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Update: Cold Injuries, Active and Reserve Components, U.S. Armed Forces, July 2017–June 2022

From July 2021 through June 2022, a total of 482 members of the active (n=435) and reserve (n=47) components had at least 1 cold injury. The crude overall incidence rate of cold injury for all active component service members in 2021–2022 (33.1 per 100,000 person-years [p-yrs]) was slightly lower than the rate for the 2020–2021 cold season (35.5 per 100,000 p-yrs). In 2021–2022, frostbite was the most common type of cold injury among active component service members in all 4 services. Among active component members during the 2017–2022 cold seasons, overall rates of cold injuries were generally highest among male service members, non-Hispanic Black service members, the youngest (less than 20 years old), and those who were enlisted. The number of cold injuries associated with overseas deployments during the 2021–2022 cold season (n=13) was similar to the two previous cold seasons (10 in 2019-2020 and 11 in 2020-2021). Frostbite accounted for more than half (n=9) of the cold injuries identified in service members deployed outside of the U.S. during the 2021–2022 cold season.

What are the new findings?

For all active component service members, the rate of cold injuries in 2021–2022 decreased slightly compared to the previous cold year. Cold injury rates were much higher among members of the Army and Marine Corps. The number of cold injuries associated with deployment during 2021–2022 was similar to the two preceding cold years.

What is the impact on readiness and force health protection?

Military training and combat operations will require continued emphasis on effective cold injury prevention strategies and adherence to the policies and procedures in place to protect service members against such injuries.

Cold injuries are of significant military concern because of their adverse impact on operations and the high financial costs of treatment and disability.[1,2] In response, the U.S. Armed Forces have developed and improved training, doctrine, procedures, and protective equipment and clothing to counter the threat from cold environments.[3–8] Although these measures are highly effective, cold injuries have continued to affect hundreds of service members each year because of exposure to cold and wet environments.[9]

The term cold injuries is used to describe injuries that have a central effect, such as hypothermia, as well as injuries that primarily affect the peripheries of the body, such as frostbite and immersion injuries. The human physiologic response to cold exposure is to retard heat loss and preserve core body temperature, but this response may not be sufficient to prevent hypothermia if heat loss is prolonged.[9] Moreover, the response includes constriction of the peripheral (superficial) vascular system, which may result in non-freezing injuries or hasten the onset of actual freezing of tissues (frostbite).[9]

Hypothermia occurs when the core temperature of the body falls below 95°F.[7] The most common mechanisms of accidental hypothermia are convective heat loss to cold air and conductive heat loss to water.[10] Freezing temperatures are not required to produce hypothermia.[10] In response to cold stress, peripheral blood vessels constrict and the hypothalamus stimulates heat production through shivering and elevated thyroid, adrenal, and catecholamine activity.[10] The sympathetic nervous system mediates further vasoconstriction to minimize heat loss by reducing blood flow to the extremities, where the most cooling occurs.[10] As the body's basal metabolic rate decreases, core temperature falls, body functions slow down, and muscular and cerebral functions are impaired.[10] Neurologic functioning begins declining even above a core body temperature of 95°F.[11] Severe hypothermia can lead to pulmonary edema, reduced heart rate, coma, ventricular arrhythmias (including ventricular fibrillation), and asystole.[10–12]

Cold injuries affecting the body's peripheries can be classified as freezing or non-freezing injuries.[13] Freezing peripheral injury is defined as the damage sustained by tissues when exposed to temperatures below freezing.[13] The tissue damage of frostbite is the result of both direct cold-induced cell death and the secondary effects of microvascular thrombosis and subsequent ischemia.[14] Rapid freezing generally results in extra- and intracellular ice crystal formation.[15] These crystals cause direct injury to cell membranes that results in cellular dehydration, lipid derangement, electrolyte fluxes as well as membrane lysis, and cell death.[14–16] An inflammatory process follows, resulting in tissue ischemia and additional cell death.[15] The initial cellular damage and the ensuing inflammatory processes are worsened with thawing of the affected area.[15,16]

With rewarming, edema from melting ice crystals leads to epidermal blister formation, and ischemia-reperfusion injury may be initiated;[14–16] vasoconstriction and platelet aggregation caused by inflammatory mediators, prostaglandins, and thromboxanes exacerbate ischemia.[17] The areas of the body most frequently affected by frostbite include the ears, nose, cheeks, chin, fingers, and toes.[18,19] A substantial proportion of patients with peripheral frostbite experience permanent changes in their microcirculation and disruption of local neurological functions (e.g., reduced sensation in the affected area).[19] Although most frostbite damage is minor, severe injury may lead to impaired functioning and ability to work because of cold hypersensitivity, chronic ulceration, vasospasm, localized osteoarthritis, and/or chronic pain.[14,19]

Non-freezing peripheral cold injury includes a spectrum of localized injuries to the soft tissues, nerves, and vasculature of distal extremities that result from prolonged exposure (12 to 48 hours) to wet, cold (generally 32 to 59 °F) conditions; the injury process generally happens at a slower rate in warmer water.[13,20] Although non-freezing peripheral cold injuries most often involve feet (immersion foot), any dependent body part can be affected by the condition, including the hands.[21] Immersion foot generally presents as waterlogging of the feet, with the most marked effect occurring in the soles.[17,20] The foot becomes hyperemic (increased blood flow), painful, and swollen with continuous exposure; progression to blistering, decreased blood flow, ulceration, and gangrene is gradual.[17,20] Long-term complications of non-freezing cold injury such as immersion foot are similar to (e.g., hypersensitivity to cold, chronic pain) and as debilitating as (e.g., severe pain provoked by walking) those produced by frostbite.[14,16,17,20]

