential Lyme arthritis, the diagnostic workup may include serologic testing and PCR testing of synovial fluid.[6,7]

Second, and relatedly, this study indicates overreliance on laboratory testing to diagnose Lyme disease. In endemic areas, such as much of Germany,[19] patients who present with the typical erythema migrans lesion should be diagnosed and treated without awaiting the results of laboratory testing. This recommendation is based on the recognition that the vast majority of patients with erythema migrans will eventually test positive for IgM antibody but that such serologic tests are usually negative in the early stages of infection.[7,8] In this study, the 30 patients with erythema migrans represented 36.1% of the 83 patients with positive IgM immunoblots and 69.8% of the 43 patients determined to have true-positive IgM immunoblots. In the U.S.[7] and Europe,[9] serologic testing is recommended when the dermatologic presentation is unclear or if other manifestations, such as borrelial lymphocytoma, are suspected. Testing in Germany should follow a 2-tier serologic approach[10] guided by specific European immunoblot band interpretation,[13] with supplemental molecular testing for certain manifestations, as suggested by European guidelines.[8,10,24]

Third, this study highlights the issue of antibiotic misuse. Clinicians are encouraged to prescribe antibiotics judiciously. Of the 40 patients with false-positive tests, 32 were provided antibiotics for the indication of Lyme disease. Like superfluous laboratory testing, unnecessary antibiotic utilization is a wasteful expenditure. Moreover, it may lead to complications and encourage antimicrobial resistance.[1]

Fourth, this study uncovers potential mismanagement of immunoassays. According to universal recommendations regarding 2-tier testing for Lyme disease,[6–10] positive or equivocal immunoassays should be reflexively referred for immunoblotting. This occurred for only 43/62 (69.4%) eligible immunoassays. Meanwhile, 163/1,114 (14.6%) negative immunoassays were reflexed to immunoblots, and 79 immunoblots were performed without a first-tier immunoassay. Therefore, of the 285 immunoblots performed, 242 (84.9%) were not in accordance with recommendations. Laboratories conducting Lyme disease testing may consider modifying their processes.

This study has several limitations. First, it relies on serology for ascertainment of potential cases. Serologic diagnosis of Lyme disease is problematic because of imperfect sensitivity and specificity, methodological discrepancies between laboratories, and subjective interpretation of immunoblot banding patterns.[25] Second, incomplete or inaccurate data in the medical charts may have resulted in differential misclassification of cases. For example, provider failure to detect, describe, or diagnose the presence of an erythema migrans lesion would result in a false-positive misclassification. Conversely, underestimation of symptom duration in a patient with a negative IgG would result in a true-positive misclassification. Third, no data were collected on patients who had negative tests. Although the low percentage of positive immunoassays suggests a suboptimal pretest prevalence of disease in the tested population,[1,12] the appropriateness of ordering these tests could not be assessed. Fourth, patients included in this study were predominantly evaluated at U.S. air bases in southwest Germany. Given the intranational heterogeneity of Lyme disease,[19] the findings may not be generalizable to all U.S. service members, military retirees, and their dependents stationed or residing in Germany.

Lyme disease is the most commonly reported tick-borne disease in Germany[19] and the most commonly reported vector-borne disease in the U.S. Armed Forces.[26] Two air bases in Germany account for 16.4% of all vector-borne diseases reported in the U.S. Air Force.[18] The present study highlights clinical challenges associated with Lyme disease and demonstrates their applicability outside the U.S.[23] Military clinicians practicing anywhere in Germany should understand these challenges and recognize that patients may access online information that is often inaccurate.[27] High-quality, evidence-based care may include diagnosing and treating Lyme disease without laboratory testing, explaining why laboratory testing is unwarranted for non-specific symptoms, and practicing good antibiotic stewardship.

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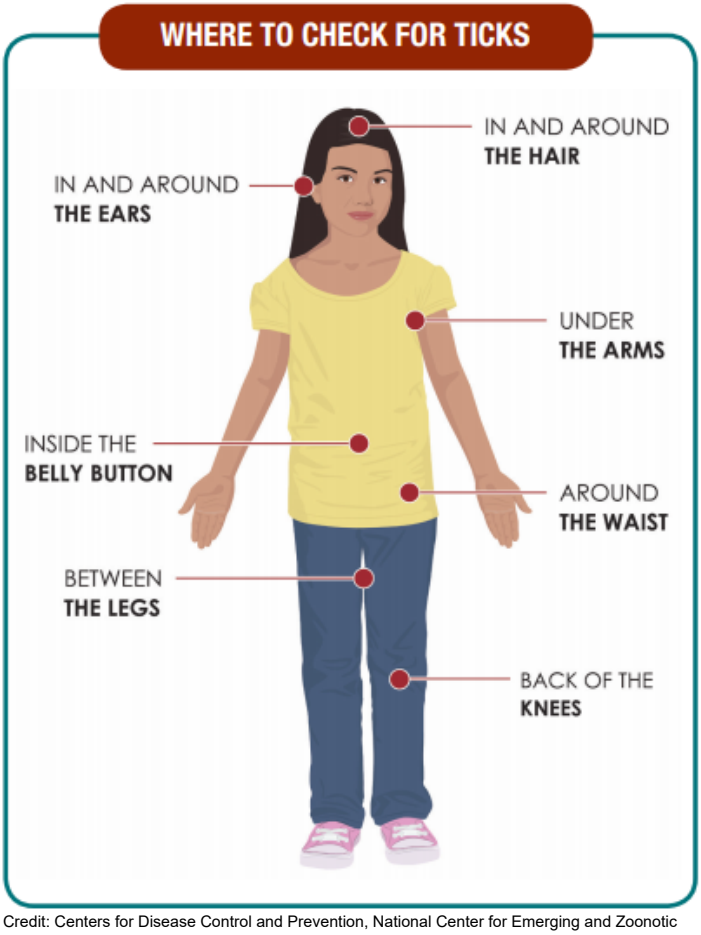

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Historical Review: Rickettsial Diseases and Their Impact on U.S. Military Forces

Leslie Clark, PhD, MS; Valerie F. Williams, MA, MS

Rickettsial diseases are vector-borne bacterial infections that cause acute febrile illness throughout the world. They are spread via arthropod vectors including ticks, fleas, mites, and lice. They are caused by bacterial species of the genus *Rickettsia* and the closely related, but genetically distinct, genus *Orientia*. The *Rickettsia* and *Orientia* genera both encompass a large group of obligate intracellular, gram-negative bacteria. Species classified within the genus *Rickettsia* are generally divided into 4 groups (i.e., clades). The ancestral group includes the tick-borne agents *Rickettsia bellii* and *R. canadensis* but does not contain pathogens that cause human disease. The spotted fever group (SFG) comprises more than 30 species and includes the etiologic agents for Rocky Mountain spotted fever (RMSF), African tick-bite fever (ATBF), and Mediterranean spotted fever (MSF). The typhus group includes the pathogens that cause epidemic and murine typhus, while the transitional group includes agents that cause rickettsialpox and Queensland tick typhus.[1,2] Scrub typhus is caused by 2 known *Orientia* species: *Orientia tsutsugamushi* (formerly *R. tsutsugamushi*) and the relatively newly discovered *O. chuto* **(Table)**.[3] Rickettsial-related diseases are caused by the bacterial species of the genera *Ehrlichia*, *Anaplasma*, *Neoehrlichia*, and *Neorickettsia*; however, for the purposes of this review, infections caused by these species are not discussed further in this article **(Table)**.

Despite the widespread distribution of rickettsial diseases worldwide, they are frequently overlooked as a cause of illness and/or misdiagnosed. This is partly due to the non-specific nature of the early symptoms of rickettsial diseases, which frequently present as undifferentiated febrile illness that is often indistinguishable from other infectious diseases, especially those common in tropical and subtropical regions (e.g., malaria, dengue fever, leptospirosis).[4] This has contributed to the underdiagnosis of these diseases and the likely significant underestimation of their incidence.[1,2]

Rickettsial diseases have had a significant impact on public health and have been a significant cause of morbidity and mortality in both civilian and military populations.[5] In addition, rickettsial pathogens continue to emerge and reemerge as causes of illness throughout the world.[6] Reported incidences of several rickettsial diseases, notably scrub typhus in the Asia/Pacific region and SFG rickettsioses in the U.S., have increased substantially.[7] Understanding of the epidemiology of rickettsial diseases continues to evolve as new information accumulates about the expanding geographic distribution of the causative pathogens,[8] the emergence of antibiotic-resistant strains,[9] and the discovery of new species in the genera *Rickettsia* and *Orientia*. To provide a summary of this and other practical information on rickettsial diseases, a brief review of epidemiologic and clinical characteristics of specific rickettsial and related diseases is provided, with an emphasis on their historical and potential future impact on U.S. military forces.

Scrub typhus

Scrub typhus is a potentially fatal acute febrile disease transmitted by larval mites (i.e., "chiggers"), primarily of species of the genus *Leptotrombidium* that are infected by the obligate intracellular bacteria *O. tsutsugamushi*. The mite serves as both the vector and the reservoir for the disease.[1,10]

Once considered endemic only to central, eastern, and Southeast Asia as well as northern Australia and islands in the Pacific and Indian oceans (i.e., the tsutsugamushi triangle), case reports of scrub typhus from South America,[11,12] Africa, the Middle East, and Europe[8] have provided substantial evidence that the geographic range of scrub typhus is more extensive than previously thought. In 2010, a new species (*O. chuto)* was described in an Australian tourist who contracted scrub typhus in Dubai.[3] Scrub typhus does not occur in the U.S. except when diagnosed in travelers who have returned from endemic areas.[1]

Globally, scrub typhus is a leading cause of febrile disease.[6] It has been estimated that over a million scrub typhus cases occur each year and that a billion people are at risk of infection.[10] Several indicators point to an overall global increase in the incidence of scrub typhus. The 5 countries with established scrub typhus surveillance systems (China, Japan, South Korea, Taiwan, and Thailand) all have reported increasing incidence of this disease over the past 10–15 years.[7] Additionally, between 2007–2017, at least 22 scrub typhus outbreaks have been documented in endemic areas, with India accounting for almost two-thirds (14/22) of reported outbreaks.[13] However, it is unclear whether the increases in the incidence of diagnosed cases or in documented outbreaks reflect an actual increase in disease incidence or whether they are the result of enhanced awareness of the disease, increased surveillance, and/or improved case ascertainment related to improved diagnostic capabilities.[7,13]

Symptoms of scrub typhus begin 7–10 days after the bite of an infected mite. Classic symptoms include headache, fever, and a generalized maculopapular rash. A necrotic lesion known as an eschar may also develop around the site of the bite. Typically, the eschar begins as a vesicle and progresses to a central brown/black crust after several days. Less common symptoms include myalgia, altered mental status, and lymphadenopathy.[1,13]

A current or past scrub typhus infection can be identified by the presence of specific antibodies (immunoglobulin M [IgM] and G [IgG]) against scrub typhus group orientiae. A single sample with a positive IgM is associated with acute infection, while detection of IgG antibodies does not adequately differentiate between current or past infection. Seroconversion or a

TABLE. Rickettsial disease agents, vectors, and geographic distributions

Disease	Agent	Vector	Geographical distribution
Spotted fever group			
Rocky Mountain spotted fever	*Rickettsia rickettsii*	Tick	North, Central, and South America
North Asian tick-borne rickettsiosis (Siberian tick typhus)	*R. sibirica*	Tick	North Asia
Queensland tick typhus	*R. australis*	Tick	Eastern Australia, Tasmania
Flinders Island spotted fever	*R. honei*	Tick	Australia and Southeast Asia
African tick bite fever	*R. africae*	Tick	Sub-Saharan Africa, Caribbean (French West Indies), and Oceania
Mediterranean spotted fever	*R. conorii*	Tick	Europe (Mediterranean basin), Middle East, Indian subcontinent, Africa
R. parkeri rickettsiosis (Maculatum disease)	*R. parkeri*	Tick	Southern U.S., South America
Japanese spotted fever	*R. japonica*	Tick	Japan and South Korea
Tick-borne lymphadenopathy	*R. slovac, R. raoultii*	Tick	Europe
364D-associated rickettsia (Pacific Coast tick fever)	*R.* species 364D	Tick	U.S.
Far Eastern spotted fever	*R. heilongjiangensis*	Tick	Eastern Asia
Transitional group			
Rickettsialpox	*R. akari*	Mite	U.S., Russia, Korea, Africa
Queensland tick typhus	*R. australis*	Tick	Eastern Australia, Tasmania
Typhus			
Epidemic typhus, Brill-Zinsser disease	*R. prowazekii*	Body lice, ectoparasites of flying squirrels	Worldwide
Murine typhus	*R. typhi, R.felis*	Rat flea, cat flea	Worldwide
Scrub Typhus			
Scrub typhus (tsutsugamushi disease)	*Orientia tsutsugamushi, O. chuto*	Trombiculid mite larvae (chiggers)	Asia-Pacific region, northern Australia, UAE, Africa, Chile

