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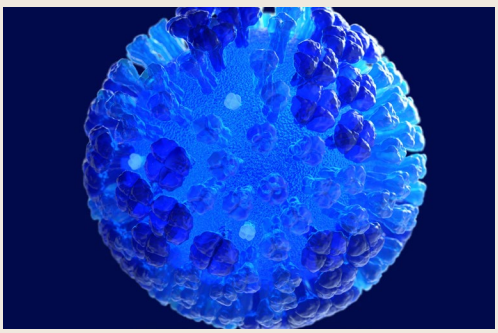

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Non-Medical Risk Factors Influencing Health and Association with Suicidal Ideation or Attempt, U.S. Active Component, 2018–2022

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This study reports the prevalence of non-medical risk factors, also known as social determinants of health, among active component service members and assesses the relationship between these factors and suicide ideation or attempts between 2018 and 2022. This analysis was performed to determine if there is opportunity to prevent suicide ideation or attempt among service members indicated for these non-medical risk factors. The findings reveal differences between demographic variables, emphasizing the disproportionate impacts of non-medical risk factors within the military population. For example, non-Hispanic Black service members had higher frequencies of diagnoses for all factors. After controlling for age, sex, service branch, race, and year of entry into military service, odds of suicidal ideation or attempt were elevated for service members with a recent diagnosis for factors related to abuse (odds ratio [OR] 13.7), family upbringing (OR 10.9), other psychosocial issues (OR 7.5), social environment (OR 7.4), lifestyle (OR 5.4), and life management (OR 5.3). This finding persisted even after excluding individuals with any prior mental health diagnosis. The results of this study suggest a need for a more comprehensive understanding of non-medical risk factors in shaping health outcomes and informing interventions to mitigate their effects.

What are the new findings?

This study documents, for the first time, the frequency of diagnosis for non-medical risk factors influencing health among U.S. active component service members. An association is identified between non-medical risk factors and suicide ideation or attempt within 1 year following diagnosis of the risk factor.

What is the impact on readiness and force health protection?

Suicide prevention is an aim of each military service. This study emphasizes the need for targeted interventions that address non-medical risk factors affecting health, to reduce mental health issues and suicide rates among service members. Improving access to resources and strengthening social support networks, to address issues related to abuse as well as economics, may enhance overall well-being and military readiness.

Non-medical risk factors that may influence health, also known as social determinants of health, pertain to the circumstances into which individuals are born, develop, reside, labor, and age, encompassing a broad spectrum of influences and systems that constitute daily living.[1] In this article, the phrase "non-medical risk factors" is used instead of "social determinants of health," as it is less fatalistic and more accurate in its description.

Non-medical factors including economic stability, education, neighborhood conditions, and access to health care play a significant role in shaping mental health and suicide outcomes in the U.S.[2] Suicide remains a major public health crisis, with over 49,000 deaths, and 13.2 million individuals seriously considering suicide, in 2022, making it the ninth leading cause of death among people ages 10-64 years.[3] Those facing financial hardship or housing instability are at an increased risk for mental illness and suicidal behaviors.[4,5] According to one meta-analysis, the strongest risk factors for suicide attempts include childhood abuse and maltreatment, sexual assault, sexual minority status, and parental suicide mortality.[6]

While U.S. service members have benefits such as steady employment, housing allowance, and accessible health care, they are also affected by non-medical factors influencing health. Prior studies have indicated that factors such as familial problems can have independent associations with adverse outcomes such as suicide and medical evacuation from overseas deployments.[7,8] The Army Study to Assess Risk and Resilience in Servicemembers (Army STARRS) found that childhood maltreatment and exposure to bullying was strongly associated with suicidal behaviors.[9,10]

Suicide is currently the leading cause of death for U.S. service members, and over 30,000 service members and veterans have died from suicide since September 11, 2001.[11] Among active component service members (ACSMs) who attempted suicide in 2023, 33% had intimate relationship problems, 20% had workplace difficulties, and 9% experienced assault or harassment.[12]

While traditional risk factors such as combat exposure and deployment-related stressors have been studied extensively, there is a growing recognition that the broader context of non-medical risk factors plays a crucial role in shaping the mental health outcomes of military personnel.[13,14] Understanding these non-medical risk factors is essential for identifying vulnerable subgroups within the active duty population and implementing interventions that address the broader contextual factors influencing suicide ideation and attempts. The objectives of this study were to 1) report the percentage of ACSMs diagnosed with non-medical factors influencing health in 2022 and 2) assess the relationship of non-medical factors influencing health with suicide ideation or attempt between 2018 and 2022.

Methods

The surveillance case definition for non-medical factors influencing health were developed in 2023 through a Health Surveillance and Epidemiology Behavioral Health Working Group within Defense Health Agency Public Health.[15,16] The International Classification of Diseases, 9th and 10th Revisions, Clinical Modification (ICD-9-CM and ICD-10-CM) code sets were based, in part, on code sets developed by the World Health Organization and the Centers for Disease Control and Prevention to monitor non-medical risk factors that may influence health, and were also based on a Veterans Administration (VA) study that looked at the effects of adverse social risk factors and their association with suicide risk and morbidity.[17] The review group reviewed and modified the code sets to make them more relevant to service members and beneficiaries of the Military Health System and to behavioral health. ICD-9-CM codes were included because they were still being utilized in the Theater Medical Data Store (TMDS). Many of the factors are self-explanatory (e.g., alcohol and drug counseling, assault victim). It is worth mentioning, however, that the "life management" factor consisted of diagnoses like stress and "problems related to life management difficulty" and the "lifestyle" factor consisted of diagnoses such as inadequate sleep hygiene and "problems related to lifestyle."

The data compiled for this study came from the Defense Medical Surveillance System (DMSS), a central repository of medical surveillance data for the U.S. Armed Forces. ACSMs diagnosed with non-medical factors influencing health were identified by having an inpatient, outpatient, or TMDS encounter with a qualifying ICD-9-CM or ICD-10-CM diagnosis in any diagnostic position.

For the first study objective, percentages were calculated as the number of ACSMs presenting with a non-medical factor influencing health in 2022 divided by the mid-year population size. Covariates included sex, age, race and ethnicity, service branch, rank, education, marital status, deployment history, and history of mental health diagnosis (ICD-9-CM: 290*-319*; ICD-10-CM: F*). A service member was counted only once for each factor. The total number and frequency of specific ICD-9-CM and ICD-10-CM diagnoses for non-medical factors influencing health in 2022 were also evaluated.

For the second study objective, a case-control study design was used to assess the relationship of past year diagnosis of non-medical factors influencing health with suicide ideation or attempt. Suicide ideation and attempt were combined into a single variable because, although these conditions can have different risk factors, many risk factors are also shared, and it is possible to attempt suicide without reporting prior ideation.[18] Incident (i.e., first-ever diagnosis since joining military service) cases of suicidal ideation or attempt were identified by an inpatient, outpatient, or TMDS encounter between 2018 and 2022 with a qualifying diagnosis (ICD-9-CM: V62.84, E958.9; ICD-10-CM: R45.851, T14.91*) in any diagnostic position. Each incident case was matched to up to 3 controls on year of birth, sex, race, service branch, and year of entry into military service. Controls were required to be in service at the time of the case diagnosis and to have no qualifying suicidal ideation or attempt diagnoses on or prior to December 31, 2022. In a secondary analysis, the case-control study was repeated on a population of ACSMs who had no history of mental health diagnoses on or prior to December 31, 2022. Conditional logistic regression was used to calculate odds ratios and 95% confidence intervals. All analyses were performed using SAS® Enterprise Guide® software (version 8.3, SAS Inst Inc, Cary, NC).

Results

Period prevalence for non-medical risk factors

In 2022 there were 634,233 diagnoses of non-medical risk factors among 161,668 ACSMs (data not shown). The percentage and number of service members diagnosed for each factor are shown in **Table 1**. A service member could have multiple diagnoses for each factor, and the most common diagnoses for each factor are shown in **Table 2**. The most commonly diagnosed factor was Family and Upbringing (179,370 diagnoses among 49,381 individuals). The most common diagnoses within the Family and Upbringing factor were 'Problems in relationship with spouse or partner' (55% of total diagnoses), 'Disappearance and death of family member' (15%), and 'Problems related to primary support group' (9%) **(Table 2)**. Employment was the second-most commonly diagnosed factor (98,159 diagnoses among 36,803 individuals), and Other Psychosocial was the third-most commonly diagnosed (95,474 diagnoses among 34,920 individuals). The Physical Environment factor only included 4 diagnoses of Z586 "Inadequate drinking-water supply" among 3 individuals, so it was excluded from further analysis.

After inspection of the data, it appeared that health care providers were diagnosing the Perpetrator of Violence factor in the medical encounters for both victims and perpetrators. Of the 196 diagnoses in 2022 for ICD-10-CM code Y0701 'Husband, perpetrator of maltreatment and neglect', 141 (72%) were listed in male encounters and 55 (28%) were listed in female encounters. Among female encounters, 34 (62%) also had an injury diagnosis (ICD-10-CM diagnosis beginning with 'S' or 'T'), suggesting these were victims of violence. Among the male encounters, almost none had an injury diagnosis, and 63 (45%) had a counseling diagnosis beginning with Z71, suggesting these were perpetrators of violence.

Non-Hispanic Black service members were more frequently diagnosed for all non-medical risk factors compared to other racial and ethnic groups, with the exception of the Education and Literacy factor, which was similar for all groups **(Table 1)**. Similarly, ACSMs with a prior diagnosis of depression, anxiety, and post-traumatic stress disorder (PTSD) had a higher prevalence of non-medical risk factor diagnosis. Women, enlisted members, and those with less education also had higher percentages of diagnoses with many non-medical risk factors as compared to men, officers, and those with higher education levels. Married service members had lower prevalence of some factors (e.g., employment, alcohol and drug counseling, and lifestyle) compared to single, never-married members. The percentage diagnosed with Family and Upbringing and Life Management factors increased with increasing age. In contrast, those younger than age 20 years had the highest prevalence of Employment factor diagnosis. The Army had the highest prevalence of non-medical risk factor diagnosis for all factors except Life Management

TABLE 1. Active Component U.S. Service Members Diagnosed with Non-Medical Factors Influencing Health, 2022