Factors that increase the risk of cold injuries include outdoor exposure, inadequate and/or wet clothing, cold water submersion, older age, exhaustion, dehydration, inadequate caloric intake, alcohol use, smoking (frostbite), previous cold injury (frostbite or immersion foot), chronic disease (e.g., peripheral vascular disease, diabetes), and medications that impair compensatory responses (e.g., oral antihyperglycemics, beta-blockers, general anesthetic agents).[12–14,17–19] Situational factors that increase risk of immersion foot include immobility, wet socks, and constricting boots.[17,22]

Traditional measures to counter the dangers associated with cold environments include minimizing loss of body heat and protecting superficial tissues through such means as protective clothing, shelter, physical activity, and nutrition. However, military training or mission requirements in cold and wet weather may place service members in situations where they may be unable to be physically active, find warm shelter, or change wet or damp clothing.[2–4]

For the military, continuous surveillance of cold injuries is essential to inform steps to reduce their impact as well as to remind leaders of this predictable threat. Since 2004, the *MSMR* has published an annual update on the incidence of cold injuries that have affected U.S. military members during the 5 most recent cold seasons.[23] This 2022 report addresses the occurrence of such injuries during the cold seasons from July 2017 through June 2022. The timing of the annual updates is intended to call attention to the recurring risks of such injuries as winter approaches in the Northern Hemisphere, where most members of the U.S. Armed Forces are assigned.

Methods

The surveillance period was 1 July 2017 through 30 June 2022. The surveillance population included all individuals who served in the active or reserve component of the U.S. Armed Forces at any time during the surveillance period. For analysis purposes, "cold years" or "cold seasons" were defined as 1 July through 30 June intervals so that complete cold weather seasons could be represented in year-to-year summaries and comparisons.

Because cold injuries represent a threat to the health of individual service members and to military training and operations, the U.S. Armed Forces require expeditious reporting of these reportable medical events (RMEs) via one of the service-specific electronic reporting systems; these reports are routinely incorporated into the Defense Medical Surveillance System (DMSS). For this analysis, the DMSS and the Theater Medical Data Store (which maintains electronic records of medical encounters of deployed service members) were searched for RMEs and inpatient and outpatient care for the diagnoses of interest: frostbite, immersion hand and foot, and hypothermia. A case was defined by the presence of an RME or one of any qualifying International Classification of Diseases, 9th or 10th revision (ICD-9 and ICD-10, respectively) code in the first diagnostic position of a record of a health care encounter **(Table 1)**. The Department of Defense guidelines for RMEs require the reporting of cases of hypothermia, freezing peripheral injuries (i.e., frostbite), and non-freezing peripheral injuries (i.e., immersion injuries, chilblains).[24] Cases of chilblains are not included in this report because the condition is common, infrequently diagnosed, usually mild in severity, and thought to have minimal medical, public health, or military impacts. Because of an update to the Disease Reporting System internet (DRSi) medical event reporting system in July 2017, the type of RMEs for cold injury (i.e., frostbite, immersion injury, hypothermia) could not be distinguished using RME records in DMSS data. Instead, information on the types of RME for cold injury between July 2017 and June 2022 were extracted from DRSi and then combined with DMSS data.

To estimate the number of unique individuals who suffered a cold injury each cold

TABLE 1. ICD-9/ICD-10 diagnostic codes for cold injuries

Case classification	ICD-9	ICD-10[a]
Frostbite	991.0, 991.1, 991.2, 991.3	T33.*, T34.*
Immersion hand and foot	991.4	T69.0*
Hypothermia	991.6	T68.*

[a]An asterisk (*) indicates that any subsequent digit/character is included.
ICD, International Classification of Diseases, 9th and 10th revisions

season and to avoid counting follow-up health care encounters after single episodes of cold injury, only 1 cold injury per individual per cold season was included. A slightly different approach was taken for summaries of the incidence of the different types of cold injury classifications, to include frostbite, immersion hand and foot, and hypothermia cases. To count these types of cold injuries, 1 of each type of cold injury per individual per cold season was included. For example, if an individual was diagnosed or reported with immersion hand and foot at one point during a cold season and then with frostbite later during the same cold season, each of those different types of injury would be counted in the tally of injuries. If a service member had multiple medical encounters for cold injuries on the same day, only 1 encounter was used for analysis (hospitalizations were prioritized over ambulatory visits, which were prioritized over RMEs).

Annual incidence rates of cold injuries among active component service members were calculated as incident cold injury diagnoses per 100,000 p-yrs of service. Annual rates of cold injuries among reservists were calculated as cases per 100,000 persons using the total number of reserve component service members for each year of the surveillance period. Counts of persons in the reserves were used as the denominator in these calculations because information on the start and end dates of active duty service periods of reserve component members was not available.

The numbers of cold injuries were summarized by the locations at which service members were treated for these injuries as identified by the Defense Medical Information System Identifier (DMIS ID) recorded in the medical records of the cold injuries. Because such injuries may be sustained during field training exercises, temporary duty, or other instances for which a service member may not be located at his/her usual duty station, DMIS ID was used as a proxy for the location where the cold injury occurred.