UAE, United Arab Emirates

4-fold rise in IgG titer using paired serum samples (acute and convalescent) are the preferred method for diagnosing scrub typhus. Historically, laboratory diagnosis of scrub typhus has mainly relied on serologic tests, particularly the indirect immunofluorescence assay (IFA). However, the IFA is an imperfect gold standard because of its high cost, the need for paired sera, the need for substantial training to perform the test, and interoperator variability in result interpretation. Increasingly, anti-*Orientia* IgM- and IgG-based rapid diagnostic tests and enzyme-linked immunosorbent assays (ELISAs) are replacing subjective IFAs. Molecular techniques such as real-time polymerase chain reaction (RT-PCR) can also be useful in scrub typhus diagnosis and the confirmation of serological results.[14]

Scrub typhus is generally easily treatable with doxycycline if diagnosed early. A recent Cochrane review demonstrated that tetracycline, azithromycin, and rifampicin are also effective antibiotics for scrub typhus treatment.[15] In untreated patients, the median mortality rate for scrub typhus is 6% (range: 0–70%), while a recent review of treated scrub typhus reported a median mortality of 1.4% (range: 0–33.3%).[7] Doxycycline has also been used as prophylaxis for scrub typhus.[16]

The possibility of antibiotic-resistant scrub typhus has been a significant concern since the 1990s when multiple reports of antibiotic resistance emerged from Thailand.[17] Subsequently, in vivo, in vitro, and clinical data have supported the existence of strains of *O. tsutsugamushi* resistant to conventional antibiotic therapy. Further research, including clinical trials and laboratory-based studies, are warranted to definitively determine the existence, distribution, and extent of antibiotic-resistant typhus.[9,13]

No vaccine for scrub typhus exists. The development of a prophylactic vaccine for scrub typhus has been a public health priority for decades. Significant obstacles, including extensive antigenic diversity and the short duration of immune protection following naturally acquired scrub typhus infection, have stymied successful vaccine development.[18,19] Current scrub typhus prevention methods are primarily focused on vector control and reducing exposure to chiggers. The latter method includes wearing long pants tucked into boots or socks, long sleeved shirts, and boots or other closed-toed shoes. The use

of both skin repellent and repellent-treated clothing is recommended. Effective skin repellent should contain 20–50% DEET (N,N-diethyl-meta-toluamide), while permethrin is an effective clothing impregnant.

Military impact

Scrub typhus was a significant cause of acute febrile illness among Allied troops in the Pacific during World War II, causing approximately 18,000 cases; over 6,000 cases and 243 deaths were reported by U.S. Armed Forces.[13] During the Vietnam War, scrub typhus was estimated to cause 20–30% of cases of fevers of unknown origin in U.S. troops. More recently, Camp Fuji in Japan has been the site of multiple outbreaks among U.S. military members, with the most recent outbreaks reported in U.S. Marines in 2000 and 2001.[5] Sporadic cases of scrub typhus have also occurred in Australian military members during training in Northern Queensland, Australia, especially at a training site called Cowley Beach.[13] In 1996, the number of scrub typhus cases at Cowley Beach prompted the Australian military to recommend doxycycline prophylaxis for military members training at that location.[13] A large 2011 outbreak (45 cases among 124 exposed; attack rate of 36%) in Australian infantry and support staff training at Cowley Beach raised concerns that a doxycycline resistant strain of *O. tsutsugamushi* was responsible for the outbreak. However, further laboratory analysis demonstrated that the outbreak strain was susceptible to doxycycline, indicating that failure to adhere to the doxycycline prophylaxis protocol was a more likely explanation for the outbreak.[16] This episode clearly demonstrates that adherence to protective measures, including prophylaxis protocols, must be a priority.

Given the endemicity of scrub typhus in countries where significant numbers of U.S. military personnel are deployed or train (e.g., South Korea, Japan, Thailand), the emergence of antibiotic resistance in these areas, and the historical impact of scrub typhus on military operations, continued focus on allocating resources to maintain robust research efforts towards vaccine development, improved laboratory diagnostics, and enhanced surveillance are warranted.[20]

Murine (endemic) typhus

Murine typhus, also known as flea-borne typhus, is a rickettsial zoonosis caused by *R. typhi*. It is transmitted mainly by the rat flea (*Xenopsylla cheopis*), and human infection can occur through flea bites, infected flea feces scratched into broken skin (i.e., a flea bite wound), or via other mucous membranes or inhalation. The primary reservoirs of *R. typhi* are the roof rat (*Rattus rattus*) and Norway rat (*Rattus norvegicus*).[1] However, in the U.S., opossums and cats are important reservoirs of infection, and the cat flea has been identified as the principal vector.[21]

Murine typhus occurs at endemic levels throughout the world, especially in tropical and subtropical seaboard regions. Although murine typhus is no longer a nationally notifiable disease in the U.S., it is reportable in 14 states. It is most frequently reported in California, Hawaii, and Texas, with the majority of reported cases occurring in Texas.[22]

R. typhi infection usually produces a mild or self-limiting illness. Symptoms are generally non-specific and include fever, headache, and myalgia. Rash occurs with varying frequency. Murine typhus is commonly misdiagnosed when rash is absent or if atypical symptoms, such as gastrointestinal manifestations, are prominent.[23] Severe complications are rare, but, where present, can cause meningoencephalitis, pneumonia, shock, renal failure, myocarditis, endocarditis, and splenic rupture. The primary treatment for murine typhus is doxycycline. Murine typhus has an overall case fatality rate of between 1–4%.[24]

Military impact

During World War II, 787 cases of murine typhus were reported in U.S. military members; of these, 497 cases occurred within the continental U.S., mostly in the southeast.[5] The reported mortality rate was 1.9%.[20] Although relatively few cases were reported during the Vietnam War, serologic studies indicated that approximately 10–15% of fevers of unknown origin could be attributed to murine typhus, making it second only to malaria as a cause of febrile disease during this conflict.[20] Over the past 2 decades, murine typhus has been infrequently diagnosed in U.S. service members; on average, less than 2 confirmed cases a year are reported.[25]

Deployment to endemic regions on peacekeeping or humanitarian missions could pose a substantial risk of exposure to military personnel since overcrowding and poor public health and sanitation measures (such as those that occur during natural disasters and in refugee centers) provide ideal conditions for transmission of murine typhus.

Epidemic typhus

Epidemic typhus (also known as louse-borne typhus or camp fever) is an acute febrile illness caused by *R. prowazekii*. *R. prowazekii* is transmitted by the human body louse (*Pediculus humanus*). Transmission dynamics are similar to murine typhus in that human infection occurs when infected louse feces are inhaled or enter the body through broken skin (typically through scratching the louse bite).[1,2]

A second strain of *R. prowazekii* has been identified in southern flying squirrels (*Glaucomys volans*), which has caused sporadic human cases in rural and suburban areas of the eastern U.S.[26,27] Disease resulting from this method of transmission is called sylvatic epidemic typhus or sylvatic typhus.[28] The cycle of infection involves secondary transmission to humans from flying squirrels and their ectoparasites, but the mechanism by which *R. prowazekii* is transmitted to humans remains unclear. Although infection is generally sporadic, clusters have been reported in cases of repeated and prolonged close exposure to flying squirrels and their nests.[28]

The incubation period of epidemic typhus is typically between 7 and 14 days. Onset of symptoms is sudden and includes high fever, headache, tachypnea (abnormally rapid breathing), and myalgia. Rash is also a frequent symptom and generally starts as small pink macules that spread over the trunk and become dark and maculopapular. The case-fatality ratio can reach 60% among untreated patients, decreasing to below 5% with appropriate antibiotic treatment and supportive care.[29] *R. prowazekii* infection can be reactivated in humans

years or decades after primary infection because of a waning immune system. This mild recrudescence of epidemic typhus is called Brill-Zinsser disease.[29] Cases of Brill-Zinsser disease have been reported in Europe, the U.S., and Canada. Doxycycline is the recommended treatment for both primary cases of epidemic typhus and Brill-Zinsser disease.[1,29]

Military impact

R. prowazekii caused major outbreaks of disease in many conflicts up to and including World War I. As an example of the magnitude of morbidity and mortality caused by this agent, in the period between 1917–1925 in eastern Europe and Russia, up to 25 million cases and 3 million deaths were suspected to be due to epidemic typhus.[30]

During and immediately after World War II, hundreds of thousands of cases occurred in civilian populations in Korea, Japan, Germany, Egypt, and French North Africa.[5] However, because the U.S. military implemented the Joint U.S. Typhus Commission recommendations, which included the use of dichloro-diphenyl-trichloroethane (DDT) for louse control, prophylactic immunization by the Cox-type vaccine, and other preventive measures, it experienced only 104 cases and no deaths.[5] These measures, along with newer insecticides, also proved effective during the Korean conflict, virtually eliminating cases of epidemic typhus in U.S. troops (1 case was reported).[5] However, during the Korean conflict, epidemic typhus caused significant morbidity and mortality among South Korean soldiers and civilians, with approximately 32,000 cases and 6,000 deaths.[5] No cases of epidemic typhus were reported in U.S. military members during the Vietnam conflict.[5]

Since the 1990s, epidemic typhus has reemerged. Most epidemic typhus cases are reported from Africa and Central and South America, particularly during the winter and spring, when hygiene may be compromised. In 1997, a significant outbreak occurred in Burundi during the civil war. The cases were associated with refugee camps.[31] As with murine typhus, this illustrates that U.S. military members supporting peacekeeping and humanitarian missions have the potential for exposure to *R. prowazekii.*[5,29]

SFG rickettsioses

SFG rickettsiae are all transmitted by ticks **(Table)**. These organisms infect tick species throughout the world. The SFG rickettsiae vary in pathogenicity and cause disease with a spectrum of severity ranging from those with significant morbidity and mortality (e.g., *R. rickettsii*) to those with more benign manifestations (e.g., *R. parkeri*, *R.* species 364D*).*[1,2,32] The more common and pathogenic SFG rickettsioses are briefly discussed below.

RMSF is caused by *R. rickettsii*. Despite its name, RMSF is endemic in parts of North, Central, and South America. In the U.S., RMSF is transmitted by the American dog tick (*Dermacentor variabilis*) in the southeast and south central states and the Rocky Mountain wood tick (*Dermacentor andersoni)* in the western mountainous states. In Central and South America, transmission occurs via multiple species within the genus *Amblyomma,* including the cayenne tick (*Amblyomma cajennense*).[1,32]

The incubation period for RMSF averages 7 days but ranges from 3 to 12 days.[32] A shorter incubation period presages a more severe infection. Onset is abrupt, with severe headache, fever, chills, malaise, and myalgia. Between the second and fourth day of fever, most patients develop a rash on the wrists, ankles, palms, soles, and forearms that rapidly extends to the neck, face, buttocks, and trunk. Initially macular and pink, the rash becomes maculopapular and darker, and the lesions subsequently become petechial and can coalesce to form large hemorrhagic areas that later ulcerate.[32]

RMSF is the most severe and most frequently fatal rickettsial disease in the U.S. Fatality rates range from 5–10%, depending upon the timing of initiation of treatment; fatality rates increase to 40–50% if treatment is delayed until after day 8. As with all tick-borne rickettsial disease, the Centers for Disease Control and Prevention (CDC) recommends doxycycline as the drug of choice for treatment, which should be initiated immediately in persons with signs or symptoms suggestive of RMSF.[32]

The rickettsial pathogens most likely to be encountered during travel outside the U.S. include *R. africae* (ATBF) and *R. conorii* (MSF).[1,32] ATBF is a zoonotic disease transmitted by ticks of the genus *Amblyomma* in sub-Saharan Africa. Usual symptoms include fever, 1 or more inoculation eschars, and regional lymphadenopathy. Rash is frequently absent and complications are uncommon. MSF, also called boutonneuse fever, is transmitted by the infected brown dog tick (*Rhipicephalus sanguineus*). MSF is endemic in the Mediterranean, the Indian subcontinent, regions around the Black Sea, and the sub-Saharan African countries. Symptoms include headache, fever, and a maculopapular rash. An eschar is also commonly seen at the site of the tick bite. Doxycycline is the first-line treatment of choice.