	Education and Literacy		Employment		Housing and Economic		Social Environment		Family and Upbringing		Other Psychosocial		Sexual Behavior Counseling	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	236	0.02	36,803	2.84	1,141	0.09	19,255	1.48	49,381	3.81	34,920	2.69	785	0.06
Sex														
Male	164	0.02	27,299	2.55	893	0.08	14,012	1.31	35,545	3.32	26,147	2.44	572	0.05
Female	72	0.03	9,504	4.19	248	0.11	5,243	2.31	13,836	6.10	8,773	3.87	213	0.09
Age, y														
<20	42	0.05	3,131	3.78	59	0.07	1,776	2.14	1,331	1.61	1,600	1.93	29	0.03
20–24	82	0.02	13,376	3.22	476	0.11	6,527	1.57	14,286	3.44	12,947	3.12	317	0.08
25–29	56	0.02	8,788	2.90	299	0.10	4,137	1.37	12,311	4.07	8,772	2.90	239	0.08
30–34	31	0.01	5,061	2.41	175	0.08	2,321	1.10	8,502	4.04	5,029	2.39	126	0.06
35-39	11	0.01	3,608	2.26	69	0.04	1,915	1.20	7,117	4.46	3,720	2.33	45	0.03
40–44	8	0.01	1,881	2.32	32	0.04	1,559	1.92	3,876	4.77	1,948	2.40	24	0.03
45+	6	0.01	958	2.09	31	0.07	1,020	2.22	1,958	4.27	904	1.97	5	0.01
Race and ethnicity														
White, non-Hispanic	114	0.02	16,883	2.43	472	0.07	9,381	1.35	22,643	3.26	15,622	2.25	278	0.04
Black, non-Hispanic	39	0.02	9,295	4.49	336	0.16	4,390	2.12	12,490	6.03	9,286	4.48	253	0.12
Hispanic	56	0.02	6,669	2.79	211	0.09	3,513	1.47	9,178	3.84	6,635	2.78	160	0.07
Other	22	0.02	3,521	2.55	111	0.08	1,704	1.24	4,469	3.24	3,058	2.22	77	0.06
Unknown	5	0.03	435	2.32	11	0.06	267	1.43	601	3.21	319	1.70	17	0.09
Service														
Army	118	0.03	21,055	4.57	747	0.16	11,095	2.41	29,835	6.47	24,563	5.33	201	0.04
Navy	49	0.01	7,169	2.11	192	0.06	2,669	0.79	7,023	2.07	3,582	1.05	270	0.08
Air Force	46	0.01	5,593	1.74	134	0.04	4,221	1.31	9,932	3.08	5,176	1.61	288	0.09
Marine Corps	23	0.01	2,986	1.71	68	0.04	1,270	0.73	2,591	1.48	1,599	0.92	26	0.01
Rank/grade														
Junior enlisted (E1-E4)	158	0.03	20,358	3.78	733	0.14	9,908	1.84	20,188	3.75	18,646	3.46	377	0.07
Senior enlisted (E5-E9)	46	0.01	12,741	2.43	353	0.07	7,241	1.38	23,298	4.45	13,200	2.52	293	0.06
Junior officer (O1-O3)	22	0.02	2,214	1.68	29	0.02	970	0.73	2,631	1.99	1,642	1.24	96	0.07
Senior officer (O4-O10)	9	0.01	1,076	1.28	15	0.02	845	1.01	2,330	2.78	920	1.10	17	0.02
Warrant officer (W*)	1	0.01	414	2.15	11	0.06	291	1.51	934	4.84	512	2.66	2	0.01
Education level														
High school or less	165	0.02	25,803	3.17	894	0.11	12,861	1.58	31,289	3.84	24,638	3.03	501	0.06
Some college	25	0.02	4,372	2.88	121	0.08	2,519	1.66	7,780	5.13	4,534	2.99	97	0.06
Bachelor's or advanced degree	40	0.01	6,264	2.07	115	0.04	3,676	1.21	9,734	3.21	5,431	1.79	157	0.05
Unknown	6	0.02	364	1.27	11	0.04	199	0.70	578	2.02	317	1.11	30	0.11
Marital status														
Single, never married	151	0.03	17,969	3.11	480	0.08	8,774	1.52	12,081	2.09	14,676	2.54	521	0.09
Married	78	0.01	16,709	2.56	588	0.09	9,231	1.41	33,844	5.18	17,767	2.72	206	0.03
Other	7	0.01	2,125	3.19	73	0.11	1,250	1.88	3,456	5.19	2,477	3.72	58	0.09
Deployment history														
Ever deployed	31	0.01	7,632	1.91	183	0.05	4,979	1.25	14,372	3.60	7,696	1.93	182	0.05
Never deployed	205	0.02	29,171	3.25	958	0.11	14,276	1.59	35,009	3.90	27,224	3.03	603	0.07
Any prior mental health diagnosis														
Yes	125	0.03	24,085	4.98	841	0.17	12,162	2.52	35,445	7.34	23,318	4.83	357	0.07
No	111	0.01	12,718	1.56	300	0.04	7,093	0.87	13,936	1.71	11,602	1.42	428	0.05
Prior depressive disorder diagnosis														
Yes	54	0.04	9,118	7.30	384	0.31	4,369	3.50	13,839	11.08	8,144	6.52	112	0.09
No	182	0.02	27,685	2.36	757	0.06	14,886	1.27	35,542	3.03	26,776	2.28	673	0.06
Prior anxiety disorder diagnosis														
Yes	56	0.04	9,539	6.03	366	0.23	4,907	3.10	14,898	9.42	8,812	5.57	130	0.08
No	180	0.02	27,264	2.39	775	0.07	14,348	1.26	34,483	3.03	26,108	2.29	655	0.06
Prior PTSD diagnosis														
Yes	14	0.03	2,880	5.97	125	0.26	1,494	3.09	5,289	10.95	2,846	5.89	43	0.09
No	222	0.02	33,923	2.72	1,016	0.08	17,761	1.42	44,092	3.53	32,074	2.57	742	0.06

Abbreviations: y, year; PTSD, post-traumatic stress disorder.

TABLE 1 (cont.). Active Component U.S. Service Members Diagnosed with Non-Medical Factors Influencing Health, 2022

	Alcohol and Drug Counseling		Lifestyle		Life Management		Physical, Sexual and Psychological Abuse Victim		Assault Victim		Perpetrator of Violence	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Total	4,185	0.32	22,696	1.75	31,453	2.42	20,151	1.55	2,329	0.18	251	0.02
Sex												
Male	3,575	0.33	18,347	1.71	22,164	2.07	10,830	1.01	1,776	0.17	102	0.01
Female	610	0.27	4,349	1.92	9,289	4.10	9,321	4.11	553	0.24	149	0.07
Age, y												
<20	257	0.31	1,061	1.28	1,262	1.52	1,311	1.58	209	0.25	20	0.02
20–4	1,722	0.41	9,269	2.23	9,161	2.21	8,332	2.01	1,216	0.29	107	0.03
25–29	1,083	0.36	5,664	1.87	7,559	2.50	4,894	1.62	510	0.17	59	0.02
30–34	515	0.24	2,949	1.40	4,837	2.30	2,584	1.23	207	0.10	31	0.01
35–39	377	0.24	2,110	1.32	4,434	2.78	1,808	1.13	114	0.07	24	0.02
40–44	176	0.22	1,091	1.34	2,649	3.26	850	1.05	50	0.06	7	0.01
45+	55	0.12	552	1.20	1,551	3.38	372	0.81	23	0.05	3	0.01
Race and ethnicity												
White, non-Hispanic	1,990	0.29	9,846	1.42	14,806	2.13	9,127	1.31	1,043	0.15	93	0.01
Black, non-Hispanic	959	0.46	5,859	2.83	6,978	3.37	5,163	2.49	539	0.26	76	0.04
Hispanic	805	0.34	4,633	1.94	5,819	2.44	3,996	1.67	512	0.21	60	0.03
Other	362	0.26	2,101	1.52	3,353	2.43	1,654	1.20	210	0.15	19	0.01
Unknown	69	0.37	257	1.37	497	2.65	211	1.13	25	0.13	3	0.02
Service												
Army	725	0.16	10,937	2.37	13,036	2.83	11,240	2.44	1,053	0.23	130	0.03
Navy	1,935	0.57	3,602	1.06	6,318	1.86	2,776	0.82	507	0.15	56	0.02
Air Force	1,315	0.41	5,029	1.56	9,700	3.01	4,930	1.53	316	0.10	56	0.02
Marine Corps	210	0.12	3,128	1.79	2,399	1.37	1,205	0.69	453	0.26	9	0.01
Rank/grade												
Junior enlisted (E1-E4)	2,503	0.46	12,129	2.25	12,888	2.39	11,389	2.12	1,623	0.30	159	0.03
Senior enlisted (E5-E9)	1,417	0.27	8,387	1.60	14,188	2.71	7,331	1.40	579	0.11	79	0.02
Junior officer (O1-O3)	161	0.12	1,335	1.01	2,173	1.65	794	0.60	94	0.07	9	0.01
Senior officer (O4-O10)	80	0.10	610	0.73	1,813	2.16	428	0.51	20	0.02	4	0.00
Warrant officer (W*)	24	0.12	235	1.22	391	2.03	209	1.08	13	0.07		
Education level												
High school or less	3,369	0.41	16,185	1.99	18,979	2.33	14,753	1.81	1,903	0.23	190	0.02
Some college	337	0.22	2,584	1.70	4,768	3.14	2,546	1.68	197	0.13	35	0.02
Bachelor's or advanced degree	417	0.14	3,635	1.20	7,247	2.39	2,702	0.89	205	0.07	25	0.01
Unknown	62	0.22	292	1.02	459	1.61	150	0.53	24	0.08	1	0.00
Marital status												
Single, never married	2,365	0.41	12,252	2.12	11,563	2.00	8,184	1.42	1,395	0.24	102	0.02
Married	1,581	0.24	8,817	1.35	17,605	2.69	10,298	1.58	817	0.13	133	0.02
Other	239	0.36	1,627	2.44	2,285	3.43	1,669	2.50	117	0.18	16	0.02
Deployment history												
Ever deployed	1,119	0.28	5,294	1.33	10,369	2.60	4,364	1.09	326	0.08	39	0.01
Never deployed	3,066	0.34	17,402	1.94	21,084	2.35	15,787	1.76	2,003	0.22	212	0.02
Any prior mental health diagnosis												
Yes	2,759	0.57	12,742	2.64	19,901	4.12	14,885	3.08	1,091	0.23	154	0.03
No	1,426	0.18	9,954	1.22	11,552	1.42	5,266	0.65	1,238	0.15	97	0.01
Prior depressive disorder diagnosis												
Yes	977	0.78	4,130	3.31	6,201	4.97	6,746	5.40	352	0.28	73	0.06
No	3,208	0.27	18,566	1.58	25,252	2.15	13,405	1.14	1,977	0.17	178	0.02
Prior anxiety disorder diagnosis												
Yes	925	0.59	4,546	2.88	8,035	5.08	6,715	4.25	381	0.24	64	0.04
No	3,260	0.29	18,150	1.59	23,418	2.06	13,436	1.18	1,948	0.17	187	0.02
Prior PTSD diagnosis												
Yes	325	0.67	1,452	3.01	2,310	4.78	3,271	6.78	171	0.35	32	0.07
No	3,860	0.31	21,244	1.70	29,143	2.33	16,880	1.35	2,158	0.17	219	0.02

Abbreviations: y, year; PTSD, post-traumatic stress disorder.

TABLE 2. Three Most Common Diagnoses for Each Non-Medical Factor, Total Diagnoses, Active Component U.S. Service Members, 2022[a]

ICD Code	ICD Code Description	No.	%
Education and literacy (n=438)			
Z559	Problems related to education and literacy, unspecified	267	61.0
Z558	Other problems related to education and literacy	101	23.1
Z552	Failed school examinations	53	12.1
Employment (n=98,159)			
Z5689	Other problems related to employment	48,765	49.7
Z569	Unspecified problems related to employment	20,669	21.1
Z566	Other physical and mental strain related to work	18,300	18.6
Housing, economic (n=2,348)			
Z5989	Other problems related to housing and economic circumstances	877	37.4
Z599	Problem related to housing and economic circumstances, unspecified	837	35.6
Z5900	Homelessness, unspecified	169	7.2
Social environment (n=45,191)			
Z600	Problems of adjustment to life cycle transitions	36,120	79.9
Z609	Problem related to social environment, unspecified	3,112	6.9
Z603	Acculturation difficulty	2,394	5.3
Family and upbringing (n=179,370)			
Z630	Problems in relationship with spouse or partner	99,122	55.3
Z634	Disappearance and death of family member	26,288	14.7
Z638	Other specified problems related to primary support group	15,547	8.7
Other psychosocial (n=95,474)			
Z658	Other problems related to psychosocial circumstances	58,221	61.0
Z659	Problem related to unspecified psychosocial circumstances	17,326	18.1
Z653	Problems related to other legal circumstances	13,322	14.0
Sexual behavior counseling (n=1,235)			
Z701	Counseling related to patient's sexual behavior and orientation	1,053	85.3
Z703	Counseling related to combined concerns regarding sexual attitude, behavior and orientation	105	8.5
Z700	Counseling related to sexual attitude	70	5.7
Alcohol, drug counseling (n=13,552)			
Z7141	Alcohol abuse counseling and surveillance of alcoholic	12,449	91.9
Z7151	Drug abuse counseling and surveillance of drug abuser	889	6.6
Z714	Alcohol abuse counseling and surveillance	110	0.8
Lifestyle (n=41,119)			
Z72821	Inadequate sleep hygiene	13,091	31.8
Z7289	Other problems related to lifestyle	11,908	29.0
Z7251	High risk heterosexual behavior	5,432	13.2
Life management (n=65,954)			
Z733	Stress, not elsewhere classified	59,059	89.5
Z7389	Other problems related to life management difficulty	3,947	6.0
Z739	Problem related to life management difficulty, unspecified	845	1.3
Victim of physical, sexual, psychological abuse (n=87,094)			
Z62810	Personal history of physical and sexual abuse in childhood	18,578	21.3
Z91410	Personal history of adult physical and sexual abuse	14,176	16.3
Z62811	Personal history of psychological abuse in childhood	7,394	8.5
Victim of assault (n=3,785)			
Y040XXA	Assault by unarmed brawl or fight, initial encounter	801	21.2
Y09	Assault by unspecified means	652	17.2
Y042XXA	Assault by strike against or bumped into by another person, initial encounter	588	15.5
Perpetrator of violence (n=510)			
Y0701	Husband, perpetrator of maltreatment and neglect	196	38.4
Y079	Unspecified perpetrator of maltreatment and neglect	130	25.5
Y0759	Other non-family member, perpetrator of maltreat and neglect	61	12.0

Abbreviations: ICD, International Classification of Diseases; n, number.
[a] Physical Environment factor only included 4 diagnoses of Z586 “Inadequate drinking-water supply” among 3 individuals, so it was excluded from further analysis.