Results

2021–2022 cold season

From July 2021 through June 2022 a total of 482 members of the active (n=435) and reserve (n=47) components had at least 1 cold injury **(Table 2)**. Among the 435 active component cold injuries, 143 (32.9%) were reported as RMEs **(data not shown)**. The Army contributed nearly two-thirds (63.4%; n=276) of active component service members affected by any cold injury during the 2021–2022 cold season; across the services during this period,

TABLE 2. Annual incidence of service members affected by any cold injury (1 per person per year), by service and component, July 2017-June 2022

	Army		Navy		Air Force		Marine Corps		All services	
Active component	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
All years (2017-2022)	1,373	58.4	134	8.1	252	15.5	438	48.2	2,197	33.6
Jul 2017-Jun 2018	299	64.3	29	9.1	46	14.5	93	50.7	467	36.3
Jul 2018-Jun 2019	275	59.1	21	6.4	46	14.3	118	63.9	460	35.4
Jul 2019-Jun 2020	232	49.0	27	8.1	46	14.0	59	32.0	364	27.6
Jul 2020-Jun 2021	291	61.0	26	7.6	56	17.0	98	54.4	471	35.5
Jul 2021-Jun 2022	276	58.5	31	9.1	58	17.9	70	39.6	435	33.1
Reserve component										
All years (2017-2022)	212		13		40		50		315	
Jul 2017-Jun 2018	54	25.0	3	4.6	5	6.6	17	36.8	79	19.6
Jul 2018-Jun 2019	44	20.7	1	1.5	6	7.9	16	34.7	67	16.7
Jul 2019-Jun 2020	36	16.9	2	3.0	10	13.1	4	8.9	52	13.0
Jul 2020-Jun 2021	42	20.1	5	7.7	13	17.0	10	22.8	70	17.8
Jul 2021-Jun 2022	36	17.8	2	3.2	6	7.8	3	7.0	47	12.2
Overall, active and reserve										
All years (2017-2022)	1,585		147		292		488		2,512	
Jul 2017-Jun 2018	353		32		51		110		546	
Jul 2018-Jun 2019	319		22		52		134		527	
Jul 2019-Jun 2020	268		29		56		63		416	
Jul 2020-Jun 2021	333		31		69		108		541	
Jul 2021-Jun 2022	312		33		64		73		482	

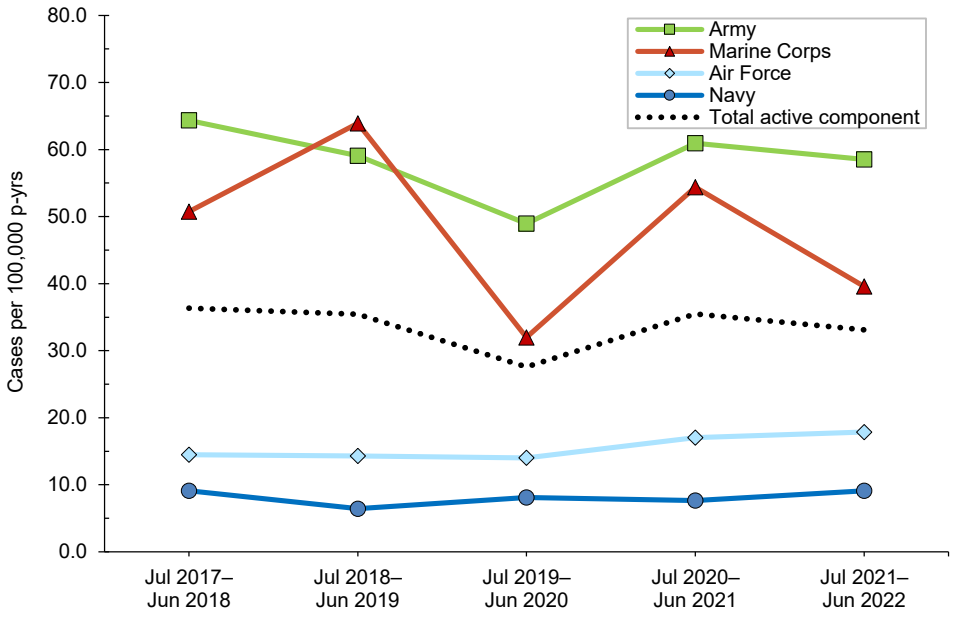
[a] For active component, rate is per 100,000 person-years. For reserve component, rate is per 100,000 persons.
No., number.

active component Army members had the highest rate of any cold injury (58.5 per 100,000 p-yrs). Active component Marine Corps members had the second highest cold injury rate during the 2021–2022 cold season (39.6 per 100,000 p-yrs). Navy service members (n=31) had the lowest service-specific rate of any cold injury during the 2021–2022 cold season (9.1 per 100,000 p-yrs) **(Table 2, Figure 1)**.

Army personnel (n=36) accounted for three-quarters (76.6%) of all reserve component service members (n=47) affected by cold injuries during 2021–2022 **(Table 2)**. Service-specific annual rates of cold injuries among reserve component members were highest among those in the Army (17.8 per 100,000 persons) and lowest among those in the Navy (3.2 per 100,000 persons) **(Figure 2)**.