In the U.S., the annual incidence of SFG rickettsioses has increased substantially. Between 2000 and 2016, the annual incidence of SFG increased more than 7-fold from 1.7 cases per 1 million persons to 13.2 cases per 1 million persons.[32] These data are subject to two main limitations. Before 2010, only RMSF was a notifiable disease. However, because serologic assays developed for the diagnosis of RMSF may react non-specifically with antigens of less pathogenic species, the category was changed to the more general SFG rickettsioses. This change in classification may have contributed to the increase in SFG incidence.[32]

In addition, concerns regarding the magnitude of this increase have prompted an examination of the underlying data reported to CDC, which highlighted some potential issues that could affect the accuracy of SFG incidence estimates in the U.S. In brief, in the U.S., all SFG rickettsioses, including RMSF are nationally notifiable diseases. The CDC is notified of SFG cases through 2 passive surveillance systems: the National Notifiable Diseases Surveillance System (NNDSS) and Tick-borne Rickettsial Disease case report forms. SFG rickettsioses are identified using the Council of State and Territorial Epidemiologist case criteria, which include serologic methods (some of which are of limited interpretability [e.g., IFA]) as supportive evidence and non-specific laboratory criteria to support

diagnosis.[33] To illustrate the implications of this practice, CDC performed a review of cases with illness onset reported during 2010–2015. CDC determined that of 16,807 reported cases, only 167 (1.0%) met the confirmed case definition and the remaining 16,640 (99.0%) met the probable case definition.[33] The most common laboratory criteria used to support probable cases was elevated IgG antibody titer by IFA. The use of IFA is problematic because antibodies to SFG *Rickettsia* persist for months following infection; a single antibody titer may represent prevalent (previous) infection rather than incident (acute) infection.[33] It would be preferable for a greater percentage of cases to meet the more stringent criteria for a confirmed SFG case (e.g., a 4-fold change in anti-SFG IgG antibody titers in paired specimens, PCR, immunohistochemistry, or culture). However, the majority of probable cases were not confirmed because of incomplete serologic testing.[33] This investigation demonstrated that the quality of passive surveillance data depends on provider awareness and use of appropriate diagnostic tests coupled with timely reporting and documentation of epidemiologic factors associated with the reported case.[33] Moreover, this investigation highlighted the need for a complete and thorough understanding of the case definitions and knowledge of the relative proportions of confirmed and probable cases in order to appropriately interpret estimated incidence rates of SFG rickettsioses.[33]

Military impact

Multiple studies have demonstrated that U.S. military personnel are at significant risk of exposure to SFG rickettsioses. This risk can be due to residence in or deployment to endemic regions or from field training in areas where infected ticks live. As the most severe SFG rickettsiosis, RMSF may be the rickettsial disease with the most significant consequences for the U.S. military, given its prevalence in areas where military training takes place. Epidemiologic studies have demonstrated SFG rickettial infections (including *R. rickettsia*) in several military units conducting training exercises in Arkansas and Virginia[34] and among male personnel in combat occupations stationed in South Korea.[35] One of the most significant outbreaks of SFG rickettsiosis occurred in 1992 among members of U.S. Army 82nd Airborne Division conducting a training mission in Botswana. Approximately 50% of the unit were diagnosed with ATBF.[5]

Transitional group rickettsioses

Briefly, pathogenic rickettsial species in the transitional group include *R. akari*, the causative agent of rickettsialpox, and *R. australis,* which causes Queensland tick typhus **(Table)**. Rickettsialpox is transmitted by mites, while Queensland tick typhus is transmitted by *Ixodes holocyclus* ticks in Australia. Rickettsialpox occurs in many areas of the U.S., Russia, Korea, and Africa and is generally seen in urban areas.[1] Common symptoms include fever, vesicular rash, and eschar. Rickettsialpox is a mild, self-limiting condition, and no deaths from this disease have been reported.[1]

Queensland tick typhus also presents with fever and maculopapular rash, and, less commonly, an eschar and associated regional lymphadenopathy can occur.[1] While Queensland tick typhus is also generally a mild disease, both severe and fatal cases have occurred.[1] Because of the mild presentation of both diseases, the impact on military forces would likely be relatively limited compared to more pathogenic rickettsial diseases.

EDITORIAL COMMENT

Deployment of troops to endemic areas and exposure during humanitarian and peacekeeping missions will ensure that rickettsial diseases will remain a threat to military personnel. Unfortunately, rickettsial infections are not routinely diagnosed by most military medical providers, which is why they continue to pose a threat. Providers need to remain vigilant in considering rickettsial diseases during their diagnostic workup of military members who live, work, or train in rickettsial-endemic areas. While prophylaxis and personal protective measures can be effective, the necessary command support is required to ensure that these measures are adhered to, or they will not be effective.

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Surveillance Snapshot: Incidence of Rickettsial Diseases Among Active and Reserve Component Service Members, U.S. Armed Forces, 2010–2018

TABLE 1. ICD-9 and ICD-10 diagnostic codes used for classification of possible and suspected cases of rickettsial[a] and related diseases

Disease name	ICD-9	ICD-10
Anaplasmosis/ehrlichiosis	082.4*	A77.4*
Spotted fever rickettsiosis	082.0–082.3, 082.8–082.9	A77.0–A77.3, A77.8–A77.9
Typhus	080, 081.0, 081.1, 081.2, 081.9	A75.*

[a]"Rickettsial" infections and diseases are caused by members of the order Rickettsiales, which includes the genera *Rickettsia*, *Anaplasma*, *Ehrlichia*, and *Orientia*, among others.

ICD, International Classification of Diseases.

TABLE 2. Numbers of confirmed, possible, and suspected cases of rickettsial and related diseases, U.S. Armed Forces, 2010–2018

	Confirmed cases			Possible cases			Suspected cases		
	AC only	RC only	AC + RC	AC only	RC only	AC + RC	AC only	RC only	AC + RC
Spotted fever rickettsiosis	81	14	95	46	18	64	426	227	653
Anaplasmosis/ehrlichiosis	15	1	16	29	17	46	91	68	159
Typhus	3	2	5	4	1	5	27	9	36
Total	99	17	116	79	36	115	544	304	848

AC, active component service members; RC, reserve component service members.

Rickettsial diseases are vector-borne, bacterial infections that cause acute febrile illness throughout the world. Because symptoms of rickettsial diseases are often non-specific in nature and overlap with other febrile diseases with similar epidemiology, their diagnosis is challenging. The diagnostic difficulties likely contribute to the historical underreporting of cases of these diseases.

In 2018, the *MSMR* published a report on the surveillance of vector-borne disease in active and reserve component service members that included estimates of incident cases of rickettsial and related diseases during the surveillance period from 2010 through 2016.[1] The analysis for this snapshot used similar methodology but restricted the analysis to rickettsial diseases and extended the surveillance period through 2018. A "confirmed" case was defined as an individual identified through a reportable medical event (RME) report of a rickettsial or related disease that was described as "confirmed" by having met specific laboratory and/or epidemiologic criteria.[2] A "possible" case was defined by a record of hospitalization with a diagnosis for a rickettsial disease **(Table 1)** in any diagnostic position. A "suspected" case was defined by either an RME of a rickettsial disease without laboratory or epidemiologic confirmation or a record of an outpatient medical encounter with a diagnosis of a rickettsial disease in the first or second diagnostic position. An individual could be counted once per lifetime for each type of rickettsial disease. Individuals diagnosed as a case before the start of the surveillance period were excluded. Confirmed cases were prioritized over possible and suspected cases, respectively **(Table 2)**.

These data indicate that a continued multidisciplinary focus on preventive measures to counter the threat of these diseases is warranted. Most important are effective vector control and adherence to personal protective measures.

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DoD
HEALTH
OF THE
FORCE
2018

INTRODUCTION

The Health of the DoD Force represents a coordinated effort by the Defense Health Agency, and the Army, Navy, and Air Force public health centers to provide a snapshot of Service member health and well-being. It is meant to be a resource for military leaders and decision makers to help identify changes in the health status of Service members, emerging health problems, and gaps in prevention and treatment efforts. It may also be of interest to program planners, health practitioners, researchers, and others interested in the well-being of Service members.

The current report focuses on four subject areas: injury, behavioral health, sleep disorders, and obesity. Future reports will expand on the number of subject areas covered. The intent is to develop an annual report that provides timely, concise, and useful information to generate ideas and drive progress toward enhancing the vitality and lethality of our fighting force.

ORGANIZATION OF THIS REPORT

This report is based on data from calendar year 2018. It is divided into two sections, Health Metrics and Service Profiles. The Health Metrics section provides health index measures for each of the four subject areas; the Service Profiles section compares measures across Services.

Methodology is critical to understanding and using healthcare metrics, especially because of the growing number of sources of healthcare data. The appendices of this report present detailed information about the methods used to analyze data in each of the four subject areas as well as specific limitations associated with the data analysis.

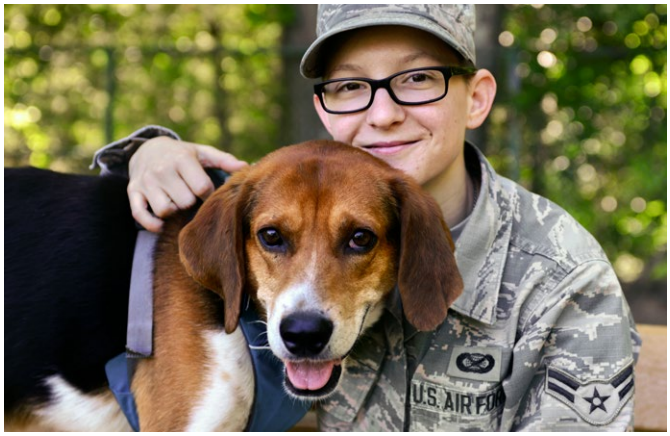
LIMITATIONS

There are many challenges associated with processing and interpreting healthcare data.[1, 2] Variability in the collection, collation, and processing of data, differences in study design and analytic methods, and the inherent intricacies of defining and measuring health itself contribute to complexity that cannot be fully resolved or explained in a summary report. Accordingly, this report is meant to be an adjunct to, rather than a substitute for, other reports related to Service member health, deployability, readiness, and total force fitness. Specific limitations include those associated with using electronic medical records for surveillance data (e.g., missing data, under-representation of conditions that do not come to the attention of the healthcare delivery system, miscoding) and failure to account for potentially important covariates such as age and sex when comparing Service populations.

This report is meant to evolve over time. In addition to adding subject areas, it is anticipated that specific measures will change over time to account for data-related limitations and changing paradigms related to public health surveillance. Input related to improving this report is critical and welcomed.

HIGHLIGHTS

- There were 305 acute and 988 cumulative traumatic injuries per 1,000 Service members in 2018. Sprains and strains were the most common acute injury and the lower extremities were the most commonly affected body region. The rate of acute injuries decreased by 12.9% between 2016 and 2018 and the rate of cumulative traumatic injuries decreased 3.9% between 2016 and 2018.
- In 2018, 8.3% of Service members had a behavioral health disorder. The prevalence of behavioral health disorders remained stable between 2014 and 2018. Adjustment disorder was the most common behavioral health disorder among both male and female Service members.
- In 2018, 11.8% of Service members had a sleep disorder. The prevalence of sleep disorders remained stable between 2014 and 2018. The most common sleep disorder among male Service members was sleep apnea; the most common sleep disorder among female Service members was insomnia.
- The overall prevalence of obesity was 17.4% in 2018. The overall prevalence of obesity has increased steadily since 2014. Obesity rates were higher among males (18.4%) compared to females (12.6%), and in older compared to younger Service members.



Acute and Cumulative Traumatic Injury

Injuries consistently rank among the top healthcare burdens in the DoD. In this report, non-battle injury was evaluated using two broad categories: acute injury (which includes musculoskeletal and other types of injury) and cumulative traumatic injury (musculoskeletal injury resulting from repeated micro-trauma).

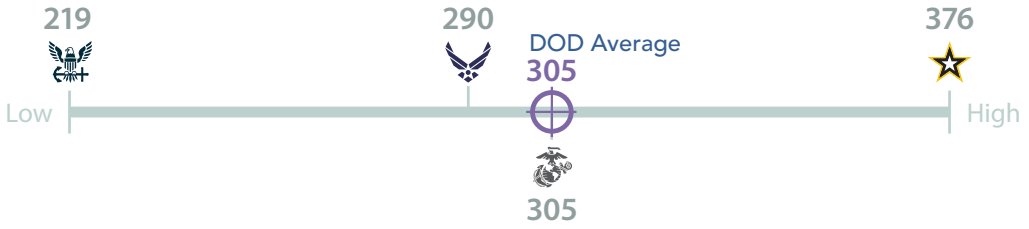
Acute injuries were identified in inpatient and outpatient medical records using the *International Classification of Diseases, Tenth Revision, Clinical Modification* (ICD-10-CM) injury codes ("S" and "T" codes) and further described utilizing the injury diagnosis matrix proposed by the National Center for Health Statistics (NCHS).[3] This matrix consists of rows composed of body regions and columns representing nature-of-injury groups, i.e., the type of anatomic or physiologic disruption that occurred to the body region, such as a fracture, dislocation, open wound, burns, internal organ injury, or poisoning.

Cumulative traumatic musculoskeletal injuries were identified in inpatient and outpatient medical records using ICD-10-CM musculoskeletal condition ("M") codes. Cumulative traumatic injuries were also described by body region and nature-of-injury groups, i.e., inflammation and pain (overuse), joint derangement with and without neurological involvement, stress fracture, sprain/strain/rupture, and dislocation.[4]

In 2018 there were 395,127 acute and 1,280,028 cumulative traumatic injuries among active component (AC) Service members, with rates of 305 per 1,000 persons and 988 per 1,000 persons, respectively. Injury rates were higher in females as compared to males in all Services and in both injury categories. Acute injury rates were highest in the youngest age group for both males and females. Cumulative traumatic injury rates were markedly higher among older Service members, especially males, where the rate among males aged 45 years or older was more than triple that of males less than 25 years.