(which was highest among Air Force members) and Alcohol and Drug Counseling (highest among Navy members).

Suicide ideation or attempt and non-medical risk factors

There were 85,962 cases and 242,763 matched controls identified to assess the relationship between suicide ideation or attempt and non-medical risk factors diagnosed in the preceding year (data not shown). Of the identified cases, 95% were diagnosed with suicide ideation and 5% were diagnosed with suicide attempt. A total of 42,672 (49.6%) cases had a diagnosis for any non-medical risk factor within a year preceding incident diagnosis, compared to 18,921 (7.8%) controls. For cases, the average (mean) number of days between non-medical factor diagnosis and incident suicide ideation or attempt was 66 days, and the median was 203 days.

After controlling for year of birth, sex, race, branch of military service, and year of entry into service, there was a statistically significant positive association between past year diagnosis of all non-medical risk factors and diagnosis of suicide ideation or attempt **(Table 3)**. Odds of suicidal ideation or attempt were highest for Housing and Economics (odds ratio [OR] 27.3), followed by Physical, Sexual and Psychological Abuse (OR 13.7), Employment (OR

TABLE 3. Adjusted Odds of Incident Suicidal Ideation or Attempt, Active Component U.S. Service Members, 2018–2022

	Cases		Controls					
	No.	%	No.	%	OR	95% LL	95% UL	*p*-value
Education and literacy[a]								
Yes	108	0.1	47	0.0	6.4	4.5	9.0	<.0001
No	85,854	99.9	242,716	100.0	Reference	–	–	
Employment[a]								
Yes	15,678	18.2	4,302	1.8	12.9	12.4	13.4	<.0001
No	70,284	81.8	238,461	98.2	Reference	–	–	
Housing, economic[a]								
Yes	1,123	1.3	122	0.1	27.3	22.5	33.1	<.0001
No	84,839	98.7	242,641	99.9	Reference	–	–	
Social environment[a]								
Yes	6,334	7.4	2,608	1.1	7.4	7.1	7.8	<.0001
No	79,628	92.6	240,155	98.9	Reference	–	–	
Family upbringing[a]								
Yes	16,708	19.4	5,931	2.4	10.9	10.5	11.2	<.0001
No	69,254	80.6	236,832	97.6	Reference	–	–	
Other psychosocial[a]								
Yes	9,623	11.2	4,392	1.8	7.5	7.2	7.8	<.0001
No	76,339	88.8	238,371	98.2	Reference	–	–	
Sexual behavior[a]								
Yes	195	0.2	271	0.1	2.0	1.7	2.5	<.0001
No	85,767	99.8	242,492	99.9	Reference	–	–	
Alcohol, drugs[a]								
Yes	975	1.1	781	0.3	3.6	3.3	4.0	<.0001
No	84,987	98.9	241,982	99.7	Reference	–	–	
Lifestyle[a]								
Yes	4,531	5.3	2,529	1.0	5.4	5.1	5.7	<.0001
No	81,431	94.7	240,234	99.0	Reference	–	–	
Life management[a]								
Yes	4,537	5.3	2,558	1.1	5.3	5.0	5.6	<.0001
No	81,425	94.7	240,205	98.9	Reference	–	–	
Victim of physical, sexual, psychological abuse[a]								
Yes	9,998	11.6	2,521	1.0	13.7	13.1	14.4	<.0001
No	75,964	88.4	240,242	99.0	Reference	–	–	
Victim of assault[a]								
Yes	654	0.8	507	0.2	3.7	3.3	4.2	<.0001
No	85,308	99.2	242,256	99.8	Reference	–	–	
Perpetrator of violence[a]								
Yes	108	0.1	50	0.0	5.8	4.2	8.2	<.0001
No	85,854	99.9	242,713	100.0	Reference	–	–	

Abbreviations: No., number; OR, odds ratio; LL, lower limit; UL, upper limit.
[a] Diagnosis within preceding 365 days.

12.9), and Family and Upbringing (OR 10.9) factors.

A secondary analysis calculated the odds of suicidal ideation or attempt among service members without prior mental health diagnoses, using the same matching factors as the primary analysis. After exclusions, 3,204 cases were matched to 9,239 controls. Among service members with no prior mental health diagnoses, there was a statistically significant positive association between past year diagnosis of Employment (OR 56.0), Social Environment (OR 35.9), Life Management (OR 16.6), Family Upbringing (OR 15.5), Other Psychosocial (OR 11.5), Physical, Sexual and Psychological Abuse (OR 8.3), and Lifestyle (OR 4.17), factor with diagnosis of suicide ideation or attempt **(Table 4)**.

A sensitivity analysis was conducted to determine whether adjustment for deployment history or marital status would change the odds ratio estimates in both the primary and secondary logistic regression analyses. No significant deviations from the original odds ratio estimates were observed, suggesting that deployment history and marital status were not significant confounders in these associations.

TABLE 4. Adjusted Odds of Incident Suicidal Ideation or Attempt, Active Component U.S. Service Members with No History of Mental Health Diagnoses, 2018–2022

	Cases		Controls					
	No.	%	No.	%	OR	95% LL	95% UL	*p*-value
Education and literacy[b]								
Yes	0	0.0	0	0.0	N/A[a]			
No	3,204	100.0	9,239	100.0	Reference	–	–	
Employment[b]								
Yes	490	15.3	34	0.4	56.0	37.5	83.8	<.0001
No	2,714	84.7	9,205	99.6	Reference	–	–	
Housing, economic[b]								
Yes	4	0.1	0	0.0	N/A[a]			
No	3,200	99.9	9,239	100.0	Reference	–	–	
Social environment[b]								
Yes	375	11.7	33	0.4	35.9	24.7	52.1	<.0001
No	2,829	88.3	9,206	99.6	Reference	–	–	
Family upbringing[b]								
Yes	234	7.3	50	0.5	15.5	11.2	21.4	<.0001
No	2,970	92.7	9,189	99.5	Reference	–	–	
Other psychosocial[b]								
Yes	190	5.9	49	0.5	11.5	8.4	15.9	<.0001
No	3,014	94.1	9,190	99.5	Reference	–	–	
Sexual behavior[b]								
Yes	0	0.0	6	0.1	N/A[a]			
No	3,204	100.0	9,233	99.9	Reference	–	–	
Alcohol, drugs[b]								
Yes	3	0.1	9	0.1	1.0	0.3	3.7	1.0000
No	3,201	99.9	9,230	99.9	Reference	–	–	
Lifestyle[b]								
Yes	43	1.3	30	0.3	4.2	2.6	6.7	<.0001
No	3,161	98.7	9,209	99.7	Reference	–	–	
Life management[b]								
Yes	125	3.9	23	0.2	16.6	10.5	26.1	<.0001
No	3,079	96.1	9,216	99.8	Reference	–	–	
Victim of physical, sexual, psychological abuse[b]								
Yes	42	1.3	14	0.2	8.3	4.5	15.3	<.0001
No	3,162	98.7	9,225	99.8	Reference	–	–	
Victim of assault[b]								
Yes	3	0.1	13	0.1	0.6	0.2	2.3	0.4787
No	3,201	99.9	9,226	99.9	Reference	–	–	
Perpetrator of violence[b]								
Yes	1	0.0	1	0.0	3.0	0.2	48.0	0.4373
No	3,203	100.0	9,238	100.0	Reference	–	–	

Abbreviations: No., number; OR, odds ratio; LL, lower limit; UL, upper limit.
[a] Odds ratio could not be calculated due to small number of cases or controls.
[b] Diagnosis within preceding 365 days.

Discussion

The study documents, for the first time, the frequency of diagnosis for non-medical risk factors influencing health among ACSMs. Notably, non-Hispanic Black individuals consistently exhibited the highest percentages in all risk categories, highlighting the disproportionate burden they face. This finding is consistent with other research within the U.S. population showing that the non-Hispanic Black population has less economic security and more problems associated with family and upbringing.[19,20]

Despite facing greater social adversity, non-Hispanic Black service members exhibit lower rates of suicidal ideation and attempts.[21] Future research should explore the protective factors, such as cultural or social resilience, that may contribute to this trend. Additionally, studies should assess whether non-medical risk factor codes accurately capture suicide risk across different racial groups. Addressing these gaps could enhance suicide prevention efforts and improve risk assessment strategies.

Age proved interesting, as those trends were not consistent for all factors. Categories such as Family and Upbringing and Life Management demonstrated a percentage increase with increase in age, while non-medical factors affecting Employment and Lifestyle saw inverse effects with increasing age. Similar findings are demonstrated within the U.S. population for employment factors, as those who are older tend to find more fulfillment and less likelihood of feeling overwhelmed compared to their younger counterparts.[22] The vast majority of Life Management diagnoses (89%) in this study were for 'Stress, not elsewhere classified', the opposite of what is observed in the U.S. population, where stress levels typically decrease as individuals age.[23] This could be due to unique military experiences such as deployments, change in duty station, or combat exposures. Additional military-specific research should, however, investigate these age-related trends.

This analysis further revealed that individuals with diagnoses of certain factors were at heightened risk for suicide ideation or attempt both before and after excluding those with prior histories of mental health diagnoses. This finding is consistent with findings from broader U.S. population studies and studies conducted in veterans,[17,24,25] suggesting that certain non-medical factors, including elements of family background, upbringing, prior trauma, and adverse life experiences, are critical considerations, as they may contribute to suicidal behaviors long before individuals enlist in the military. This finding also presents an opportunity for possible interventions, particularly for service members presenting with these factors but not already engaged in mental health treatment.

Limitations to this study include variability in coding practices among providers or coders. The use of ICD-9-CM and ICD-10-CM diagnoses to identify both factors and suicidal ideation and attempt outcomes likely led to the under-capture of both exposures and outcomes. It is also possible that those with a factor diagnosis may be followed more closely by their providers for suicidal ideation or attempt, which could contribute towards the associations observed in this study. Additional analyses such as by using self-reported mental health and suicidal ideation from Periodic Health Assessments could help to confirm the associations reported in this study.

Future studies could also consider investigating additional comorbidities associated with these factors, such as obesity and stroke,[26,27] as well as the compound effects of multiple non-medical risk factors. Service members should be encouraged to report any non-medical factors influencing health so interventions can be targeted, and so that more complete data exist on the magnitude of issues. Understanding the effects of non-medical risk factors on medical conditions, like suicide ideation or attempt, can hopefully mitigate their effects and decrease their prevalence within the Military Health System.