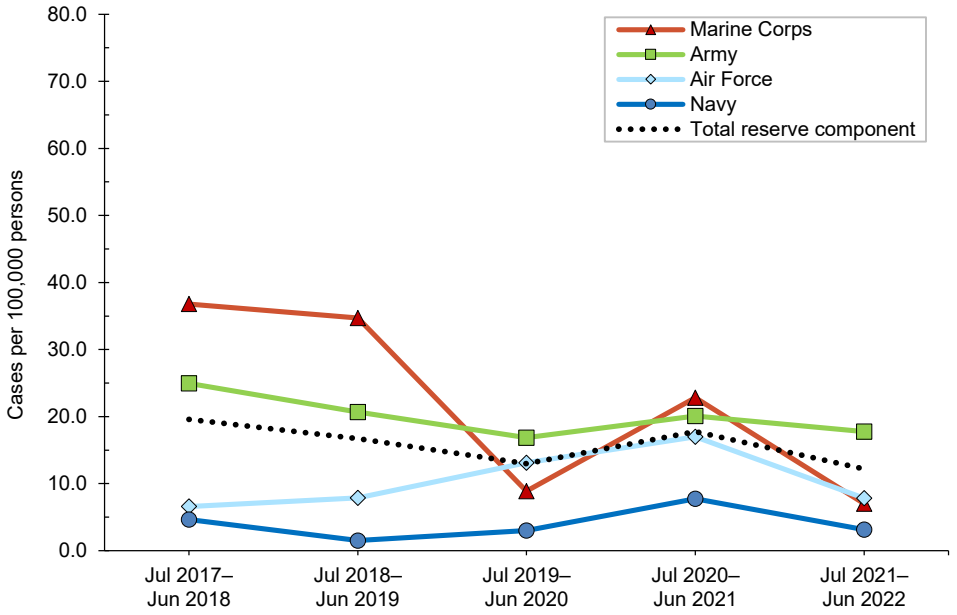
When the major types of cold injury case classifications were considered, not just the numbers of individuals affected, frostbite was the most common type of cold injury (n=277; 62.1% of all cold injuries) among active component service members in 2021–2022 **(Tables 3a–3d)**. In the Air Force during the 2021–2022 season, 83.1% of all cold injuries were frostbite, whereas the proportions in the Army (65.1%), Marine Corps (44.4%), and Navy (35.5%) were much lower. For all active component service members during 2021–2022, the proportions of total cold injuries that were hypothermia and immersion injuries were 15.2% and 22.6%, respectively **(Tables 3a–3d)**. Among active component Air Force members, the numbers and rates of frostbite and immersion hand and foot injuries in the 2021–2022 cold season were the highest of the past 5 years, while the number and rate of hypothermia cases were the lowest during this period **(Table 3c)**. Among active component Army members, the numbers and rates of hypothermia and immersion foot injuries in the 2021–2022 cold season were the lowest of the 5-year period **(Table 3a)**.

FIGURE 1. Annual incidence rates of service members affected by any cold injury (1 per person per year), by service, active component, U.S. Armed Forces, July 2017–June 2022



P-yrs, person-years.

FIGURE 2. Annual incidence rates of service members affected by any cold injury (1 per person per year), by service, reserve component, U.S. Armed Forces, July 2017–June 2022



Five cold seasons: July 2017–June 2022

The crude overall incidence rate of cold injury for all active component service members in 2021–2022 (33.1 per 100,000 p-yrs) was 7.3% lower than the rate for the 2020–2021 cold season (35.5 per 100,000 p-yrs) **(Table 2, Figure 1)**. Throughout the surveillance period, the cold injury rates were consistently higher among active component members of the Army and the Marine Corps than among those in the Air Force and Navy **(Figure 1)**. In 2021–2022, the service-specific incidence rate for active component Army members (60.2 per 100,000 p-yrs) was similar to the 2020–2021 Army rate (61.4 per 100,000 p-yrs). For the Marine Corps, the active component rate

for 2021–2022 decreased 25.1% between the 2020–2021 season and the 2021–2022 season. Service-specific annual rates of cold injuries among reserve component members were consistently higher among those in the Army than among those in the Air Force or the Navy **(Figure 2)**. As was true for active component Marine Corps members, the 2021–2022 rate of cold injuries among reserve component Marine Corps members was lower (69.3%) than the rate for the previous season.

TABLE 3a. Annual incidence of frostbite, immersion hand and foot, and hypothermia among all cold injuries (1 type per person per year), active component, U.S. Army, July 2017–June 2022