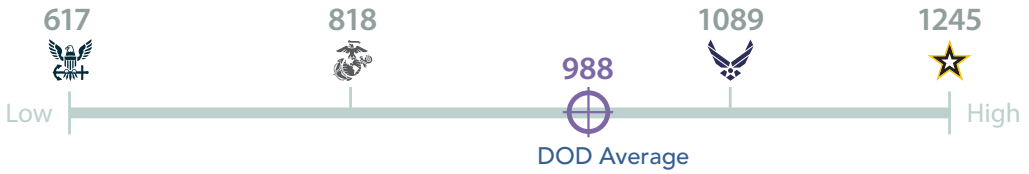
Among Service members who suffered **acute injuries,** the top five body regions and the top five nature-of-injury categories were similar for all Services and accounted for 89.3% and 80.1% of injuries, respectively. **The rate of acute injuries decreased by 12.9% between 2016 and 2018.**

Among Service members who suffered **cumulative traumatic injuries**, the most commonly injured body regions were the lumbar region (22.6%), knee and lower leg (22.1%), ankle and foot (15.2%), and shoulder (10.6%). Inflammation and pain was the most common nature-of-injury category accounting for 86.6% of all cumulative traumatic injuries. **The rate of cumulative traumatic injuries decreased 3.9% between 2016 and 2018.**



Overall, there were 305 acute injuries per 1,000 AC Service members in 2018.

Rates ranged from 219 to 376 per 1,000 AC Service members.



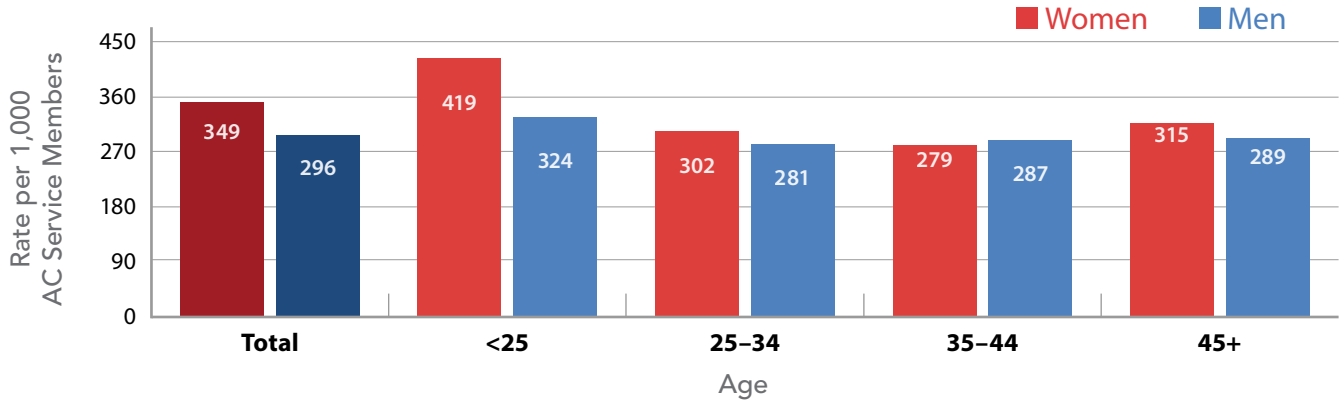
Overall, there were 988 cumulative traumatic injuries per 1,000 AC Service members in 2018.

Rates ranged from 617 to 1245 per 1,000 AC Service members.

Army | Navy | Marine Corps | Air Force

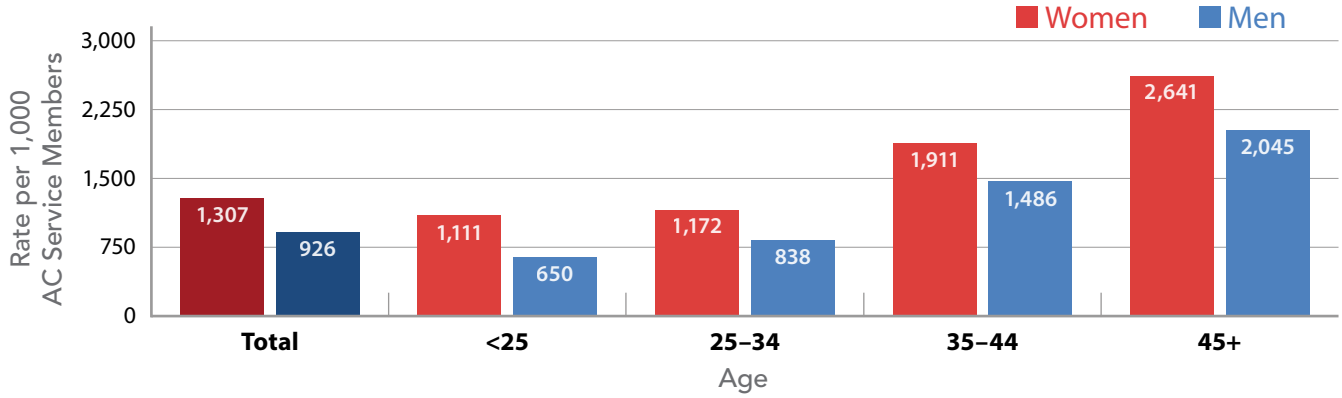
Incidence of Acute Injury by Sex and Age, AC Service Members, 2018

Overall, acute injury rates were higher for females (349 per 1,000) compared to males (296 per 1,000). Among both males and females, acute injury rates were highest in the youngest age group.



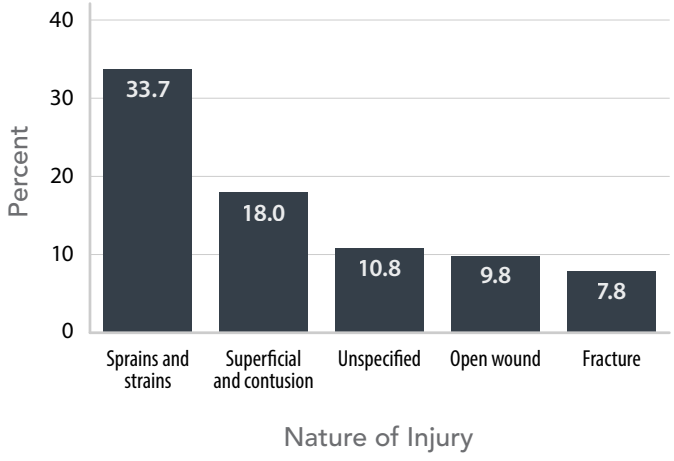
Incidence of Cumulative Traumatic Injury by Sex and Age, AC Service Members, 2018

Cumulative traumatic injury rates were higher for older compared to younger Service members and higher for females (1,307 per 1,000) compared to males (926 per 1,000).



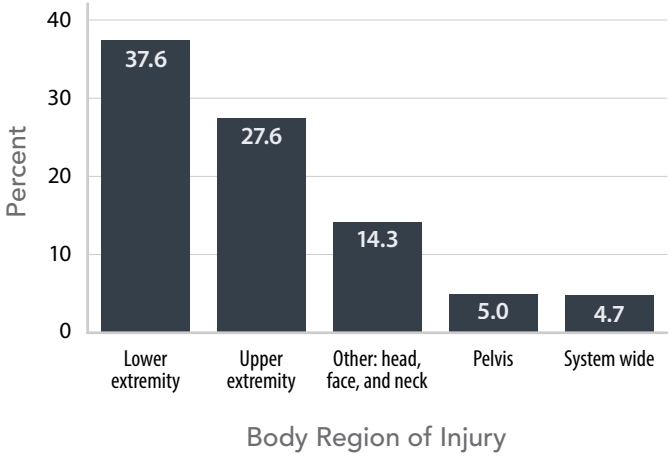
Nature of Acute Injury, Top 5 Categories, AC Service Members, 2018

Sprains and strains was the most common nature-of-injury category, accounting for 33.7% of all incident acute injuries.



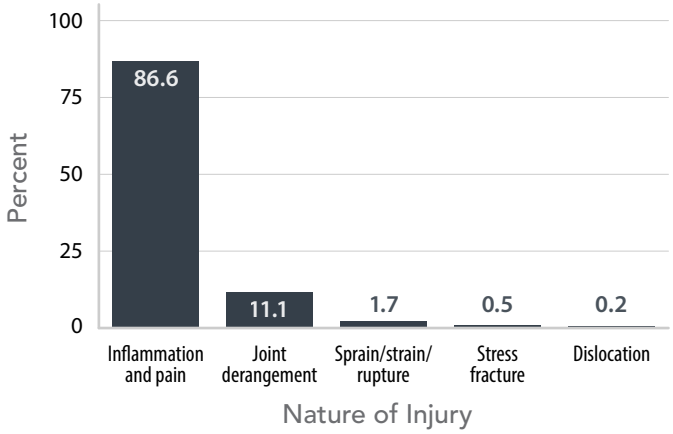
Body Region of Acute Injury, Top 5 Categories, AC Service Members, 2018

Lower extremity was the most common region affected by acute injury, accounting for 37.6% of all incident acute injuries.



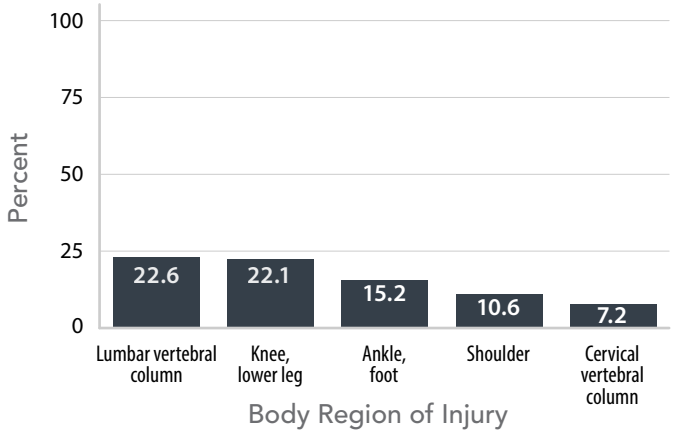
Nature of Cumulative Traumatic Injury, AC Service Members, 2018

Inflammation and pain was the most common nature-of-injury category, accounting for 86.6% of all incident cumulative traumatic injuries.



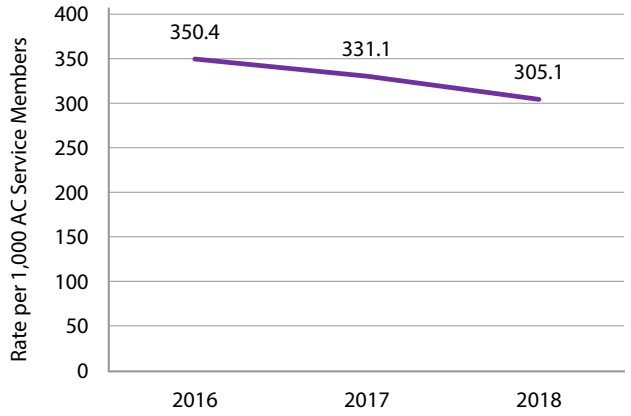
Body Region of Cumulative Traumatic Injury, Top 5 Categories, AC Service Members, 2018

Lumbar vertebral column (22.6%) and lower leg/knee (22.1%) were the most common regions affected by cumulative traumatic injury.



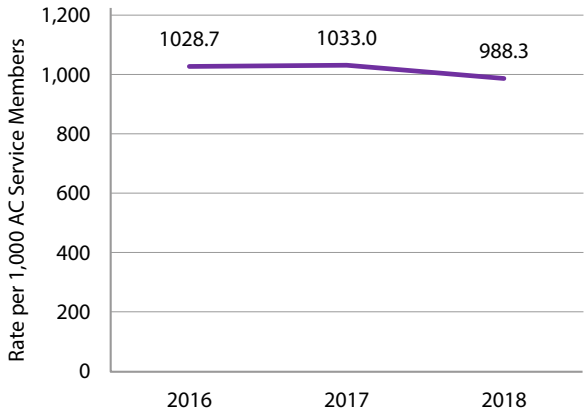
Incidence of Acute Injury, AC Service Members, 2016–2018

The rate of acute injuries decreased from 350.4 per 1,000 to 305.1 per 1,000 (12.9%) between 2016 and 2018.



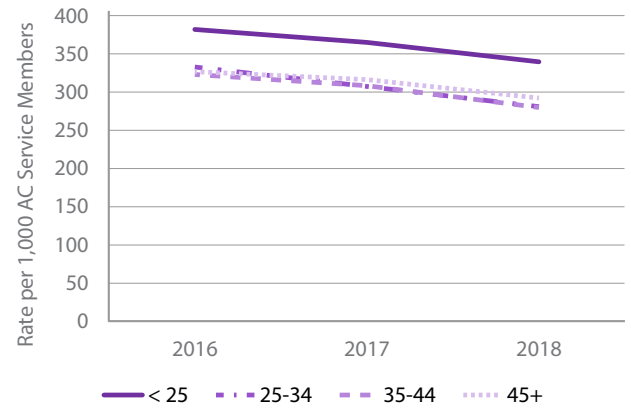
Incidence of Cumulative Traumatic Injury, AC Service Members, 2016–2018

The rate of cumulative traumatic injuries decreased from 1028.7 per 1,000 to 988.3 per 1,000 (9%) between 2016 and 2018.