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Correlation Between Mean Temperature and Incidence of Tick-borne Diseases Among Active Duty Service Members in the Contiguous U.S., 2000–2023

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Medical encounter data and reportable medical events from the Defense Medical Surveillance System were utilized to establish that from 2000 to 2023 there were 2,869 cases of Lyme disease and 175 cases of Rocky Mountain spotted fever among U.S. active component service members within the contiguous U.S. Coincident with a 5.3% (0.63°C) increase in annual mean temperature over the course of the 24-year surveillance period, annual Lyme disease incidence rates increased 35.5% overall, concurrently peaking with mean temperature in 2012 and 2016. After adjusting for annual mean, minimum and maximum temperatures, annual total precipitation, and regional climate, in addition to adjusting for age group, race and ethnicity, sex, and service, incidence rate ratios of both tick-borne diseases did not significantly change with increases in climatic variables. Adjusted incidence rate ratios of both tick-borne diseases increased with increasing age group.

What are the new findings?

Annual Lyme disease incidence rates peaked concurrently with annual mean temperatures. Incidence rate ratios for Lyme disease were highest in the Southeast compared to the Northeast, while Rocky Mountain spotted fever incidence rate ratios were highest in the South compared to the Southeast. Annual Lyme disease and Rocky Mountain spotted fever incidence rates ratios increased with increasing age group.

What is the impact on readiness and force health protection?

Incidence of both Lyme disease and Rocky Mountain spotted fever among U.S. active component service members may increase with worsening global warming. Evaluating how temperature affects these tick-borne diseases regionally helps identify protective measures for service members at risk.

Global warming can facilitate tick-borne disease (TBD) transmission through improved environmental favorability for ticks, extending their geographic range and periods of activity.[1] Given that nearly 1.1 million U.S. active component service members (ACSMs) are stationed across the U.S., where several TBDs are endemic, it is crucial to understand how rising temperatures may influence the burden of such diseases.[2,3]

Evidence for the relationship between temperature and TBD in the U.S. is conflicting. Analysis of Lyme disease cases reported from 2000 to 2017 to the Centers for Disease Control and Prevention (CDC) determined that warming annual temperatures were associated with increasing incidence in the Northeast.[4] A separate study used data from high-incidence states during 2000 to 2016 to predict that in subsequent decades, Lyme disease cases will increase by 21%, given the projected 2°C increase in annual mean temperature by mid-century.[5] Meanwhile, a study utilizing data from the Kansas, Missouri, Arkansas, and Oklahoma state departments of health determined that average daytime land surface temperature above 35°C was a limiting factor for Rocky Mountain spotted fever (RMSF) incidence from 2005 to 2014.[6] In further contrast, within the same surveillance period a cross-sectional study found that temperature was not associated with the presence or abundance of Lyme disease cases in southwest Virginia.[7] Research on ACSMs in the eastern U.S. demonstrated a 5.7% increase in Lyme disease from 2006-2012, while another study has shown the Northeast has the highest incidence of Lyme disease from 2004 to 2013.[8,9] Considering that minute changes in global warming can lead to considerable fluctuations in TBD burden, additional research must verify the relationship between temperature and TBD incidence, specifically among ACSMs, as there is no available literature on this topic specific to the U.S. Armed Forces.[10,11]

The objectives of this study were to identify the incidence of the 2 TBDs most frequently diagnosed within the Military Health System (MHS) among ACSMs and evaluate the correlation between temperature and incidence of each TBD, to inform pertinent public health professionals on control measures such as improvements to uniform permethrin treatment practices.[12,13] Data available to the Armed Forces Health Surveillance Division (AFHSD), in conjunction with National Oceanic and Atmospheric Administration (NOAA) climatic data, may provide further clarity on the correlation between climate changes and TBD occurrence.

Methods

This study included ACSMs from January 1, 2000 through December 31, 2023. Demographic and medical encounter data were obtained from the Defense Medical Surveillance System (DMSS) for confirmed cases of RMSF and Lyme disease acquired in the contiguous U.S. Diagnoses were ascertained from inpatient and outpatient encounter data, and reportable medical events (RMEs) of individuals who received medical care either in the MHS or civilian facilities in the purchased care system.

Adhering to the AFHSD surveillance case definition for RMSF, a case of RMSF was defined as 1 confirmed RME of RMSF or spotted fever rickettsiosis.[14] Deviating from the AFHSD case definition, laboratory or epidemiological data were not included to confirm a RMSF case. As of January 1, 2010, RMEs of RMSF are expected to be reported as spotted fever rickettsioses, although this study identified RMEs of RMSF reported as RMSF after that date, through to 2017.[15] Adhering to the AFHSD surveillance case definition for Lyme disease, a case of Lyme disease was defined as either 1 confirmed RME of Lyme disease, 1 inpatient encounter with a qualifying code in any diagnostic position, or 2 outpatient encounters within 60 days of one another with a qualifying code in any diagnostic position.[16] Qualifying codes for Lyme disease were International Classification of Diseases, 9th Revision (ICD-9) code 088.81, or International Classification of Diseases, 10th Revision (ICD-10) codes beginning with A69.2.[16]

The first qualifying encounter or RME was deemed the incident encounter. ACSMs diagnosed with the TBD of interest before the surveillance period were excluded, and an individual could qualify as a Lyme disease or RMSF case only once. The location in which each TBD was acquired was determined to be the location of the facility in which the incident diagnosis was made. Demographic variables of interest were age, sex, race and ethnicity, service, and grade.

U.S. climate data on mean annual temperature and total annual precipitation were acquired from the National Oceanic and Atmospheric Administration (NOAA).[17]

The total numbers of each TBD were determined, and overall incidence rates for each TBD were calculated as diagnoses per 100,000 person-years (p-yrs) and stratified by age group, sex, race and ethnicity, service, and climate region (referred to as "regional climate" in this paper) as defined by NOAA.[17] Annual incidence rates for Lyme disease and RMSF were also calculated as diagnoses per 100,000 p-yrs. The subgroup of each non-ordinal demographic variable with the most incident cases was selected as the reference group for adjusted incidence rate ratios (aIRRs). Poisson regression was used to calculate aIRRs (adjusted for annual mean temperature, annual minimum temperature, annual maximum temperature, annual total precipitation, regional climate, age group, race and ethnicity, sex, and service) and 95% confidence intervals (CIs) for each TBD. All analyses were conducted using SAS-Enterprise Guide (version 8.3).

Results

Among ACSMs in the contiguous U.S. from 2000 through 2023, there were 2,869 Lyme disease cases at a rate of 10.7 per 100,000 p-yrs, and 175 RMSF cases at a rate of 0.7 per 100,000 p-yrs **(Table 1)**. Cases of both TBDs had a mean age of 31.3 years (standard deviation [SD]=8.7, range=18-61) (data not shown).

The highest incidence rates of Lyme disease (52.2 cases per 100,000 p-yrs) occurred in the Northeast while the highest rates of RMSF occurred in Ohio Valley (1.3 cases per 100,000 p-yrs) **(Table 1)**. Lyme disease incidence rates increased with increasing age group, ranging from 7.0 cases per 100,000 p-yrs among ACSMs aged less than 20 years to 19.9 cases per 100,000 p-yrs among those aged 40 or more years **(Table 1)**. Similarly, RMSF incidence rates increased with increasing age group, ranging from 0.4 cases per 100,000 p-yrs among ACSMs aged less than 20 years to 1.0 case per 100,000 p-yrs among those aged 40 or more years **(Table 1)**. Lyme disease and RMSF incidence rates were highest among non-Hispanic White ACSMs, with this racial and ethnic group experiencing 13.0 Lyme disease cases per 100,000 p-yrs and 0.8 RMSF cases per 100,000 p-yrs **(Table 1)**. Women had the highest rates of Lyme disease (14.0 cases per 100,000 p-yrs) while men had slightly higher rates of RMSF than women (0.7 cases per 100,000 p-yrs) **(Table 1)**. Despite the Army having the greatest number of ACSMs compared to all other services, the incidence rates of Lyme disease were highest among Coast Guard members (28.6 cases per 100,000 p-yrs) and incidence rates of RMSF were highest among Marines (1.2 cases per 100,000 p-yrs) **(Table 1)**.[2]

Overall annual mean temperature increased 5.3% (0.6°C) from 2000 to 2023, hitting a high of 12.9°C in 2012 and a low of 11.3°C in 2008 **(Figure 1a)**. Mean annual temperatures were highest in the South and Southeast **(Figure 1a)**. Overall total annual precipitation increased 4.5% (1.3 in.) over the surveillance period, hitting a high of 34.6 inches in 2018 and a low of 27.5 inches in 2012 **(Figure 1b)**. Total annual precipitation was highest in the Northeast, Southeast, and Ohio Valley **(Figure 1b)**.

Lyme disease incidence increased from 80 cases at a rate of 7.5 cases per 100,000 p-yrs in 2000 to 108 cases at a rate of 10.1 cases per 100,000 p-yrs in 2023 **(Figures 2, 3a)**. Over the 24-year surveillance period, the second highest peak in annual Lyme disease incidence rate (16.2 cases per 100,000 p-yrs) coincided with the highest annual mean temperature (12.9°C), highest annual maximum temperature (19.8°C), and lowest annual total precipitation (27.5 in.) **(Figures 1b, 3a)**. The highest annual Lyme disease incidence rate (18.2 cases per 100,000 p-yrs) coincided with the second-highest annual mean temperature (12.7°C), second highest annual maximum temperature (19.3°C), and highest annual minimum temperature (6.2°C) **(Figure 3a)**. As mean temperature increased by 9.9% from 2011 to 2012, Lyme disease rates increased by 24.2%, and as mean temperature increased by 2.3% from 2015 to 2016, rates increased by 41.9% **(Figure 3a)**. RMSF incidence decreased from 16 cases at a rate of 1.5 cases per 100,000 p-yrs in 2000 to 7 cases at a rate of 0.7 cases per 100,000 p-yrs in 2023, **(Figures 2, 3b)**. Rates were highest at 1.5 cases per 100,000 p-yrs in 2000 and 2017, followed by 1.1 cases per 100,000

TABLE 1. Incidence Rates of Lyme Disease and Rocky Mountain Spotted Fever, by Demographic Variables, Active Component Service Members, Contiguous U.S., 2000–2023

	Lyme disease			Rocky Mountain spotted fever		
	No.	Person-years	Rate[a]	No.	Person-years	Rate[a]
Total	2,869	26,797,177	10.7	175	26,797,177	0.7
Regional climate						
Northeast	1,161	2,222,856	52.2	13	2,222,856	0.6
Southeast	880	9,872,083	8.9	109	9,872,083	1.1
Northwest	51	1,538,504	3.3	1	1,538,504	0.1
Ohio Valley	244	2,050,622	11.9	26	2,050,622	1.3
Upper Midwest	13	98,075	13.3	0	98,075	0.0
South	280	4,748,720	5.9	20	4,748,720	0.4
Southwest	69	1,665,097	4.1	3	1,665,097	0.2
West	150	4,031,151	3.7	2	4,031,151	0.0
Northern Rockies and Plains	21	570,070	3.7	1	570,070	0.2
Age group, y						
<20	143	2,053,321	7.0	9	2,053,321	0.4
20–24	659	8,500,628	7.8	39	8,500,628	0.5
25–29	580	6,028,611	9.6	35	6,028,611	0.6
30–34	444	4,106,254	10.8	37	4,106,254	0.9
35–39	482	3,283,111	14.7	26	3,283,111	0.8
40+	561	2,825,252	19.9	29	2,825,252	1.0
Racial and ethnic group						
Non-Hispanic White	2,108	16,176,605	13.0	133	16,176,605	0.8
Non-Hispanic Black	257	4,363,708	5.9	13	4,363,708	0.3
Hispanic	254	3,474,928	7.3	17	3,474,928	0.5
Other/unknown[b]	250	2,781,936	9.0	12	2,781,936	0.4
Sex						
Male	2,290	22,659,259.0	10.1	151	22,659,259	0.7
Female	579	4,137,917.5	14.0	24	4,137,918	0.6
Service branch						
Army	1,085	9,500,810	11.4	59	9,500,810	0.6
Navy	649	6,695,784	9.7	41	6,695,784	0.6
Marine Corps	370	3,456,627	10.7	43	3,456,627	1.2
Air Force, Space Force	531	6,324,893	8.4	27	6,324,893	0.4
Coast Guard	234	819,063	28.6	5	819,063	0.6

Abbreviations: No., number; y, years.
[a] Crude incidence rate per 100,000 person-years.
[b] Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race or ethnicity.

p-yrs in 2012 **(Figure 3b)**. As mean temperature increased by 9.9% from 2011 to 2012, RMSF rates increased by 32.1% **(Figure 3b)**.