	Frostbite		Immersion hand and foot		Hypothermia		All cold injuries	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	791	33.6	435	18.5	199	8.5	1,425	60.6
Sex								
Male	668	33.5	388	19.5	178	8.9	1,234	61.9
Female	123	34.3	47	13.1	21	5.9	191	53.3
Race/ethnicity group								
Non-Hispanic White	289	22.4	200	15.5	100	7.7	589	45.6
Non-Hispanic Black	367	75.5	163	33.5	63	13.0	593	121.9
Other/unknown	135	23.5	72	12.5	36	6.3	243	42.3
Age group (years)								
<20	71	42.2	59	35.0	32	19.0	162	96.2
20–24	336	46.2	223	30.7	102	14.0	661	90.9
25–29	170	30.9	93	16.9	48	8.7	311	56.5
30–34	111	30.3	28	7.7	11	3.0	150	41.0
35–39	54	19.2	20	7.1	2	0.7	76	27.0
40–44	25	16.3	6	3.9	3	2.0	34	22.2
45+	24	22.4	6	5.6	1	0.9	31	29.0
Rank								
Enlisted	696	36.8	406	21.5	181	9.6	1,283	67.9
Officer	95	20.5	29	6.3	18	3.9	142	30.7
Military occupation								
Combat-specific[b]	294	50.1	197	33.6	111	18.9	602	102.7
Motor transport	28	37.9	14	18.9	4	5.4	46	62.2
Repair/engineering	124	25.6	75	15.5	26	5.4	225	46.5
Communications/intelligence	192	33.2	93	16.1	35	6.0	320	55.3
Health care	47	19.9	16	6.8	6	2.5	69	29.3
Other/unknown	106	26.9	40	10.2	17	4.3	163	41.4
Cold year (July–June)								
2017-2018	172	37.0	88	18.9	44	9.5	304	65.4
2018-2019	143	30.7	107	23.0	40	8.6	290	62.3
2019-2020	115	24.3	94	19.8	45	9.5	254	53.6
2020-2021	176	36.9	81	17.0	36	7.5	293	61.4
2021-2022	185	39.2	65	13.8	34	7.2	284	60.2

[a]Rate per 100,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
No., number.

During the 5-year surveillance period, the rates of cold injuries among members of the active components of the Navy, Air Force, and Marine Corps were higher among male than female service members **(Tables 3a–3d)**. Among active component members in the Navy, Air Force, and Marine Corps, the overall rates among male service members were 1.6 to 1.7 times the rates among female service members. During 2017–2022, female service members in the Army, Navy, and Marine Corps had lower rates of immersion foot than did male service members. With the exception of the Army, female service members also had lower rates of frostbite; with the exception of the Marine Corps, female service members had lower rates of hypothermia **(Tables 3a–3d)**. For active component service members in all 4 services combined, the overall rate of cold injury was 50.0% higher among male service members (36.6 per 100,000 p-yrs) than among female service members (24.4 per 100,000 p-yrs) **(data not shown)**.

In all of the services, overall rates of cold injuries were higher among non-Hispanic Black service members than among those of the other race/ethnicity groups. In particular, within the Marine Corps and Army and for all services combined, rates of cold injuries were more than twice as high among non-Hispanic Black service members as rates among either non-Hispanic White service members or those in the "other/unknown" race/ethnicity group **(Tables 3a–3d)**. The major underlying factor in these differences is that rates of frostbite among non-Hispanic Black members from all services combined was more than 3 times that of the other race/ethnicity groups, with the biggest differences apparent in the Marine Corps (more than 5 times) and the Army (more than 3 times) **(data not shown)**. Additionally, across the active components of all services during 2017–2022, non-Hispanic Black service members had incidence rates of cold injuries greater than the rates of other race/ethnicity groups in nearly every military occupational category **(data not shown)**.

Across the services, rates of cold injuries were highest among the youngest service members and tended to decrease with increasing age **(Tables 3a–3d)**. Enlisted members of all 4 services had higher rates than officers. In the Army, Air Force, and Marine Corps, rates of all cold injuries combined

were highest among service members in combat-specific occupations (infantry/artillery/combat engineering/armor) **(Tables 3a, 3c–3d)**. For active component Navy members, rates of cold injuries during the 5-year period were highest among those in motor transport occupations **(Table 3b).**

During the 5-year surveillance period, the majority of cold injuries occurred among active component service members (n=2,197; 87.5%), with 315 cold injuries (12.5%) occurring among the reserve component. Of all reserve component cold injuries, 67.3% (n=212) were members of the Army **(Table 2)**. Overall, soldiers accounted for more than three-fifths (63.1%) of all cold injuries affecting active and reserve component service members **(Table 2, Figure 3)**.

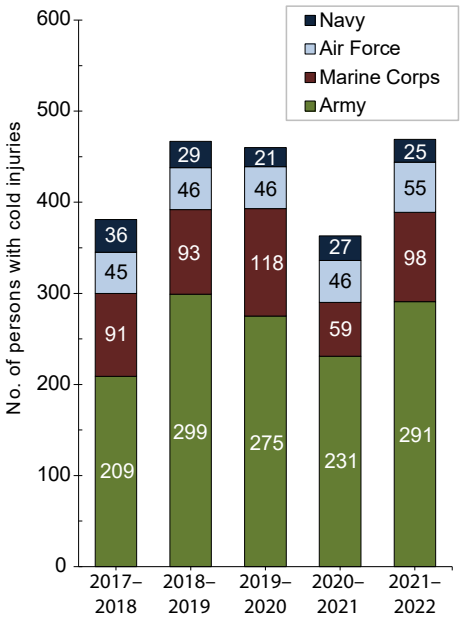
Of all active component cold injury cases presented in this report over the five-year surveillance period (n=2,197), 105 (4.8% of the total) were affected during basic training. The Army (n=39) and Marine Corps (n=61) accounted for 95.2% of all basic trainees affected by cold injuries **(data not shown)**. Additionally, during the surveillance period 64 service members (2.9% of the total) were hospitalized, and the vast majority (89.1%) of these hospitalized cold injury cases were members of either the Army (n=43) or Marine Corps (n=14) **(data not shown)**. The majority of active component service members affected by cold injury were identified from diagnostic codes; just 30.2% (n=664) were classified from RMEs **(data not shown)**.