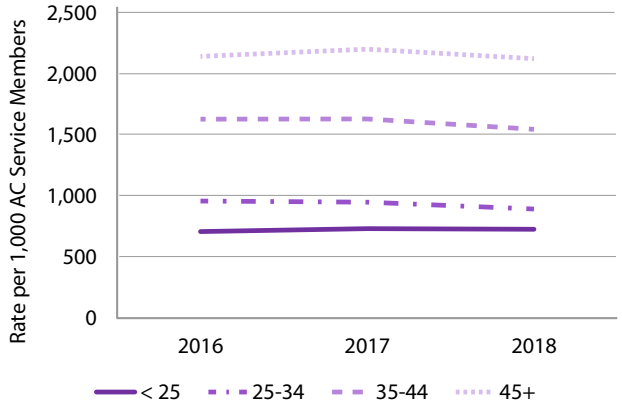
Incidence of Acute Injury by Age, AC Service Members, 2016–2018

The rate of acute injuries decreased among Service members in all age groups between 2016 and 2018.



Incidence of Cumulative Traumatic Injury by Age, AC Service Members, 2016–2018

The rate of cumulative traumatic injuries remained relatively stable among Service members in all age groups between 2016 and 2018, except for a slight increase among those in the youngest age group.



Behavioral Health

Like injury, behavioral health (BH) conditions are a leading cause of morbidity among Service members, accounting for 1.8 million (16.2%) outpatient encounters in 2018.[5]

To determine the proportion of AC Service members (including those who were deployed) with a BH diagnosis during a given 12-month period, the annual period prevalence of BH conditions was calculated. A Service member was identified as having a BH disorder if they had at least two inpatient, outpatient, or in-theater encounters for a BH condition of any type within 365 days with at least one of the diagnoses occurring during the year of interest.[6]

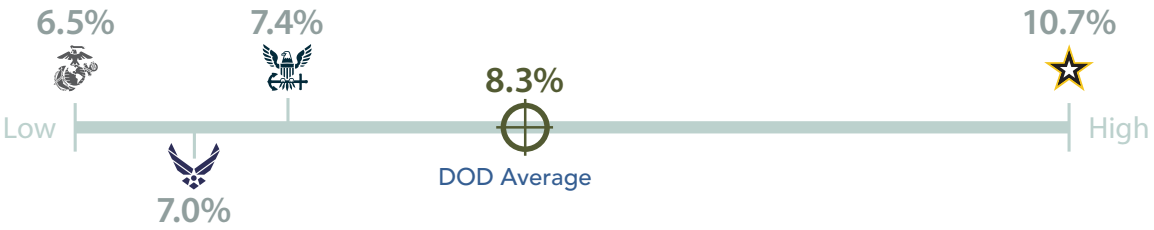
The prevalence of specific BH conditions (adjustment disorders, alcohol-related disorder, substance-related disorder, anxiety disorders, bipolar disorder, depressive disorder, psychoses, and post-traumatic stress disorder (PTSD)) during 2018 was also calculated. To be considered a case, two encounters for the same BH condition within a 365 day period were required.

To determine the proportion of Service members that had ever been diagnosed with a BH condition, the "lifetime" prevalence of BH disorders was calculated. Service members on active duty during December 2018 were used for this analysis and were considered to have a lifetime history of a BH condition if they had two BH disorder diagnoses within 365 days at any time between 2002 and 2018.

Overall, 8.3% of AC Service members were diagnosed with a BH disorder in 2018. The annual prevalence of BH disorders remained relatively stable between 2014 and 2018, with a low of 8.0% in 2014 and a high of 8.8% in 2017. Women were more likely to be diagnosed with a BH disorder (12.8%) when compared to men (7.5%). Service members in the youngest age category (less than 25 years) had the highest prevalence of BH disorders among both males and females.

Among both males and females, adjustment disorder was the leading BH diagnosis in 2018 followed by anxiety disorder and depressive disorder.

Among AC Service members on active duty during December 2018, 25.2% of women and 16.2% of men (17.7% overall) had a history (lifetime prevalence) of a BH disorder. The lifetime prevalence of BH disorders ranged from 10.4% to 21.9% across the Services.



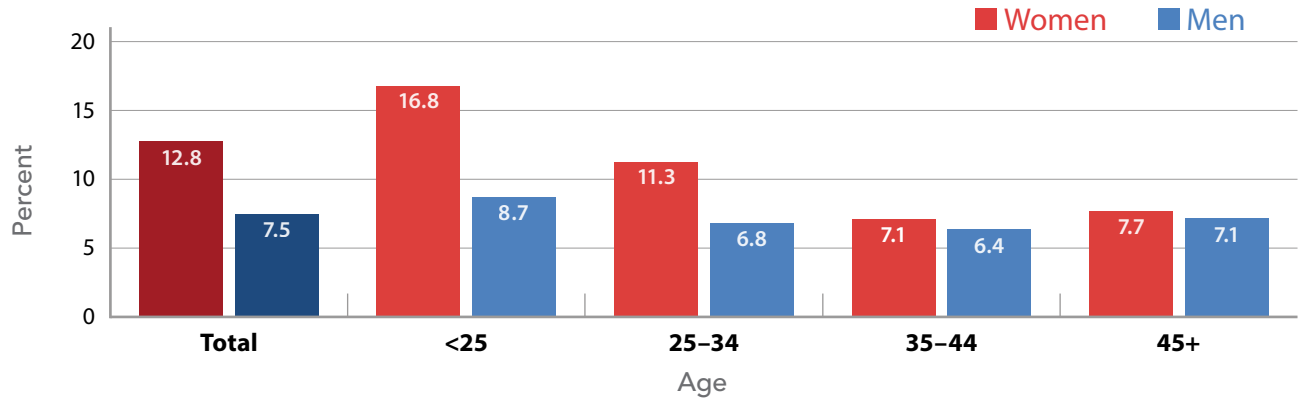
Overall, 8.3% of AC Service members had a BH disorder in 2018.

Rates ranged from 6.5% to 10.7% across Services.

Army | Navy | Marine Corps | Air Force

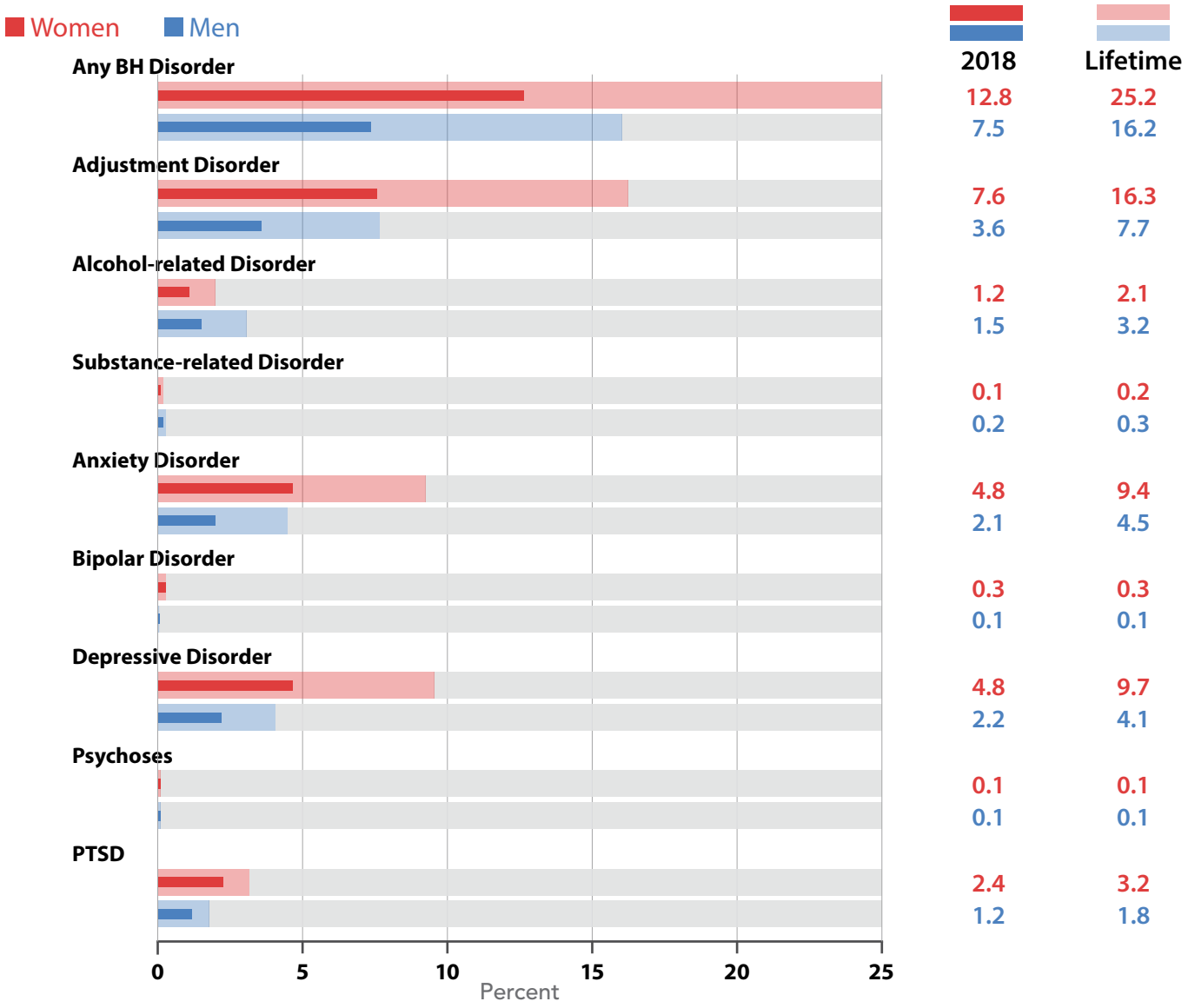
Prevalence of Behavioral Health Disorders by Sex and Age, AC Service Members, 2018

Females were more likely to be diagnosed with a behavioral health disorder compared to males, and those in the youngest age category were more likely to be diagnosed compared to older Service members.



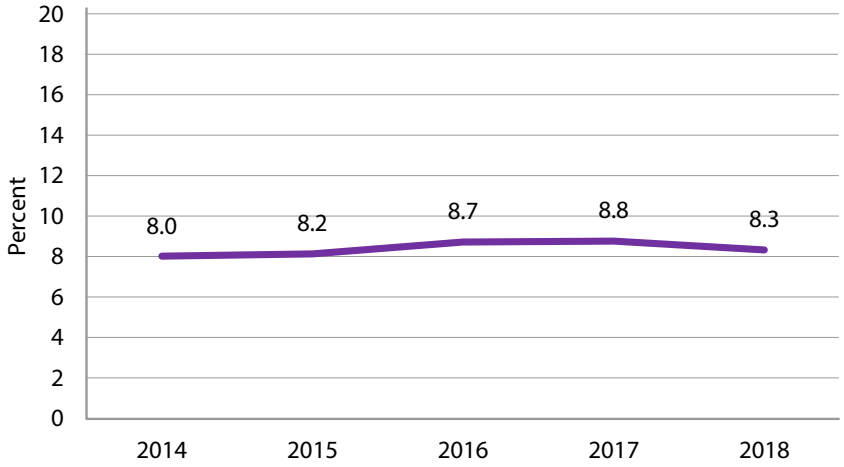
Annual and Lifetime Prevalence of Behavioral Health Disorders by Sex and Condition, 2018

Overall, 17.7% of Service members (25.2% of women and 16.2% of men) had received a diagnosis of a behavioral health disorder between 2002 and 2018. The percentage was higher for females compared to males for most behavioral health disorders.



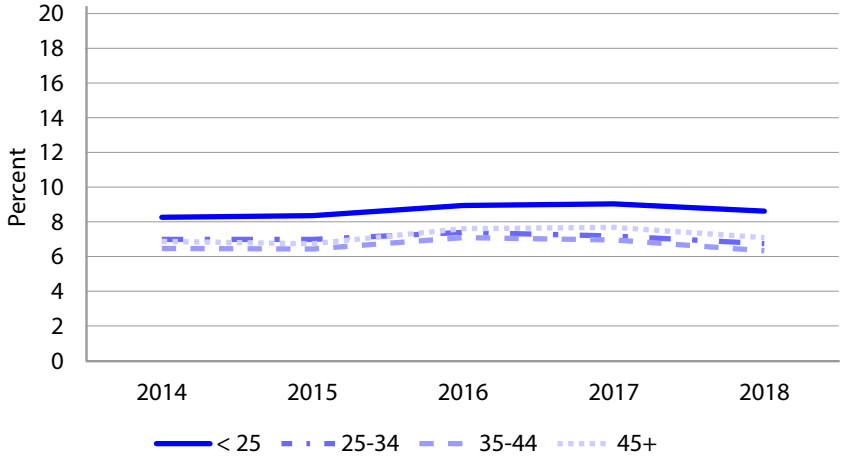
Prevalence of Behavioral Health Disorders by Year, AC Service Members, 2014–2018

The prevalence of behavioral health disorders remained relatively stable between 2014 and 2018, with fluctuation from a low of 8.0% in 2014 to a high of 8.8% in 2017.