Throughout the surveillance period, annual Lyme disease incidence rates were consistently highest in the Northeast and intermittently highest in the Upper Midwest **(Figure 4a)**. There was no clear trend in regional increases in annual RMSF incidence rates, however, the Southeast consistently had relatively high annual incidence rates over the surveillance period **(Figure 4b)**. There were also noticeable spikes in incidence rates in Ohio Valley during 2005, 2008, 2017, 2020, and 2021 **(Figure 4b)**.

After adjusting for all demographic variables of interest, for every 1°C increase in mean temperature and every 1 inch increase in total precipitation, the incidence rate of Lyme disease did not change **(Table 2)**. For every 1°C increase in annual minimum temperature, the incidence rate ratio of RMSF increased by 20% (aIRR 1.2; 95% CI, 1.0-1.4) **(Table 2)**. For every 1°C increase in annual mean temperature or 1 inch increase in total precipitation,

FIGURE 1a. Overall and Region-specific Annual Mean Temperature, Contiguous U.S., 2000–2023

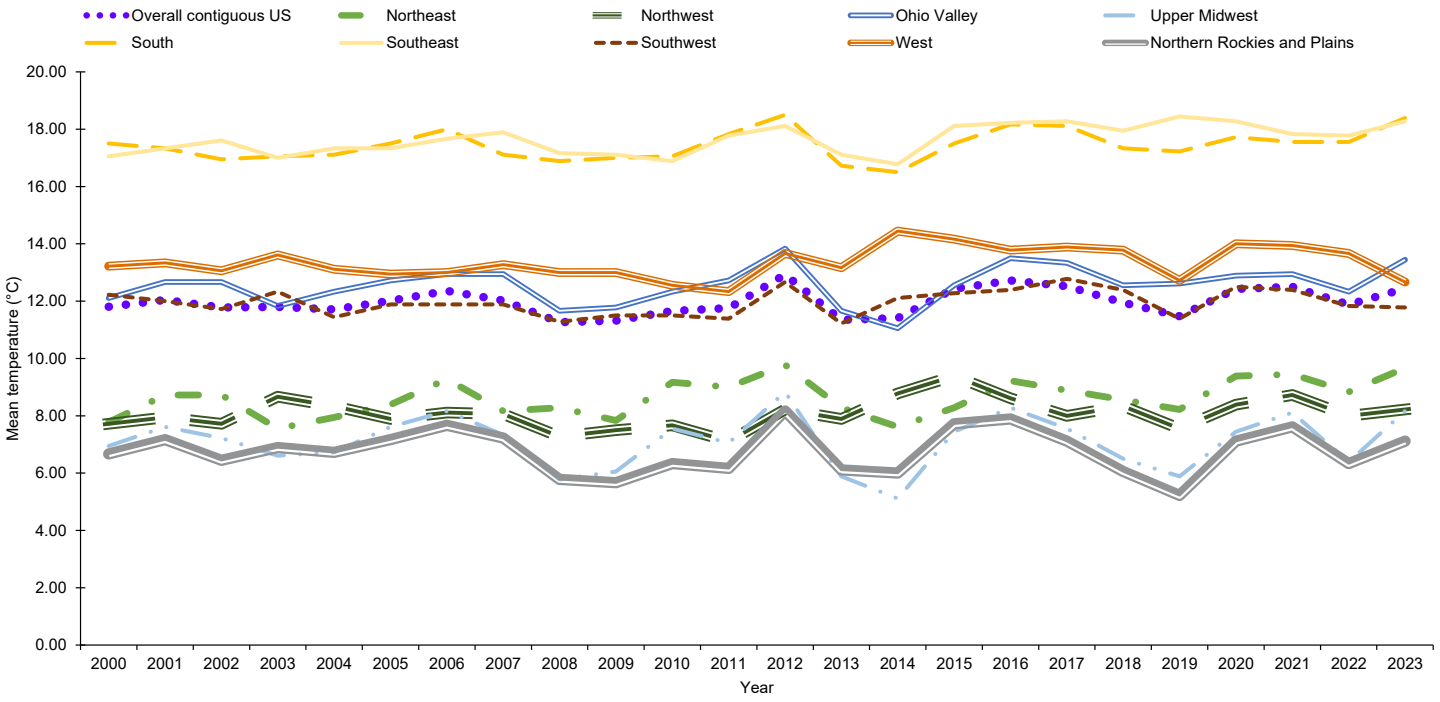


FIGURE 1b. Overall and Region-specific Annual Total Precipitation, Contiguous U.S., 2000–2023

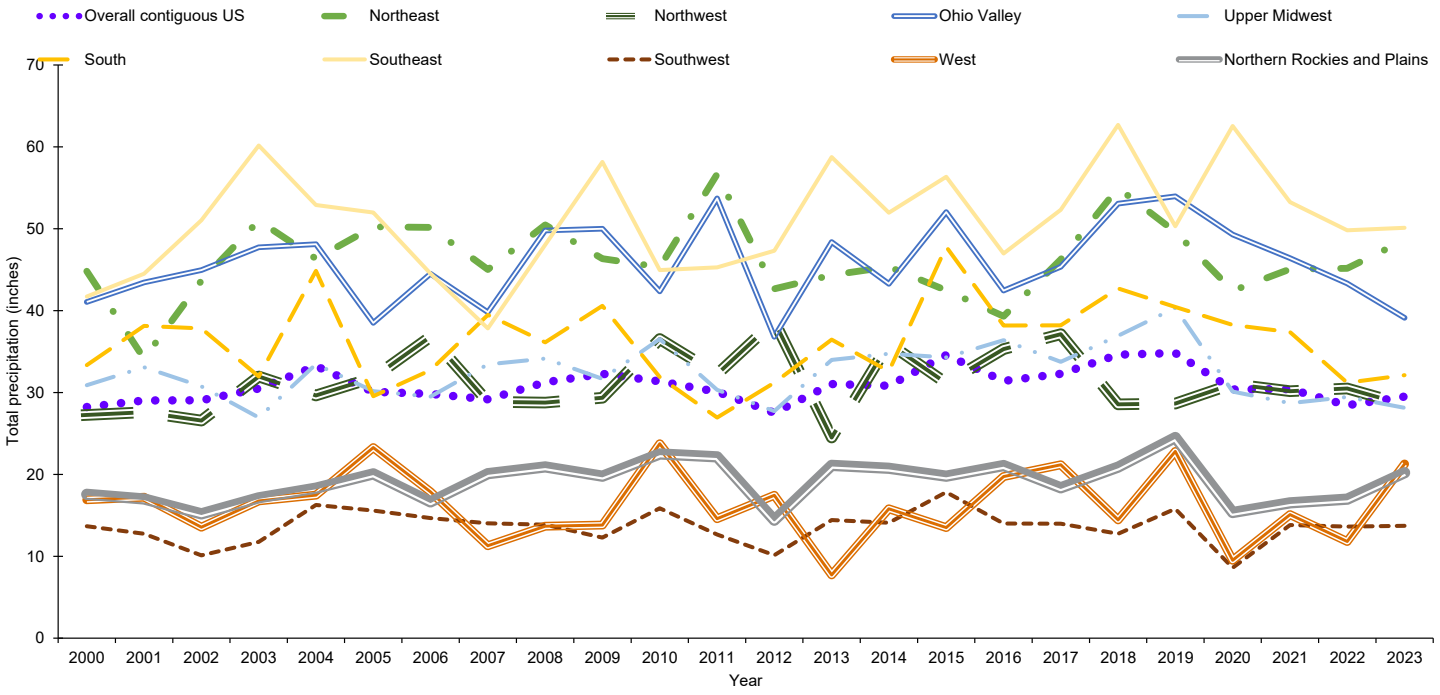


FIGURE 2. Annual Incidence of Lyme Disease and Rocky Mountain Spotted Fever, Active Component Service Members, Contiguous U.S., 2000–2023

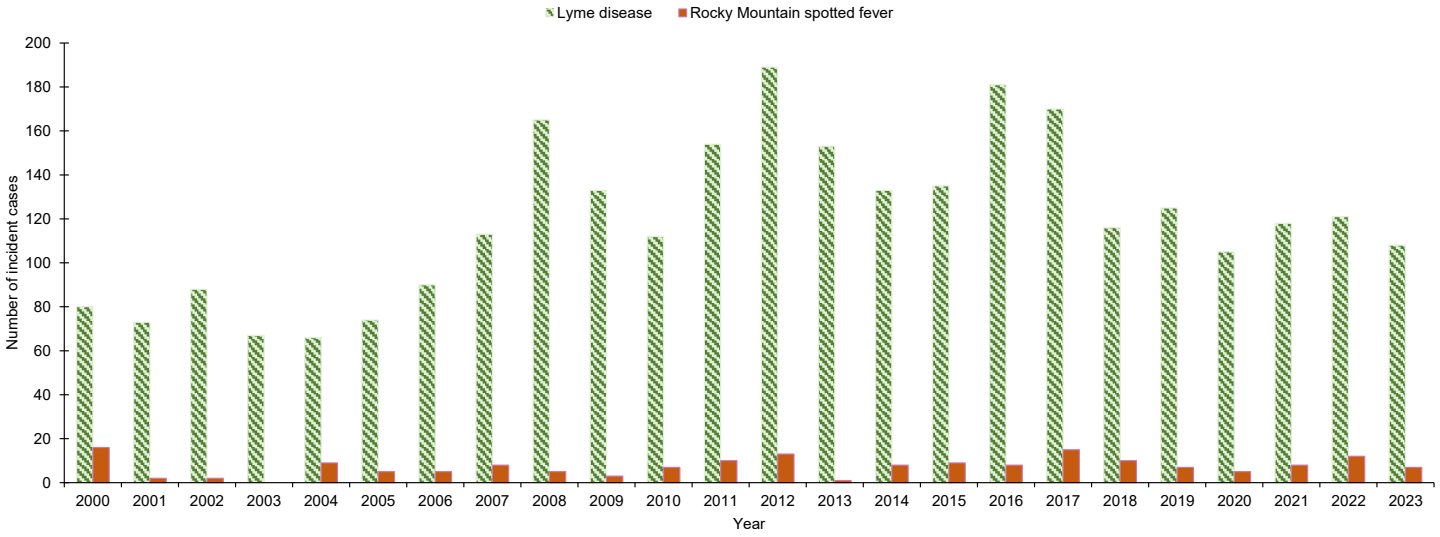
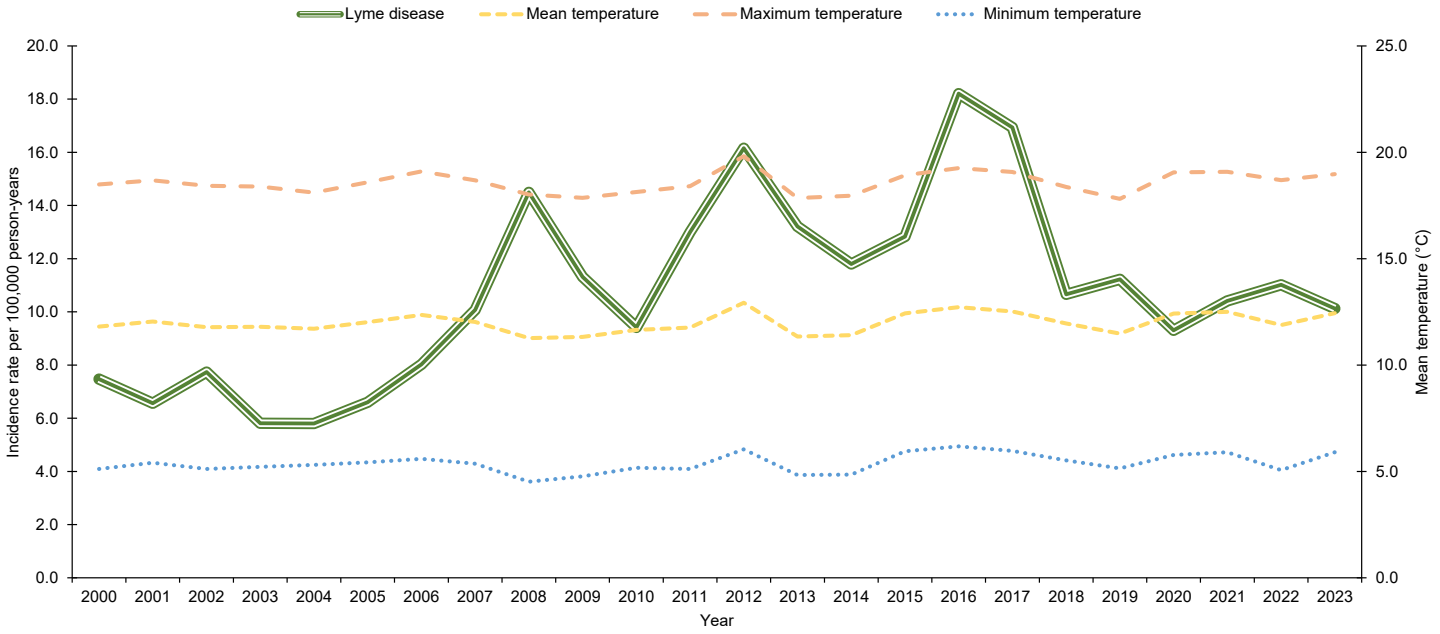