TABLE 3b. Annual incidence of frostbite, immersion hand and foot, and hypothermia among all cold injuries (1 type per person per year), active component, U.S. Navy, July 2017–June 2022

	Frostbite		Immersion hand and foot		Hypothermia		All cold injuries	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	65	3.9	27	1.6	42	2.5	134	8.1
Sex								
Male	58	4.4	24	1.8	35	2.6	117	8.8
Female	7	2.1	3	0.9	7	2.1	17	5.1
Race/ethnicity group								
Non-Hispanic White	30	3.6	11	1.3	20	2.4	61	7.3
Non-Hispanic Black	20	7.8	6	2.3	7	2.7	33	12.8
Other/unknown	15	2.6	10	1.8	15	2.6	40	7.0
Age group (years)								
<20	3	3.1	4	4.1	7	7.2	14	14.3
20–24	17	3.4	9	1.8	15	3.0	41	8.3
25–29	27	6.6	5	1.2	14	3.4	46	11.2
30–34	8	2.8	4	1.4	4	1.4	16	5.6
35–39	5	2.4	2	1.0	2	1.0	9	4.4
40–44	0	0.0	2	1.9	0	0.0	2	1.9
45+	5	7.6	1	1.5	0	0.0	6	9.2
Rank								
Enlisted	51	3.7	26	1.9	39	2.8	116	8.4
Officer	14	5.1	1	0.4	3	1.1	18	6.5
Military occupation								
Combat-specific[b]	6	5.8	0	0.0	4	3.9	10	9.7
Motor transport	2	3.0	0	0.0	15	22.7	17	25.8
Repair/engineering	16	2.2	12	1.6	9	1.2	37	5.1
Communications/intelligence	8	3.0	6	2.3	3	1.1	17	6.4
Health care	17	9.5	0	0.0	5	2.8	22	12.2
Other/unknown	16	5.0	9	2.8	6	1.9	31	9.8
Cold year (July–June)								
2017-2018	15	4.7	9	2.8	5	1.6	29	9.1
2018-2019	15	4.6	1	0.3	5	1.5	21	6.4
2019-2020	14	4.2	6	1.8	7	2.1	27	8.1
2020-2021	10	2.9	3	0.9	13	3.8	26	7.6
2021-2022	11	3.2	8	2.3	12	3.5	31	9.1

[a]Rate per 100,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
No., number.

FIGURE 3. Frequency of service members affected by any cold injury (1 per person per year), by service and cold season, July 2017-June 2022



No., number.

Cold injuries during deployments

During the 5-year surveillance period, a total of 75 cold injuries were identified in service members deployed outside of the U.S. **(data not shown)**. Of these, 39 (52.0%) were frostbite, 25 (33.3%) were immersion injuries, and 11 (14.7%) were hypothermia. Of these 75 cold injuries, slightly more than one-sixth (17.3%) occurred in the most recent cold season (n=13). There were 11 cold injuries during the 2020–2021 cold season, 10 during 2019–2020, 24 during 2018–2019, and 17 during 2017–2018 **(data not shown)**. Frostbite injuries accounted for more than two-thirds (n=9; 69.2%) of the cold injuries identified in service members deployed outside of the U.S during the 2021–2022 cold season.

TABLE 3c. Annual incidence of frostbite, immersion hand and foot, and hypothermia among all cold injuries (1 type per person per year), active component, U.S. Air Force, July 2017–June 2022

	Frostbite		Immersion hand and foot		Hypothermia		All cold injuries	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	212	13.1	12	0.7	31	1.9	255	15.7
Sex								
Male	182	14.2	9	0.7	28	2.2	219	17.0
Female	30	8.9	3	0.9	3	0.9	36	10.7
Race/ethnicity								
Non-Hispanic White	125	12.9	7	0.7	19	2.0	151	15.5
Non-Hispanic Black	45	20.4	3	1.4	7	3.2	55	24.9
Other/unknown	42	9.8	2	0.5	5	1.2	49	11.4
Age group (years)								
<20	17	21.6	2	2.5	4	5.1	23	29.2
20–24	113	24.5	5	1.1	12	2.6	130	28.2
25–29	38	9.4	2	0.5	5	1.2	45	11.1
30–34	20	6.6	1	0.3	4	1.3	25	8.3
35–39	13	5.7	2	0.9	4	1.8	19	8.4
40–44	4	4.0	0	0.0	1	1.0	5	4.9
45+	7	14.8	0	0.0	1	2.1	8	16.9
Rank								
Enlisted	191	14.6	11	0.8	26	2.0	228	17.5
Officer	21	6.7	1	0.3	5	1.6	27	8.6
Military occupation								
Combat-specific[b]	7	58.4	0	0.0	0	0.0	7	58.4
Motor transport	2	16.4	0	0.0	0	0.0	2	16.4
Repair/engineering	89	17.6	5	1.0	7	1.4	101	19.9
Communications/intelligence	31	9.1	1	0.3	7	2.1	39	11.4
Health care	11	7.3	1	0.7	2	1.3	14	9.3
Other/unknown	72	12.0	5	0.8	15	2.5	92	15.3
Cold year (July–June)								
2017-2018	39	12.3	2	0.6	5	1.6	46	14.5
2018-2019	40	12.4	2	0.6	5	1.6	47	14.6
2019-2020	38	11.6	2	0.6	7	2.1	47	14.3
2020-2021	46	14.0	1	0.3	9	2.7	56	17.0
2021-2022	49	15.1	5	1.5	5	1.5	59	18.2

[a]Rate per 100,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
No., number.