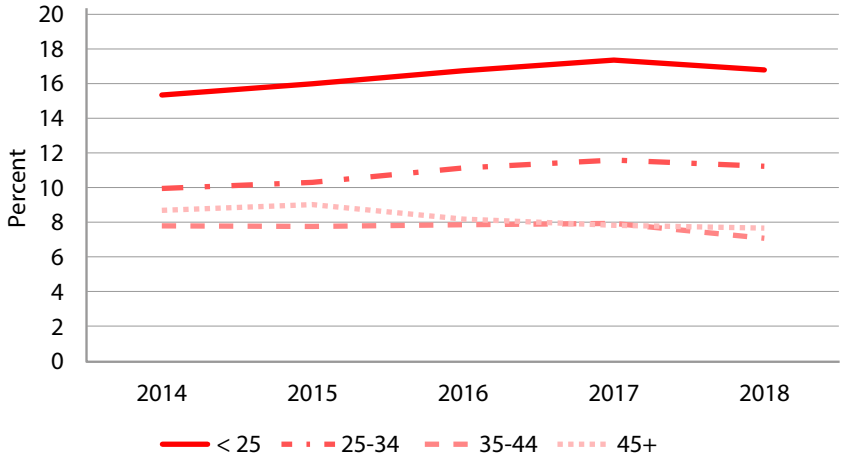
Prevalence of Behavioral Health Disorders by Age, Male AC Service Members, 2014–2018

The prevalence of behavioral health disorders remained relatively stable between 2014 and 2018 among males in all age groups.



Prevalence of Behavioral Health Disorders by Age, Female AC Service Members, 2014–2018

The prevalence of behavioral health disorders increased slightly between 2014 and 2017 among females <25 years and 25–34 years and remained relatively stable for females in other age groups.



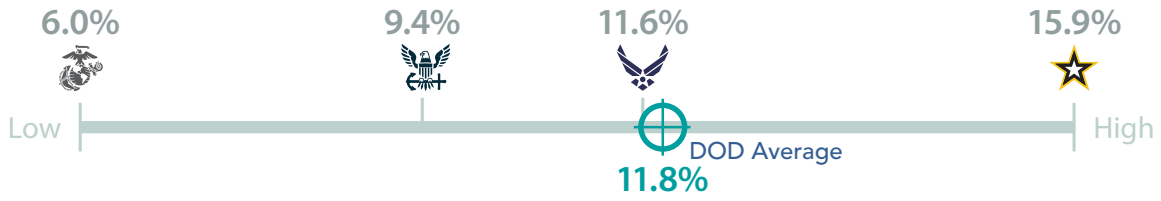
Sleep Disorders

The American Academy of Sleep Medicine recommends at least 7 hours of sleep per night for adults aged 18–60 years.[7] Lack of sleep can impair cognitive function, decreasing performance and increasing the risk for injury and accidents. Insufficient sleep is also associated with a number of chronic diseases including diabetes, heart disease, obesity, and depression.[8]

The overall prevalence and time trends related to sleep disorders (including sleep apnea, insomnia, hypersomnia, circadian rhythm disorders, narcolepsy, parasomnia, and sleep-related movement disorders) among AC Service members in 2018 are reported here, along with the prevalence of the most commonly diagnosed sleep disorders.

In 2018, 11.8% of Service members were diagnosed with at least one sleep disorder. Proportions were similar for males and females (12.0% and 11.0%, respectively). **The most commonly diagnosed sleep disorders were sleep apnea and insomnia (6.5% and 4.6%, respectively).** Male Service members were far more likely to be diagnosed with sleep apnea than females (7.2% and 2.9%, respectively), while a greater percentage of female Service members were diagnosed with insomnia compared to males (6.4% and 4.3%, respectively).

The prevalence of sleep disorders remained relatively stable during the study period, with a slight decrease of 2.6% from 2014 to 2018. However, the prevalence of sleep disorders among male Service members in the 45 years and older age group increased from 39.0% in 2014 to 46.8% in 2018. Previous studies have demonstrated increases in the incidence rates of some conditions, including sleep disorders, when comparing rates during the early, middle, and last phases of a Service member's career. These increases were independent of age and thought to be due in part to increased reporting during separation and retirement physicals.[9] The impact of career phase was not evaluated here and may be important to consider in the future.



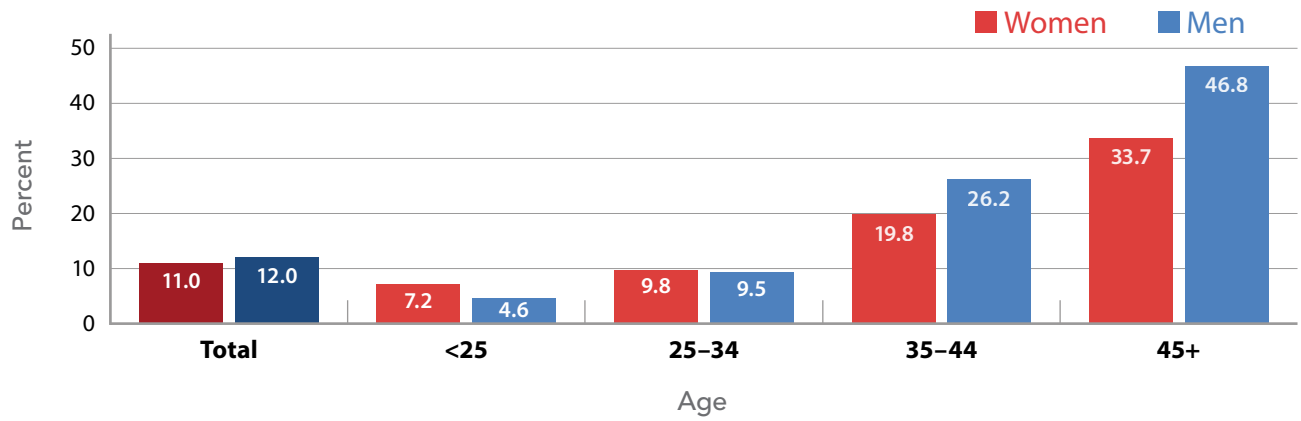
Overall, 11.8% of AC Service members had a sleep disorder in 2018.

Rates ranged from 6.0% to 15.9% across Services.

Army | Navy | Marine Corps | Air Force

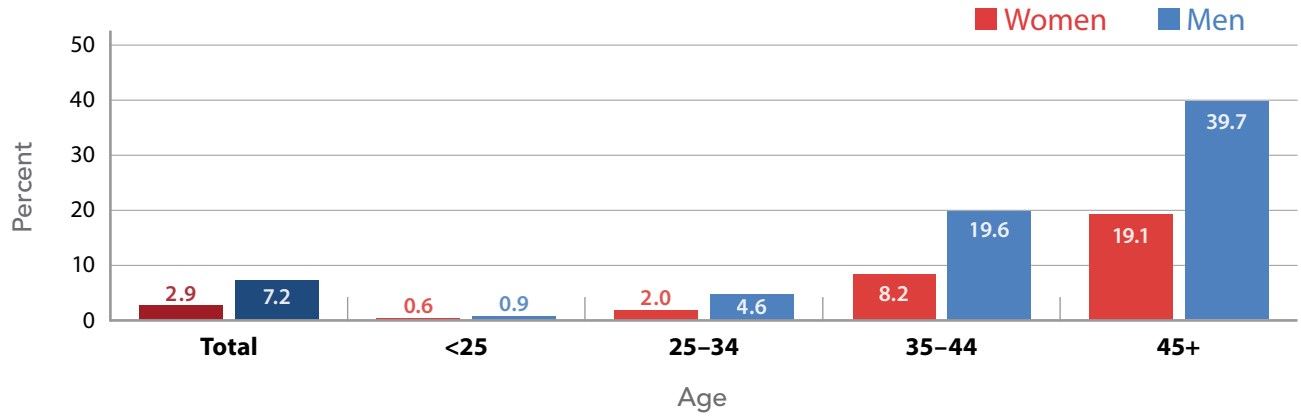
Prevalence of Sleep Disorders by Sex and Age, AC Service Members, 2018

The prevalence of sleep disorders was similar for males (12.0%) and females (11.0%) but increased with increasing age for both sexes.



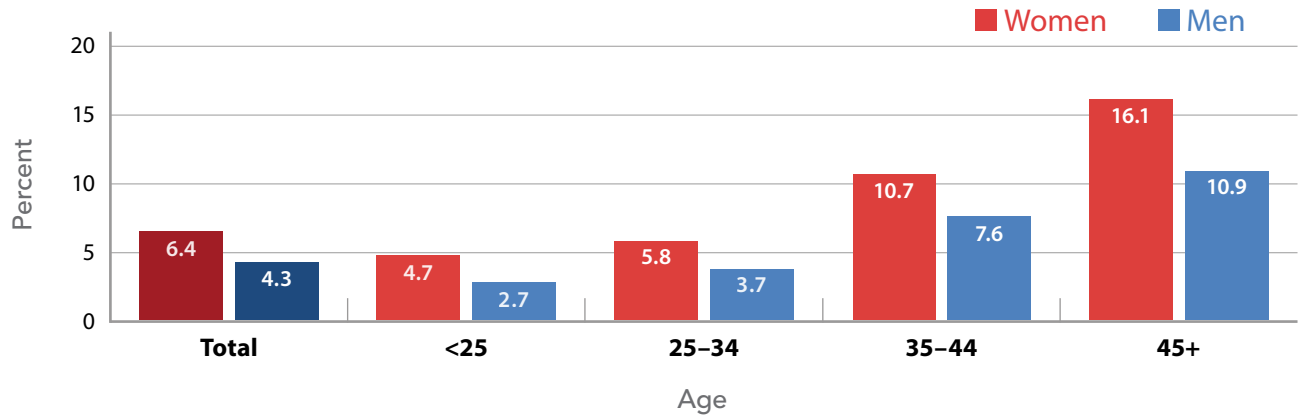
Prevalence of Sleep Apnea by Sex and Age, AC Service Members, 2018

The prevalence of sleep apnea was higher for males (7.2%) compared to females (2.9%), and prevalence increased with increasing age.



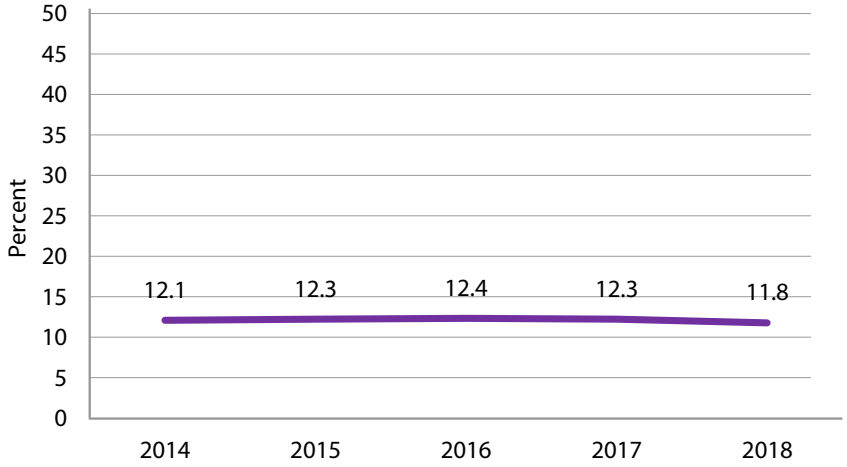
Prevalence of Insomnia by Sex and Age, AC Service Members, 2018

The prevalence of insomnia was higher for females (6.4%) compared to males (4.3%), and prevalence increased with increasing age.



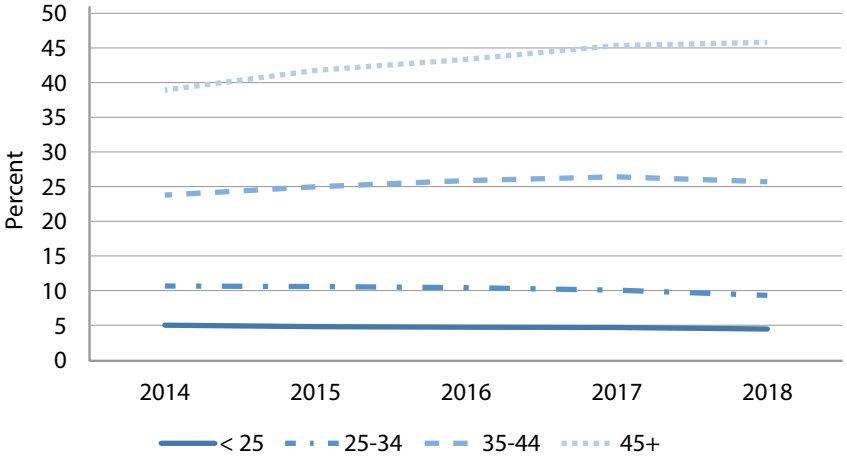
Prevalence of Sleep Disorders by Year, AC Service Members, 2014-2018

The prevalence of sleep disorders remained relatively stable between 2014 and 2018, with a slight decrease of 2.6% from 2014 to 2018.