FIGURE 3a. Overall Annual Mean Temperature and Crude Annual Incidence Rate of Lyme Disease, Active Component Service Members, Contiguous U.S., 2000–2023



the incidence rate ratio of RMSF did not change **(Table 2)**.

The aIRR of Lyme disease was highest in the Southeast compared to the Northeast at 1.5 (95% CI, 1.3-1.6) **(Table 2)**. When compared to the Southeast, there was no significant increase in aIRR for RMSF by regional climate **(Table 2)**. The aIRRs of both TBDs increased with increasing age group compared to ACSMs less than 20 years of age, ranging from 1.0 (95% CI, 1.0-1.0) among ACSMs aged 20-24 years to 2.3 (95% CI, 2.3-2.4) among those aged 40 years or older for Lyme disease, and ranging from 1.0 (95% CI, 0.9-1.2) among ACSMs aged 20-24 years to 2.6 (95% CI, 2.3-3.0) among those aged 40 years or older for RMSF **(Table 2)**. There was no significant increase in TBDs by race and ethnicity **(Table 2)**. Women had the highest aIRR for Lyme disease compared to males, with this sex group having an aIRRs of 1.5 (95% CI, 1.5-1.5), while there was no significant difference in aIRRs by sex for RMSF **(Table 2)**.

FIGURE 3b. Overall Annual Mean Temperature and Crude Annual Incidence Rate of Rocky Mountain Spotted Fever, Active Component Service Members, Contiguous U.S., 2000–2023

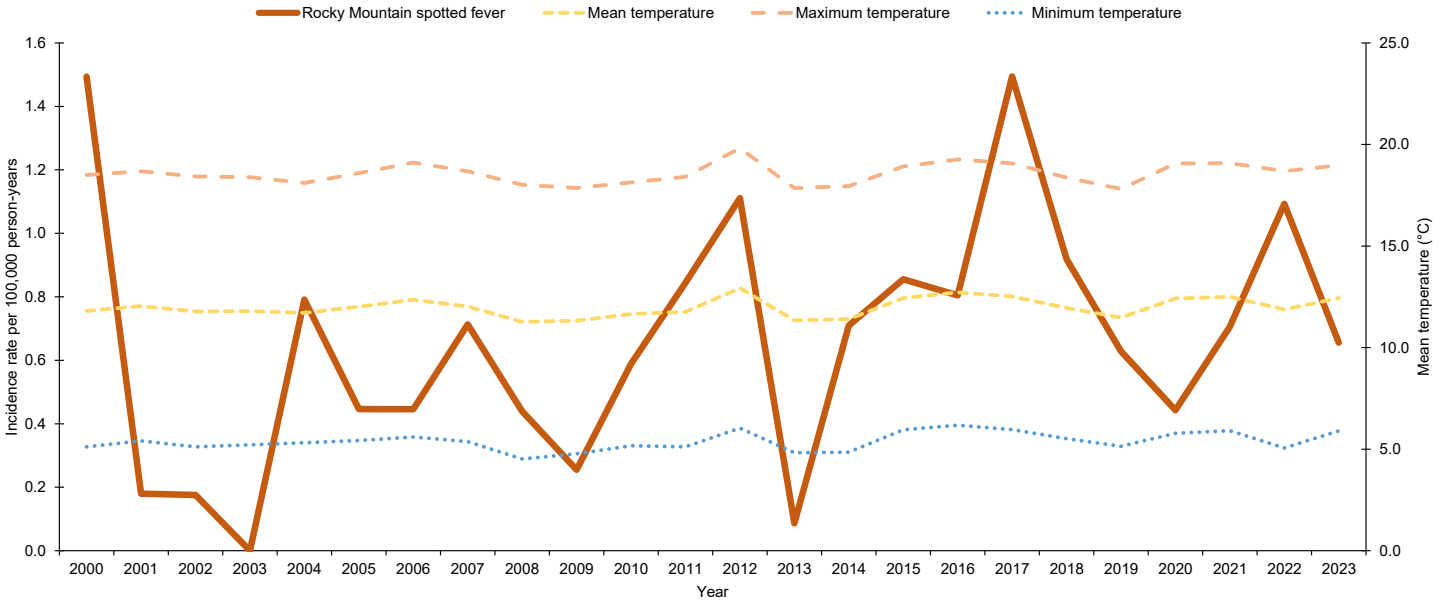


FIGURE 4a. Overall and Region-specific Crude Annual Incidence Rates of Lyme Disease, Active Component Service Members, Contiguous U.S., 2000–2023

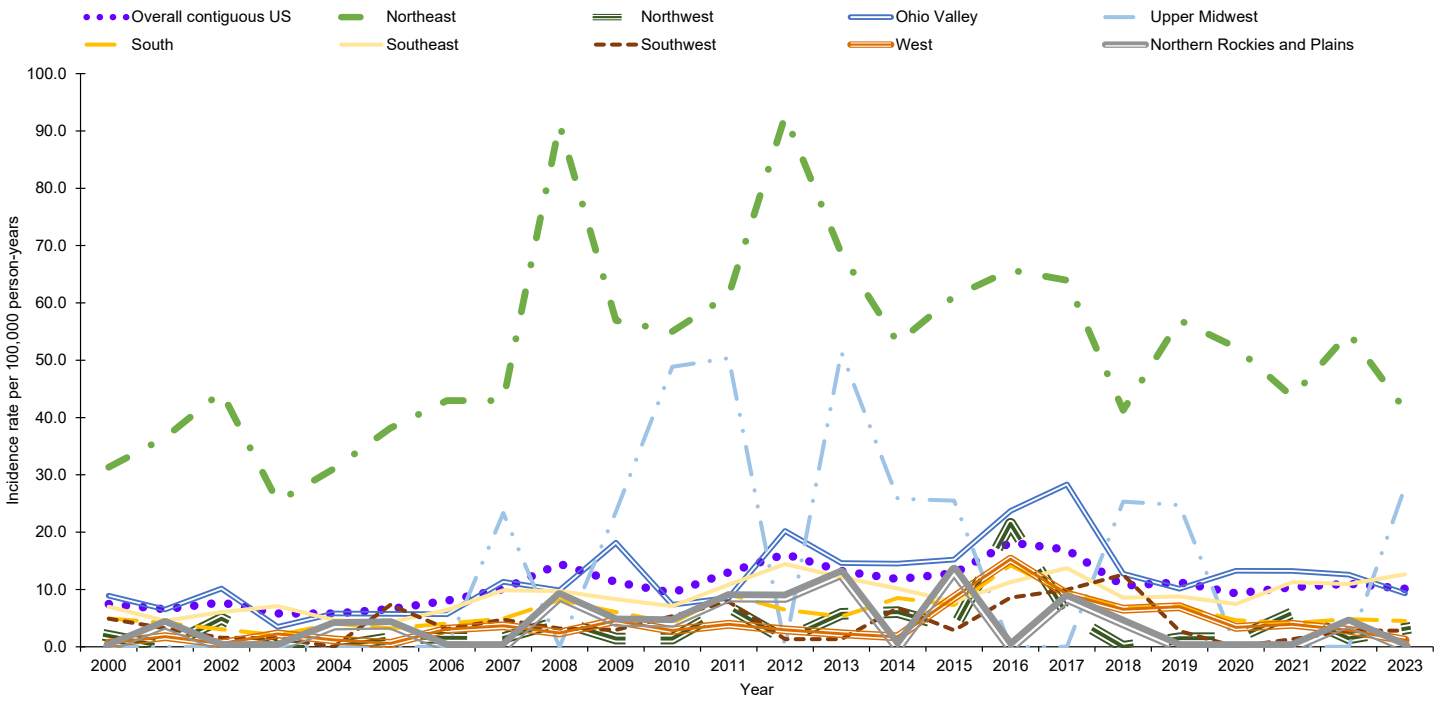


FIGURE 4b. Overall and Region-specific Crude Annual Incidence Rates of Rocky Mountain Spotted Fever, Active Component Service Members, Contiguous U.S., 2000–2023

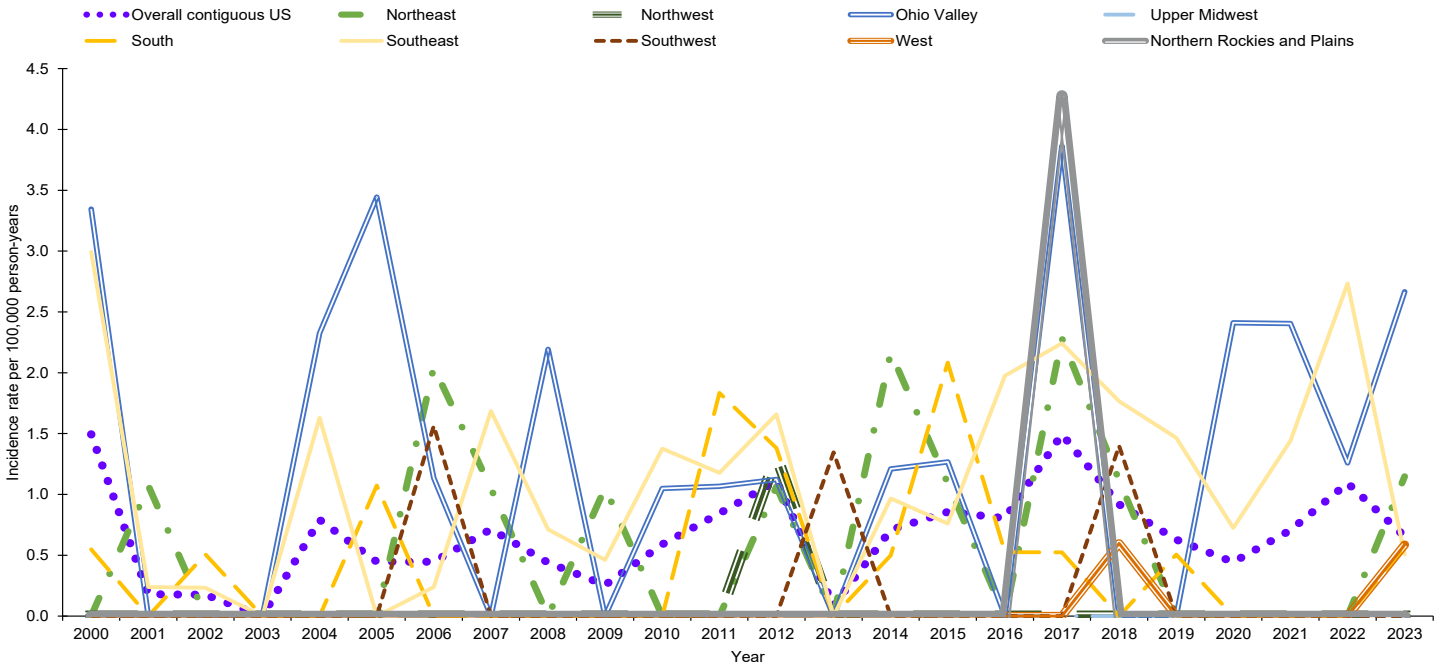


TABLE 2. Adjusted Incidence Rate Ratios of Lyme Disease and Rocky Mountain Spotted Fever, by Climatic and Demographic Variables, Active Component Service Members, Contiguous U.S., 2000–2023