Cold injuries by location

During the 5-year surveillance period, 19 military locations had at least 25 incident cold injuries (1 per person per year) among active and reserve component service members **(Figure 4)**. Among these locations, those with the highest 5-year counts of incident injuries were Fort Wainwright, AK (n=208); Joint Base Elmendorf-Richardson, AK (n=203); Fort Campbell, KY (n=104); Camp Lejeune, NC (n=101); Fort Drum, NY (n=93); Naval Medical Center San Diego, CA (n=82); Fort Carson, CO (n=77); and Fort Benning, GA (n=76) **(data not shown)**. During the 2021–2022 cold season, the numbers of incident cases of cold injuries were higher than the counts for the previous 2020–2021 cold season at 6 of the 19 locations **(data not shown)**. The most noteworthy increase was observed at the Army's Fort Wainwright, where there were 100 total cases identified in 2021–2022, compared to 42 the year before **(data not shown)**. **Figure 4** shows the numbers of cold injuries during 2021–2022 and the median numbers of cases for the previous 4 years at those locations that had at least 25 cases during the surveillance period. For 13 of the 19 installations, the numbers of cases in 2021–2022 were less than the median counts for the previous 4 years **(Figure 4)**.

Editorial Comment

The overall rate of cold injuries in 2021–2022 decreased slightly compared to the previous cold year. As in previous years, cold injury rates were much higher among members of the Army and Marine Corps.

In 2021–2022, frostbite was the most common type of cold injury among active

component service members in all 4 of the services. Factors associated with increased risk of cold injury in previous years were again noted during the most recent cold season. Compared to their respective counterparts, overall rates of cold injuries were higher among male service members, non-Hispanic Black service members, the youngest (less than 20 years old), and those who were enlisted. Increased rates of cold injuries affected nearly all enlisted and officer occupations among non-Hispanic Black service members. Of note, rates of frostbite were markedly higher among non-Hispanic Blacks compared to non-Hispanic Whites and those in the other/unknown race/ethnicity group. These differences have been noted in prior *MSMR* updates, and the results of several studies suggest that other factors such as physiologic differences are possible explanations for increased susceptibility.[9,14,25–27] The numbers of cold injuries associated with deployments during 2020–2021 and 2021–2022 were the lowest numbers during the 5-year surveillance period; frostbite injuries accounted for the majority of the cold injuries in service members deployed outside of the U.S. during the 2021–2022 cold season.

It should be noted that this analysis of cold injuries was unable to distinguish between injuries sustained during official military duties (training or operations) and injuries associated with personal activities not related to official duties. RMEs for non-freezing peripheral injuries were excluded if "chilblains" was listed in the case comments; however, there may have been some RMEs for chilblains that were misclassified as immersion injury if chilblains was not listed in the case comments. To provide for all circumstances that pose the threat of cold injury, service members should know the signs of cold injury well and how to protect themselves against such injuries whether they are training, operating, fighting, or recreating under wet and freezing conditions.

The most current cold injury prevention materials are available at: https://phc.amedd.army.mil/topics/discond/cip/Pages/Cold-Weather-Casualties-and-Injuries.aspx.

TABLE 3d. Annual incidence of frostbite, immersion hand and foot, and hypothermia among all cold injuries (1 type per person per year), active component, U.S. Marines, July 2017–June 2022

	Frostbite		Immersion hand and foot		Hypothermia		All cold injuries	
	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a]
Total	205	22.5	134	14.7	107	11.8	446	49.0
Sex								
Male	196	23.6	128	15.4	96	11.6	420	50.7
Female	9	11.2	6	7.5	11	13.7	26	32.4
Race/ethnicity								
Non-Hispanic White	89	16.7	88	16.5	48	9.0	225	42.2
Non-Hispanic Black	73	81.2	8	8.9	22	24.5	103	114.6
Other/unknown	43	15.0	38	13.3	37	12.9	118	41.2
Age group (years)								
<20	29	23.3	65	52.1	36	28.9	130	104.3
20–24	120	27.4	57	13.0	56	12.8	233	53.3
25–29	31	19.7	10	6.4	12	7.6	53	33.7
30–34	15	17.7	2	2.4	3	3.5	20	23.6
35–39	9	14.6	0	0.0	0	0.0	9	14.6
40–44	1	3.5	0	0.0	0	0.0	1	3.5
45+	0	0.0	0	0.0	0	0.0	0	0.0
Rank								
Enlisted	179	22.3	126	15.7	103	12.9	408	50.9
Officer	26	24.1	8	7.4	4	3.7	38	35.2
Military occupation								
Combat-specific[b]	117	59.1	19	9.6	46	23.2	182	91.9
Motor transport	5	11.6	2	4.6	5	11.6	12	27.9
Repair/engineering	18	8.1	14	6.3	3	1.4	35	15.8
Communications/intelligence	29	13.5	11	5.1	7	3.3	47	22.0
Health care	0	0.0	0	0.0	0	0.0	0	0.0
Other/unknown	36	15.4	88	37.7	46	19.7	170	72.9
Cold year (July–June)								
2017-2018	36	19.6	36	19.6	25	13.6	97	52.9
2018-2019	54	29.3	36	19.5	30	16.3	120	65.0
2019-2020	26	14.1	15	8.1	18	9.8	59	32.0
2020-2021	57	31.6	24	13.3	17	9.4	98	54.4
2021-2022	32	18.1	23	13.0	17	9.6	72	40.7

[a]Rate per 100,000 person-years.
[b]Infantry/artillery/combat engineering/armor.
No., number.