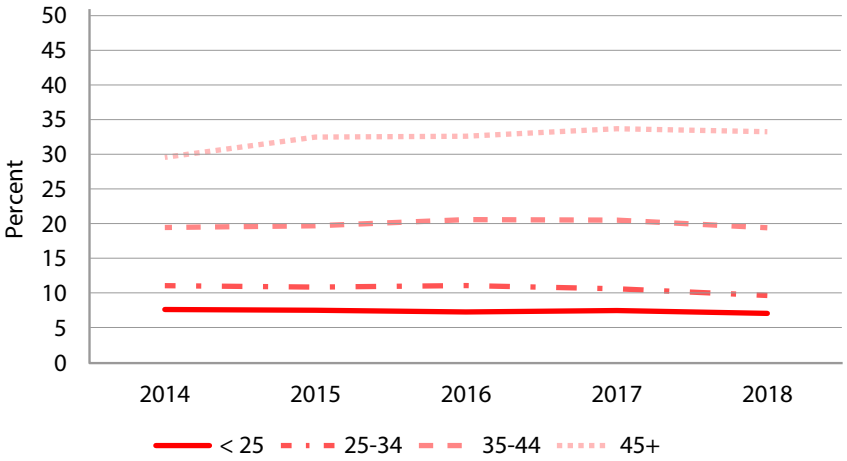
Prevalence of Sleep Disorders by Age, Male AC Service Members, 2014-2018

The prevalence of sleep disorders remained relatively stable among males ≤44 years between 2014 and 2018. The prevalence of sleep disorders among male Service members in the 45 years and older age group increased from 39.0% in 2014 to 46.8% in 2018.



Prevalence of Sleep Disorders by Age, Female AC Service Members, 2014-2018

The prevalence of sleep disorders remained relatively stable among females of all age groups between 2014 and 2018.

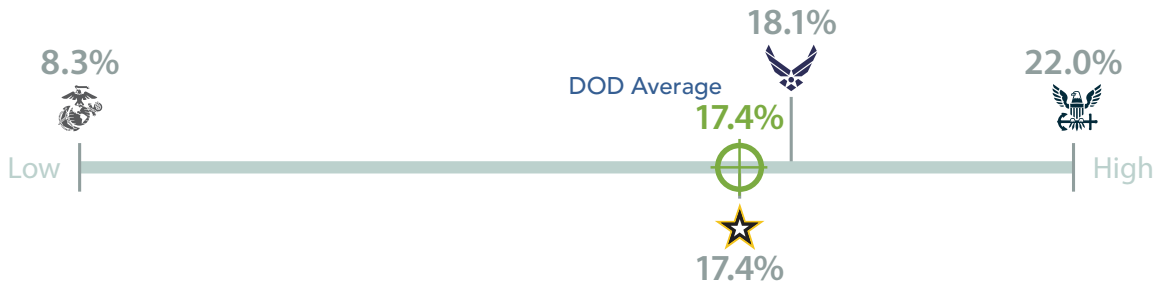


Obesity

Obesity negatively impacts physical performance and military readiness and is associated with long-term health problems such as hypertension, diabetes, coronary heart disease, stroke, cancer, and risk for all-cause mortality. Studies also suggest that healthcare utilization is higher among obese Service members than their normal-weight counterparts.[10]

The Clinical Data Repository (CDR) vital sign table within the Military Health System Data Repository (MDR) was used to identify all records for AC Service members with a height and weight measurement available on the same day; pregnant Service members were excluded. Height and weight data were then matched to the Armed Forces Health Surveillance Branch (AFHSB) Defense Medical Surveillance System (DMSS) to identify the date of birth, sex, and Service for each record. Body mass index (BMI) was calculated utilizing the latest height and weight record in a given year. BMI measurements less than 12 and greater than 45 were considered erroneous and excluded. In accordance with the Centers for Disease Control and Prevention (CDC), a BMI ≥30 was considered obese.[11]

The overall prevalence of obesity was 17.4% in 2018. Obesity rates were higher among males (18.4%) compared to females (12.6%). The lowest prevalence of obesity was found in Service members less than 25 years of age (overall prevalence: 9.7%) and the highest was found in those in the 35–44 year age group (overall prevalence: 28.2%). The overall prevalence of obesity has increased steadily since 2014.



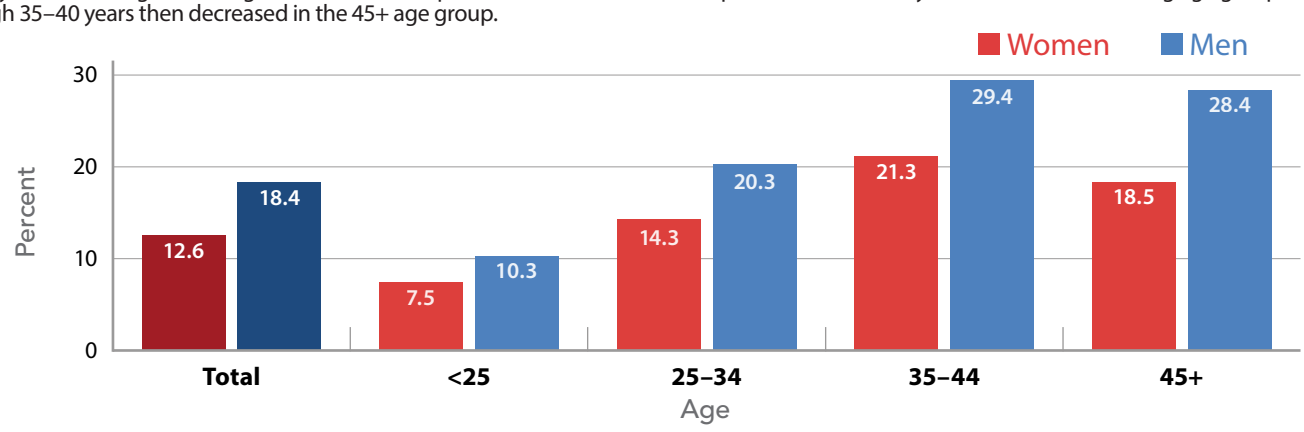
Overall, 17.4% of AC Service members were classified as obese in 2018.

Rates ranged from 8.3% to 22.0% across Services.

Army | Navy | Marine Corps | Air Force

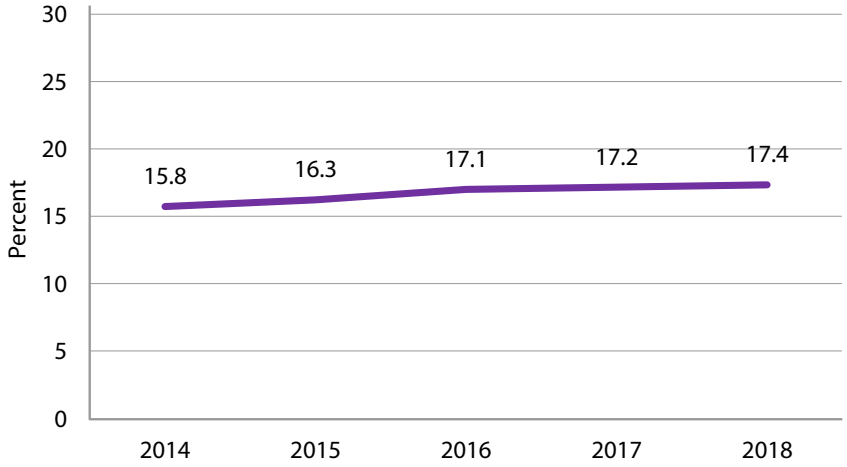
Prevalence of Obesity by Sex and Age, AC Service Members, 2018

Obesity rates were higher among males (18.4%) compared to females (12.6%). The prevalence of obesity increased with increasing age group through 35–40 years then decreased in the 45+ age group.



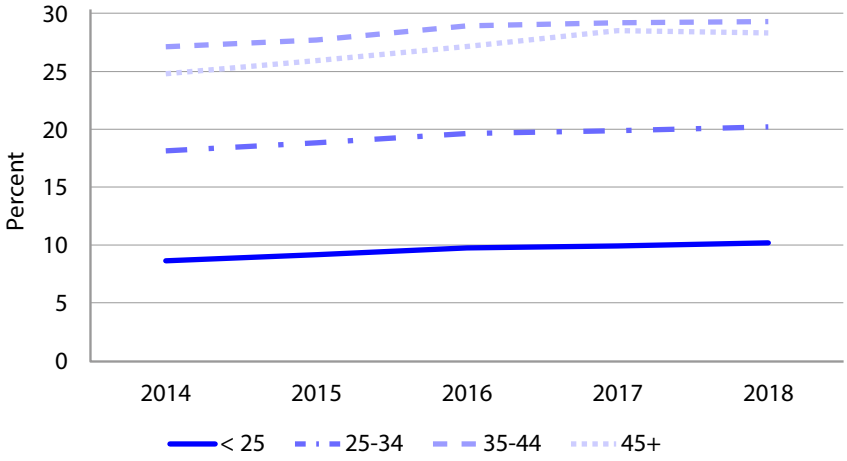
Prevalence of Obesity by Year, AC Service Members, 2014–2018

The prevalence of obesity increased slightly from 15.8% in 2014 to 17.4% in 2018.



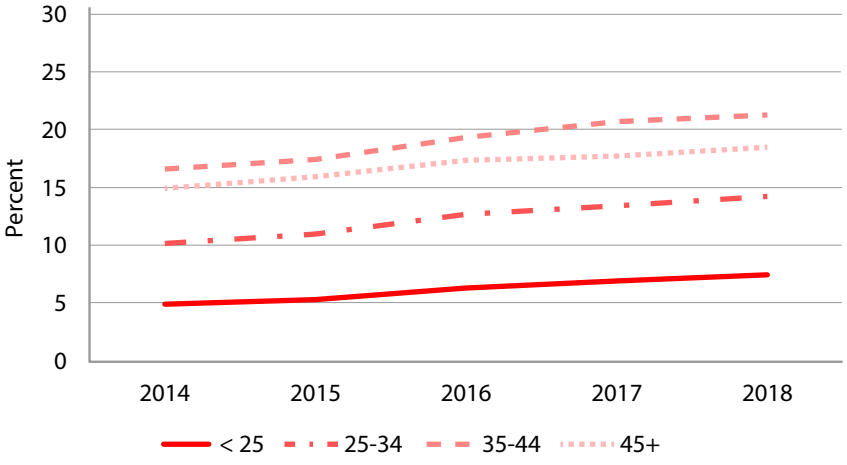
Prevalence of Obesity by Age, Male AC Service Members, 2014–2018

The prevalence of obesity increased slightly among males for all age groups between 2014 and 2018.



Prevalence of Obesity by Age, Female AC Service Members, 2014–2018

The prevalence of obesity increased slightly among females for all age groups between 2014 and 2018.



Army

Service Profile (2018):*

Population: Approximately 465,000 Army Service members
78.8% under 35 years old, 14.9% female

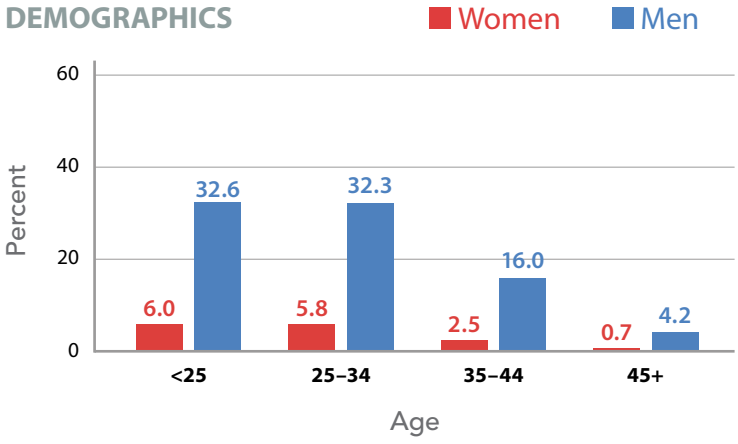
HEALTH INDEX MEASURES**

MEASURE	ARMY VALUE	DOD AVERAGE	DOD RANGE
Acute Injury (rate per 1,000)	375.7	305.1	218.9–375.7
Cumulative Traumatic Injury (rate per 1,000)	1,245.3	988.3	616.5–1,245.3
Behavioral Health 1-year (%)	10.7	8.3	6.5–10.7
Behavioral Health Lifetime (%)	21.9	17.7	10.4–21.9
Sleep Disorders (%)	15.9	11.8	6.0–15.9
Obesity (%)	17.4	17.4	8.3–22.0

ADDITIONAL INFORMATION

Injury rates in the Army were found to be higher than rates found in the Navy, Air Force, and Marine Corps. Mission-specific training and operational requirements likely contribute to the risk for injury among Soldiers. Rates of BH and sleep disorders were also higher among Soldiers than Sailors, Airmen, and Marines. Given the potential for each of these conditions to contribute to decreased performance, disability, and separation, further exploration of potential causes and interventions is warranted.

DEMOGRAPHICS



* Number of AC Service members, June 2018; see Appendix for details.
** See Appendix for details regarding measure computations.