	Lyme Disease			Rocky Mountain Spotted Fever		
Climactic or Demographic Variable	aIRR[a]	95% LL	95% UL	aIRR[a]	95% LL	95% UL
Annual mean temperature	1.0	1.0	1.1	0.7	0.6	0.9
Annual minimum temperature	0.9	0.9	1.0	1.2	1.0	1.4
Annual maximum temperature	0.9	0.9	1.0	1.0	0.9	1.2
Annual total precipitation	1.0	1.0	1.0	1.0	1.0	1.0
Regional climate						
Northeast	Reference	–	–	0.2	0.1	0.3
Southeast	1.5	1.3	1.6	Reference	–	–
Northwest	0.2	0.2	0.3	0.0	0.0	0.1
Ohio Valley	0.7	0.7	0.8	0.4	0.3	0.6
Upper Midwest	0.4	0.3	0.4	0.1	0.0	0.2
South	1.0	0.9	1.2	0.6	0.5	0.7
Southwest	0.4	0.4	0.5	0.1	0.1	0.2
West	0.5	0.4	0.5	0.1	0.1	0.2
Northern Rockies and Plains	0.2	0.2	0.2	0.1	0.0	0.1
Age group, y						
<20	Reference	–	–	Reference	–	–
20–24	1.0	1.0	1.0	1.0	0.9	1.2
25–29	1.5	1.5	1.6	1.7	1.6	2.0
30–34	2.1	2.0	2.1	2.5	2.2	2.8
35–39	2.1	2.1	2.2	2.3	2.1	2.6
40+	2.3	2.2	2.4	2.6	2.3	3.0
Racial and ethnic group						
White, Non-Hispanic	Reference	–	–	Reference	–	–
Black, Non-Hispanic	0.4	0.4	0.4	0.4	0.4	0.4
Hispanic	0.6	0.6	0.6	0.5	0.5	0.6
Other/unknown[b]	0.7	0.7	0.7	0.6	0.6	0.7
Sex						
Male	Reference	–	–	Reference	–	–
Female	1.5	1.5	1.5	1.0	0.9	1.0
Service branch						
Army	Reference	–	–	Reference	–	–
Navy	0.9	0.9	0.9	1.4	1.3	1.5
Marine Corps	1.1	1.0	1.1	3.1	2.8	3.3
Air Force, Space Force	0.7	0.7	0.7	0.9	0.8	1.0
Coast Guard	1.9	1.9	1.9	1.5	1.4	1.8

Abbreviations: aIRR, adjusted incidence rate ratio; LL, lower limit; UL, upper limit; y, years.
[a] Adjusted for annual mean temperature, annual minimum temperature, annual maximum temperature, annual total precipitation, regional climate, age group, racial/ethnic group, sex, and service.
[b] Includes those of American Indian/Alaska Native, Asian/Pacific Islander, and unknown race/ethnicity.

Discussion

This study found that from 2000 to 2023 in the contiguous U.S., Lyme disease incidence rates increased 35.5% among ACSMs alongside a 5.3% (0.6°C) increase in overall annual mean temperature, meaning rates increased by 4.2 cases per 100,000 p-yrs for every 1°C increase in annual mean temperature. The CDC observed a more dramatic Lyme disease rate increase of 200% in the general U.S. population from 2000 to 2022, though it is important to note that in their analysis, suspect and probable cases were included starting in 2008, while this study included only confirmed cases.[18]

Conversely, RMSF incidence rates decreased 55.7% overall, or by 1.3 cases per 100,000 p-yrs for every 1°C increase in annual mean temperature, among ACSMs over the surveillance period. Although CDC data demonstrated an upward trend in incidence rates of confirmed and probable RMSF cases in the general U.S. population from 2000 to 2007, the proportion of confirmed cases over this period decreased from 15% to 4%.[19]

During the surveillance period, the highest annual Lyme disease incidence rate (18.2 cases per 100,000 p-yrs) coincided with the second highest annual mean temperature (12.7°C), while the second highest peak in annual Lyme disease incidence rate (16.2 cases per 100,000 p-yrs) coincided with the highest annual mean temperature (12.9°C) and lowest annual total precipitation (27.5 in.). Although previous research supports that increased Lyme disease incidence are correlated with warmer temperatures, the same data suggest that dry conditions reduce activity of the relevant tick vectors, which in turn lowers disease incidence.[4]

Over the 24-year surveillance period, RMSF incidence rates spiked at 1.1 cases per 100,000 p-yrs during the highest annual mean temperature (12.9°C) and lowest annual total precipitation (27.5 in.). Research has shown that increases in both average relative humidity and daytime land surface temperatures below 35°C increase RMSF incidence.[6]

Although crude Lyme disease rates were highest in the Northeast, adjusted results show that compared to the Northeast, rate ratios were highest in the Southeast. Although crude RMSF rates were highest in Ohio Valley, adjusted results show that compared to the Southeast, rate ratios were highest in the South. Surveillance of these TBDs has shown Lyme disease incidence rates among ACSMs were highest in the Northeast while spotted fever rickettsioses including RMSF are highly endemic to 5 states, 4 of which are in the South and Southeast.[9,20,21]

Crude rates as well as adjusted rate ratios of both TBDs increased with increasing age group. Women had 1.5 times the adjusted rate of Lyme disease than men but had an equal adjusted rate of RMSF compared to men. A previous study of ACSMs in the eastern U.S. also found that Lyme disease incidence rates increased with increasing age and women.[8] Likewise, a 2000-2007 study of RMSF determined that incidence rates increased with increasing age group and cumulative incidence was higher among men than women.[19]

Crude rates and adjusted rate ratios were highest in the Coast Guard for Lyme disease and highest in the Marine Corps for RMSF. Many Coast Guard installations are concentrated in the Northeast, where Lyme disease is most incident.[20,22] Similarly, one of the largest Marine Corps installations is located in North Carolina, which is a high incidence jurisdiction for RMSF.[21,23] Furthermore, the location of Coast Guard and Marine Corps installations in coastal areas may explain the elevated incidence of TBD in each service, as rising sea levels may create environmental conditions that are more conducive to TBD transmission.[24,25] Since the DMSS did not receive encounter data from the Coast Guard between 2015 and 2021, it is possible that Lyme disease and RMSF were even more incident in this service.[26] Coast Guard combat uniforms are not factory treated with permethrin, which may also contribute to why ACSMs in this service experienced the highest aIRR of Lyme disease compared to Army members, whose combat uniforms are factory treated with permethrin.[13]

To our knowledge, this is the first study to investigate the relationship between climatic factors and TBD incidence in ACSMs, with a few limitations. First, the location of disease acquisition was deemed to be the location at which the incident encounter or RME occurred. Due to the range of possible incubation periods for each TBD, individuals may have developed symptoms and sought care in a location inconsistent with the location of infection.[27] Therefore, the regional climate associated with ACSMs may be inaccurate. Likewise, the data do not clarify if the disease was acquired during or outside of work, making it difficult to ascertain a true correlation between TBD incidence and military activities. As a result, this may affect the control measures implemented to prevent infection within the Armed Forces as well as their efficacies. Furthermore, this study's cohort may not include all cases, as Lyme disease and RMSF often present with nonspecific symptoms, which can make them difficult to diagnose.[27] Lastly, the analysis does not account for anthropogenic factors such as land cover and host movement, which influence how climate affects TBD incidence.[28]

Although no significant correlation between temperature and TBD incidence was found, the observed peaks in annual Lyme disease incidence with rising mean temperatures reaffirm patterns in existing literature. Small changes in temperature can have substantial effects on TBD incidence, and these illnesses can reduce force readiness by causing fevers, headaches, and in some instances, neurologic and cardiac conditions.[10,27] Further research is needed to explore the temporality of how climatic conditions affect incidence of both Lyme disease and RMSF. This information is essential to understand and improve the management of these illnesses among ACSMs.

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Disclaimer
The views expressed in this article are those of the authors and do not necessarily reflect the official policy of the Department of Defense nor the U.S. Government.

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Surveillance Snapshot

Mid-Season Influenza Vaccine Effectiveness Against Laboratory-Confirmed Ambulatory Influenza Among U.S. Active Component Service Members, December 1, 2024–February 8, 2025

Angelia A. Eick-Cost, PhD, ScM; Zheng Hu, MS

TABLE. Influenza Vaccine Effectiveness Against Medically Attended, Laboratory-Confirmed Ambulatory Influenza, Active Component U.S. Service Members, 2024–2025 Season

Influenza Type	Vaccinated	Cases		Test-Negative Controls		Crude VE (95% CI)	Adjusted VE[a] (95% CI)
		No.	%	No.	%		
Any type	Yes	3,883	83	10,532	82	-5 (-14, 4)	15 (7, 23)
	No	794	17	2,255	18	–	–
A (any subtype)	Yes	3,680	83	10,532	82	-7 (-18, 2)	14 (5, 22)
	No	733	17	2,255	18	–	–
A(H1N1)pdm09	Yes	126	77	10,532	82	27 (-5, 50)	41 (14, 60)
	No	37	23	2,255	18	–	–
A(H3N2)	Yes	290	75	10,532	82	37 (21, 50)	50 (36, 60)
	No	99	25	2,255	18	–	–
B	Yes	213	78	10,532	82	25 (0, 44)	33 (9, 50)
	No	61	22	2,255	18	–	–

Abbreviations: VE, vaccine effectiveness; CI, confidence interval.
[a]Adjusted for sex, age category, prior vaccination (any influenza vaccine in previous 5 years), month of diagnosis.

This Surveillance Snapshot provides an overview of the 2024-2025 mid-season analysis of influenza vaccine effectiveness (VE) against medically-attended ambulatory influenza infections among active component U.S. service members.

A case test-negative study design was implemented among the population of active component service members (ACSMs) from all services who were tested for influenza between December 1, 2024 and February 8, 2025—the period of peak influenza activity for the season. Data from the Defense Medical Surveillance System and standardized laboratory data provided by the Defense Centers for Public Health–Portsmouth were used for this analysis.[1] Cases were defined as individuals with a positive influenza result from a rapid antigen, reverse transcription polymerase chain reaction (RT-PCR), or culture influenza assay. Test-negative controls (TNCs) were individuals with a negative influenza result from a RT-PCR or culture influenza assay. Crude odds ratios (ORs) were calculated, and multivariate logistic regression was used to calculate adjusted ORs (adjusted for sex, age category, any influenza vaccination in the previous 5 years, and month of diagnosis) and 95% confidence intervals (CIs). Estimates of VE were defined as (1 – OR) x 100.

There were 4,677 cases (4,413 A any subtype, 389 A[H3N2], 163 A[H1N1]pdm09, 274 B any subtype) and 12,787 TNC. Ten cases were both influenza A- and influenza B-positive. VE varied by influenza type **(Table)**. Adjusted VE estimates for all influenza types and subtypes reached statistical significance. The results indicate moderate mid-season protection against influenza A(H1N1)pdm09 (adjusted VE 41%; 95% CI, 14-60) and A(H3N2) (adjusted VE 50%; 95% CI, 36-60) and low mid-season protection against influenza A (any subtype) (adjusted VE 14%; 95% CI, 5-22) and influenza B (adjusted VE 33%; 95% CI, 9-50).

The results of this analysis show low to moderate mid-season protection of the 2024-2025 seasonal influenza vaccines against medically-attended influenza A and B infections that resulted in an ambulatory care visit among ACSMs. As these estimates were obtained during the middle of the influenza season, VE estimates and confidence intervals may change when data for the full season are available and the sample sizes increase.

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Reportable Medical Events at Military Health System Facilities 2024 Annual Review, January 1, 2024–December 31, 2024

Idalia Aguirre, MPH; Matthew W. R. Allman, MPH; Anthony R. Marquez, MPH; Katherine S. Kotas, MPH; John F. Ambrose, PhD, MPH

This month's edition of the *MSMR* Reportable Medical Events (RMEs) at Military Health System (MHS) facilities feature provides an overview of annual data for 2024 for active component service members (ACSMs) and MHS beneficiaries. RMEs are reported in the Disease Reporting System internet (DRSi) by health care providers and public health officials throughout the MHS for monitoring, controlling, and preventing the occurrence and spread of diseases of public health interest. These reports are validated by the Defense Health Agency–Public Health (DHA-PH).

The DRSi collects reports on over 70 different RMEs, including infectious and non-infectious conditions, outbreak reports, sexually transmitted infection (STI) risk surveys, and tuberculosis contact investigation reports. A complete list of RMEs is available in the *2022 Armed Forces Reportable Medical Events Guidelines and Case Definitions*.[1] Data presented in this report are considered provisional and do not represent conclusive evidence until case reports are fully validated.

Top 5 RMEs in 2024, by MMWR Week, for ACSMs and MHS Beneficiaries

The top 5 RMEs reported to DRSi in 2024 are displayed on the following page, by week, for ACSMs and MHS beneficiaries. The top 5 RMEs reported for ACSMs were chlamydia, gonorrhea, norovirus, heat illness, and syphilis **(Figure 1)**. Among MHS beneficiaries, the top 5 RMEs reported were chlamydia, norovirus, COVID-19-associated hospitalization or death, gonorrhea, and campylobacteriosis **(Figure 2)**.

Ratios of RMEs for 2024 Compared to 2023 for ACSMs and MHS Beneficiaries

The current ratio data are based on incidence counts comparing year 2024 to 2023; low numbers for many conditions limit data interpretation and are not included in the figures. Conditions with less than 10 medical event reports (MERs) per year, as well as COVID-19-associated hospitalizations and deaths, and syphilis, were excluded from the ratio comparisons. COVID-19-associated hospitalizations and deaths were excluded due to changes in the case definition in May 2023; syphilis cases were excluded due to changes in case validation processes implemented in January 2024. Ratios presented in **Figures 3** and **4** include any RMEs that had, at minimum, a 30% increase or decrease in MERs in 2024 compared to MERs in 2023.

For ACSMs, the total number of MERs submitted to DRSi in 2024 decreased by 8.4% compared to 2023. Cases of pertussis and influenza-associated hospitalizations had the most prominent increases in 2024 compared to 2023, with 153% and 86% increases, respectively. Increases of case counts in 2024 were also seen for norovirus infections (53%), coccidioidomycosis (47%), Lyme disease (44%), Shiga toxin-producing *E. coli* (35%), and varicella (31%) **(Figure 3)**.

Three RMEs decreased among ACSMs in 2024 versus 2023: spotted fever rickettsiosis (-32%), acute and chronic hepatitis B (-34%), and acute and chronic hepatitis C (-44%).

For MHS beneficiaries, the total number of MERs submitted to DRSi in 2024 increased by 1.6% compared to 2023. Like ACSMs, MHS beneficiaries also saw the most prominent increases for cases of pertussis and influenza-associated hospitalizations in 2024, with 161% and 81% increases, respectively. Increases were also seen for varicella (74%), giardiasis (71%), norovirus infections (57%), Shiga toxin-producing *E. coli* (49%), and cryptosporidiosis (33%) **(Figure 4)**. There were no substantial decreases in specific RMEs in 2024 versus 2023 for MHS beneficiaries.

Like the DHA-PH, the Centers for Disease Control and Prevention (CDC) have reported similar trends for increased incidence of pertussis, influenza-associated hospitalizations, and norovirus. According to preliminary CDC data, as of week 52 of 2024 over 6 times as many cases of pertussis had been reported compared to the same period in 2023.[2] An increase in influenza-associated hospitalizations was reported during the 2023-2024 influenza season compared to the 2022-2023 influenza season.[3] The CDC also noted an increase in norovirus outbreaks between August 1 and December 11, 2024, with 495 outbreaks versus 363 during the same period the preceding year.[4]

For questions about this report, please contact the Disease Epidemiology Branch at the Defense Centers for Public Health–Aberdeen. Email: dha.apg.pub-health-a.mbx.disease-epidemiologyprogram13@health.mil

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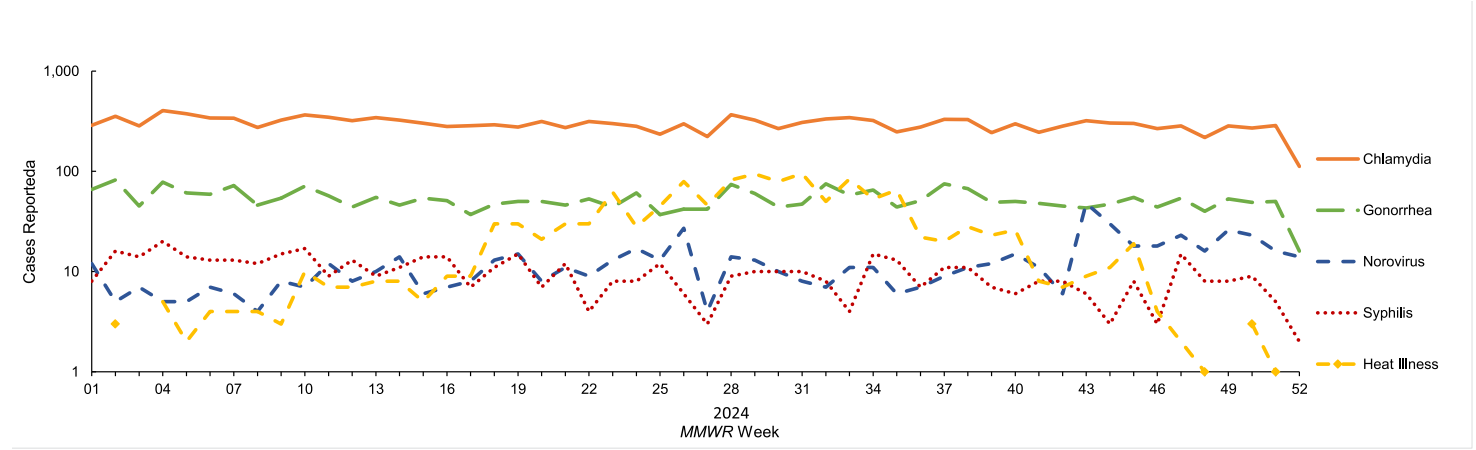
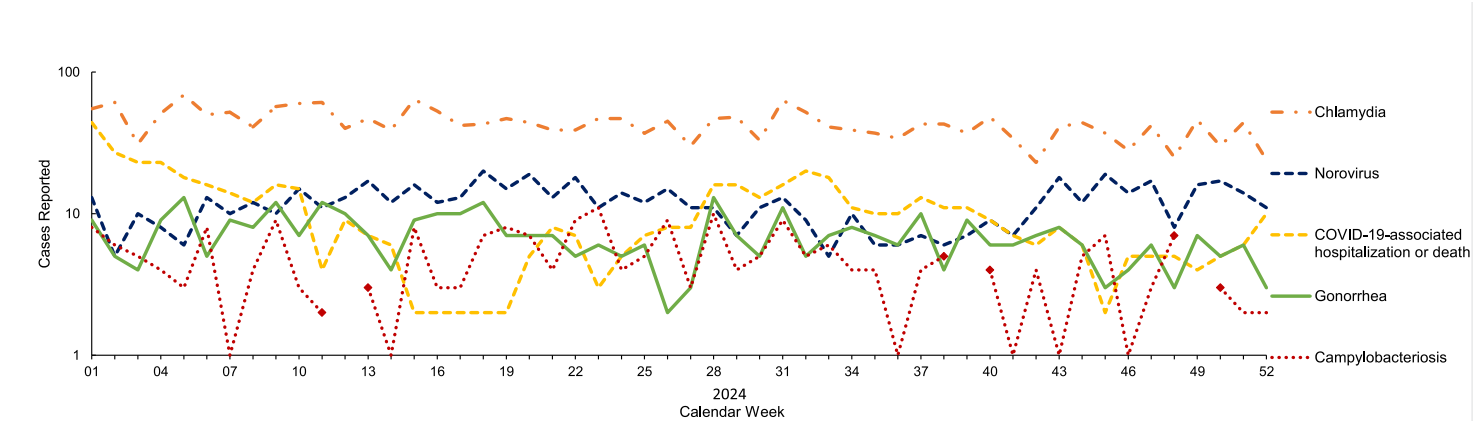
FIGURE 1. Top 5 Reportable Medical Events[a] by *MMWR* Week, Active Component U.S. Service Members, January 1, 2024–December 31, 2024



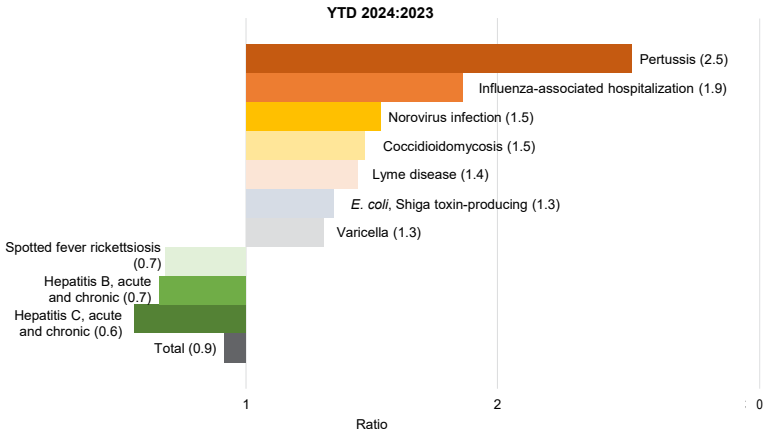
[a] Cases are shown on a logarithmic scale.
Note: There were no reported heat illness cases during weeks 1, 3, 49, and 52 of 2024. Markers added to represent instances of heat illnesses that were not visible on the logarithmic scale.

FIGURE 2. Top 5 Reportable Medical Events[a] by *MMWR* Week, Military Health System Beneficiaries, January 1, 2024–December 31, 2024



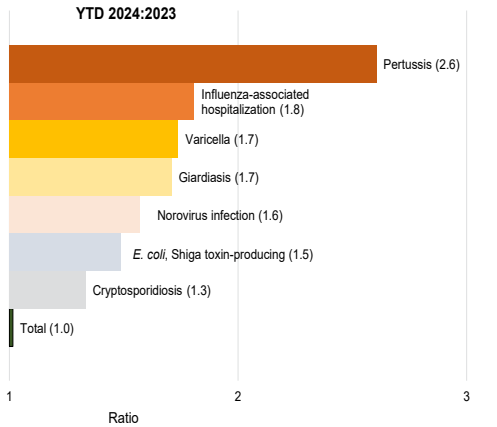
Abbreviation: RMEs, reportable medical events.
[a] Cases are shown on a logarithmic scale.
Note: There were no reported campylobacteriosis cases during the following weeks of 2024: 12, 39, and 49. Markers added to represent instances of campylobacteriosis that were not visible on the logarithmic scale.

FIGURE 3. Ratios of Selected Reportable Medical Events, Active Component U.S. Service Members



Abbreviations: YTD, year-to-date; *E., Escherichia.*

FIGURE 4. Ratios of Selected Reportable Medical Events, Military Health System Beneficiaries



Abbreviations: YTD, year-to-date; *E., Escherichia.*

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