Navy

Service Profile (2018):*

Population: Approximately 324,000 Navy Service members
77.8% under 35 years old, 19.5% female

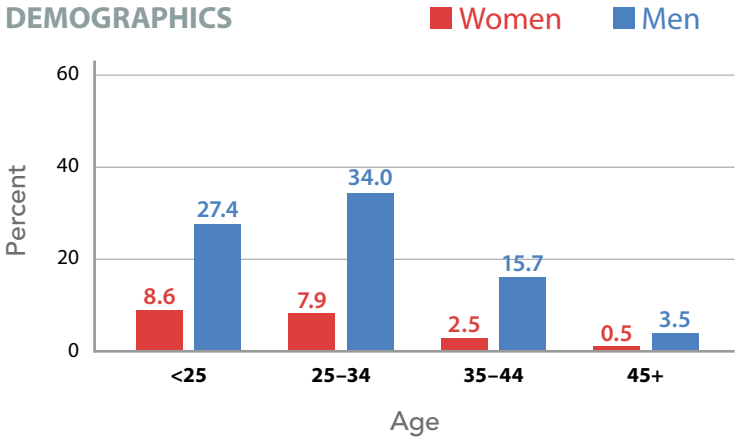
HEALTH INDEX MEASURES**

MEASURE	NAVY VALUE	DOD AVERAGE	DOD RANGE
Acute Injury (rate per 1,000)	218.9	305.1	218.9–375.7
Cumulative Traumatic Injury (rate per 1,000)	616.5	988.3	616.5–1,245.3
Behavioral Health 1-year (%)	7.4	8.3	6.5–10.7
Behavioral Health Lifetime (%)	15.8	17.7	10.4–21.9
Sleep Disorders (%)	9.4	11.8	6.0–15.9
Obesity (%)	22.0	17.4	8.3–22.0

ADDITIONAL INFORMATION

While injury, sleep disorders, and BH conditions remain important threats to Navy readiness, this report highlights obesity as a growing health concern among Sailors. Obesity contributes to hypertension, diabetes, coronary heart disease, stroke, cancer, all-cause mortality, and increased healthcare costs. It also contributes to failure of Sailors to meet physical fitness standards.

DEMOGRAPHICS



* Number of AC Service members, June 2018; see Appendix for details.
** See Appendix for details regarding measure computations.

Air Force

Service Profile (2018):*

Population: Approximately 321,000 Air Force Service members
77.1% under 35 years old, 20.1% female

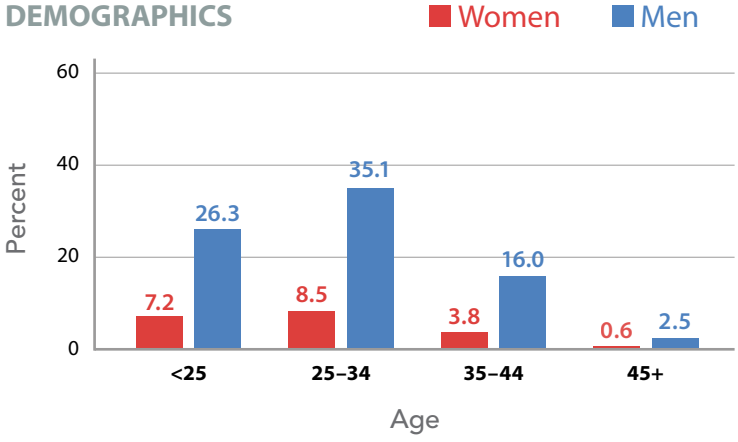
HEALTH INDEX MEASURES**

MEASURE	AIR FORCE VALUE	DOD AVERAGE	DOD RANGE
Acute Injury (rate per 1,000)	289.9	305.1	218.9–375.7
Cumulative Traumatic Injury (rate per 1,000)	1,089.1	988.3	616.5–1,245.3
Behavioral Health 1-year (%)	7.0	8.3	6.5–10.7
Behavioral Health Lifetime (%)	17.8	17.7	10.4–21.9
Sleep Disorders (%)	11.6	11.8	6.0–15.9
Obesity (%)	18.1	17.4	8.3–22.0

ADDITIONAL INFORMATION

In this analysis, cumulative traumatic injuries and obesity were found to affect Airmen at higher than average rates. Given that these conditions co-occur in the general population, it is not surprising that they were also found to co-occur among Airmen. Future efforts to address obesity and repetitive micro-trauma as separate conditions as well as efforts to better understand the interplay of these conditions have the potential to improve the readiness of Airmen.

DEMOGRAPHICS



* Number of AC Service members, June 2018; see Appendix for details.

** See Appendix for details regarding measure computations.

Marine Corps

Service Profile (2018):*

Population: Approximately 185,000 Marine Corps Service members
88.8% under 35 years old, 8.6% female

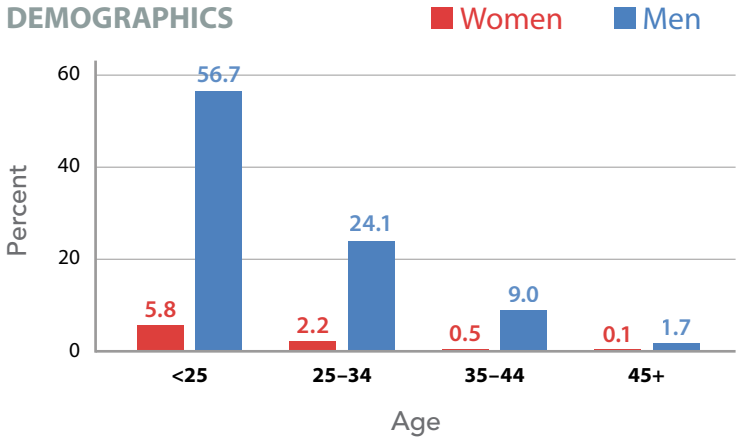
HEALTH INDEX MEASURES**

MEASURE	MARINE CORPS VALUE	DOD AVERAGE	DOD RANGE
Acute Injury (rate per 1,000)	304.6	305.1	218.9–375.7
Cumulative Traumatic Injury (rate per 1,000)	818.3	988.3	616.5–1,245.3
Behavioral Health 1-year (%)	6.5	8.3	6.5–10.7
Behavioral Health Lifetime (%)	10.4	17.7	10.4–21.9
Sleep Disorders (%)	6.0	11.8	6.0–15.9
Obesity (%)	8.3	17.4	8.3–22.0

ADDITIONAL INFORMATION

Marines have relatively low rates of BH diagnoses, sleep disorders, and obesity compared to the other Services. Injuries, especially acute injuries, however, emerge as an important area of focus for prevention efforts among Marines. Cumulative traumatic injuries such as back and knee joint disorders are the leading causes of limited duty among Marines resulting in reduced worldwide deployability and increased medical separations. Attention to reducing these injuries could increase the mission readiness among Marines.

DEMOGRAPHICS



* Number of AC Service members, June 2018; see Appendix for details.

** See Appendix for details regarding measure computations.

METHODS

Injury

Data were derived from records routinely maintained in the DMSS. These records document ambulatory encounters and hospitalizations of AC Service members in fixed military and civilian (if reimbursed through the Military Health System (MHS)) treatment facilities worldwide. Acute injuries were identified using ICD-10-CM diagnosis codes from the NCHS injury diagnosis matrix.[3] Cumulative traumatic injuries were identified using ICD-10-CM diagnosis codes from the U.S. Army Public Health Center's (APHC) cumulative trauma matrix.[4] Service members were identified as having an acute injury if they had any acute injury diagnosis in any position of an inpatient or outpatient medical encounter. Similarly, Service members were identified as having a cumulative traumatic injury if they had any cumulative traumatic injury diagnosis in any position of an inpatient or outpatient medical encounter. A 60-day gap rule was used to identify incident injuries. To be counted as a new case, at least 60 days must have passed since the last qualifying injury for the same nature of injury and body region affected, as defined by the acute and traumatic injury matrices. Encounters with a documented "war"- or "battle"- related cause of injury were excluded from the analysis. Causes of injuries were assessed based on North Atlantic Treaty Organization Standard Agreement (STANAG) 2050 and ICD-10-CM "external cause of injury" codes. The denominator was all AC Service members during June of the year of interest.

For all incident injuries, the frequency and percentage of the nature of injury and body region affected were described.

Limitations:

1. The transition from ICD-9-CM to ICD-10-CM in October 2015 presented a significant artifact for acute injury surveillance. ICD-10-CM has more than 15 times the number of acute injury codes available in ICD-9-CM and they are far more specific. It is not possible to directly compare rates of highly specific acute injuries captured in ICD-10-CM to the non-specific injuries captured in ICD-9-CM. For this reason, rates of acute injuries captured under ICD-9-CM were not reported here.
2. This report is meant to describe non-deployment related injuries; however, some deployment-related injuries may have been captured if the war- or battle- related cause of injury was not documented.
3. Diagnosing an acute injury is subjective and provider-dependent. Incident and subsequent diagnoses rendered by different providers introduces error that can result in both undercounting and overcounting injuries.
4. It is not always possible to differentiate incident injuries from re-injuries using surveillance data. The 60-day gap rule is sufficient for the vast majority of injuries, which are generally not severe, but may lead to overcounting of severe injuries if the subsequent encounters are erroneously coded as incident injuries.

Behavioral Health

Data were derived from records routinely maintained in the DMSS. Healthcare encounters of deployed Service members are documented in records that are maintained in the Theater Medical Data Store (TMDS), which is included in the DMSS. It is important to note that because the TMDS has not fully transitioned to ICD-10-CM, ICD-9-CM codes appear in this analysis.

Service members were identified as having a BH disorder if they had at least two BH disorder diagnoses (ICD-9-CM: 290-319, excluding 305.1; ICD-10-CM: F01-F99, excluding F17.200) within 365 days in any diagnostic position. Diagnoses could occur in inpatient, outpatient, or in-theater medical encounters. At least one of these diagnoses had to occur during of the year of interest. The denominator was all AC Service members during June of the year of interest.

For specific BH conditions (adjustment disorders, alcohol-related disorders, anxiety disorders, bipolar disorder, depressive disorders, psychoses, PTSD, and substance-related disorders), ICD-9-CM and ICD-10-CM codes from the AFHSB surveillance case definitions were used.[6] A Service member was considered to have a specific BH condition if they had two diagnoses for the same condition within 365 days of each other. At least one of these diagnoses had to occur during of the year of interest. The denominator was all AC Service members during June of the year of interest.

History ("lifetime" prevalence) of a BH disorder was also measured. Service members were considered to have a history of BH disorder if they had two BH disorder diagnoses within 365 days at any time between 2002 and 2018 and were in service during December 2018 (the last month of the surveillance period). The denominator was all AC Service members during December 2018.

Limitations:

1. Service members do not always seek or receive care for a BH condition within the MHS and BH disorders may be underestimated here.
2. Some diagnoses may be miscoded or incorrectly transcribed on centrally transmitted records.
3. Some encounters may have been erroneously diagnosed or miscoded as BH disorders (e.g., screening visits).

Sleep Disorders

Data were derived from records routinely maintained in the DMSS; TMDS data were included. Service members were identified as having a sleep disorder if they had a diagnosis (Table 1) in any diagnostic position during the year of interest. It is important to note that because the TMDS has not fully transitioned to ICD-10-CM, ICD-9-CM codes appear in this analysis. The denominator was all AC Service members during June of the year of interest.

Limitations:

1. Service members do not always seek care for sleep disorders and sleep disorders may be underrepresented here.
2. Increased screening associated with required medical encounters such as retirement and separation physicals may result in overdiagnosis of sleep disorders.

Table 1. ICD-9-CM/ICD-10-CM codes used to identify sleep disorders.

	ICD-9-CM	ICD-10-CM
Any sleep disorder	780.5*, 327.00–327.02, 327.09, 327.10–327.15, 327.19, 327.2*, 327.3*, 327.4*, 327.5*, 327.8, 347.*, 307.4*	G47.*, F51.*
Insomnia	780.52, 327.00, 327.01, 327.09	G47.0*
Hypersomnia	327.10–327.14, 327.19, 780.54	G47.1*
Circadian rhythm sleep disorders	327.30–327.37, 327.39, 780.55	G47.2*
Sleep apnea	327.20–327.27, 327.29, 780.51, 780.53, 780.57	G47.3*
Narcolepsy	347.00, 347.01, 347.10, 347.11	G47.4*
Parasomnia	327.40–327.44, 327.49	G47.5*
Sleep-related movement disorders	327.51–327.53, 327.59	G47.6*

*represents any subsequent digit/character

Obesity

The CDR vital sign table within the MDR was used to identify all records for AC Service members with a height and weight measurement available on the same day. Female Service members with an ICD-9-CM or ICD-10-CM code for pregnancy in any inpatient or outpatient encounter in the same year were excluded. Height and weight data were then matched to the AFHSB DMSS to identify the date of birth, sex, and Service for all records. If the Service member could not be identified in the DMSS or any demographic information was missing from the DMSS, then the height and weight record was excluded. Only the latest height and weight record for each Service member per year was retained. BMI was then calculated from height and weight. Records with BMI measurements less than 12 and greater than 45 and records with erroneous heights or weights (e.g., a weight of 8 pounds) were excluded from the analysis. Cases of obesity were assigned using BMI ≥30, according to the CDC definition of obesity.[11]

The CDR vital sign table was used to assess BMI because not all Services had complete height and weight records available from Service members' Physical Fitness Tests (PFTs). BMIs calculated from CDR data were reviewed by APHC and U.S. Air Force School of Aerospace Medicine (USAFSAM) and found to be comparable to BMIs from PFTs. This method of estimating obesity is similar to the Defense Health Agency's Better Health Prevalence Measure of overweight and obesity.[12]

Limitations:

1. Service members with higher lean body mass may be misclassified as obese based on their BMI.
2. Not all Service members had a height or weight measurement available in the Vitals data each year.
3. BMI measures should be interpreted with caution, as some of them can be based on self-reported height and weight.

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