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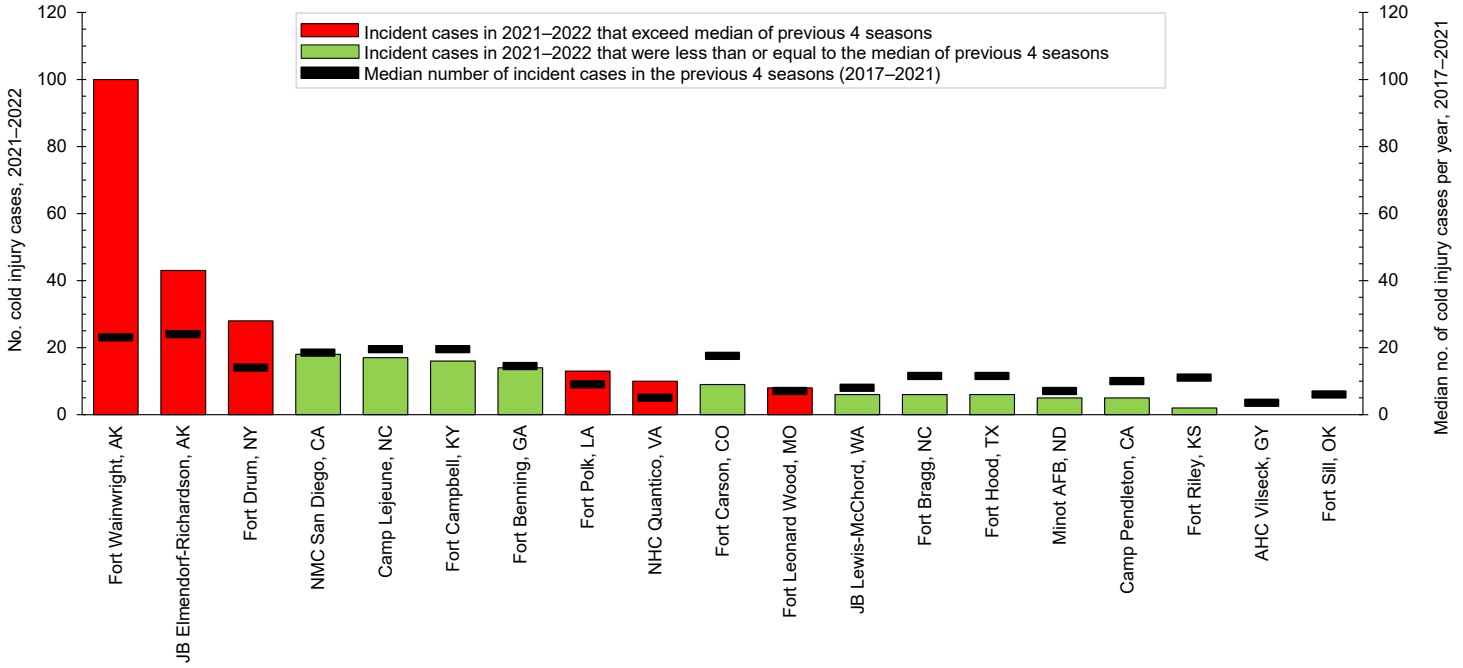
FIGURE 4. Annual frequency (cold season 2021–2022) and median numbers (cold seasons 2017–2021) of cold injuries at locations with at least 25 cold injuries during the surveillance period, active component, U.S. Armed Forces, July 2017–June 2022



No., number; JB, Joint Base; NMC, Naval Medical Center; AFB, Air Force Base; AHC, Army Health Clinic; NHC, Naval Health Clinic; GY, Germany; NH, Naval Hospital.

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In-Theater Mental Health Disorders Among U.S. Soldiers Deployed Between 2008 and 2013

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Deployed service members regularly undergo demanding and stressful experiences that can contribute to mental health difficulties; however, there is a scarcity of studies examining rates of mental health disorders in-theater. The current study examined case rates of mental health disorders among deployed U.S. Army Soldiers using diagnostic encounter data from the Theater Medical Data Store. Case rates were calculated across 12 categories of mental health disorders. While in theater, soldiers' highest rates were for stress reactions and adjustment disorders, depression, anxiety, and sleep disorders. The lowest rates in theater were for psychosis, bipolar, somatic, and eating disorders. Notably, female soldiers had higher rates than their male counterparts for disorders in each of the 12 diagnostic categories. Results provide crucial information to aid in decision making about necessary interventions and provider competencies in deployed settings. Knowledge gained from these data may improve force readiness, help lessen disease burden, and inform military policy and prevention efforts.

What are the new findings?

The disorders with the highest case rates in-theater included stress reactions/adjustment disorders, depression, anxiety, and sleep disorders, followed by PTSD and ADD/ADHD. Of particular note, in each of the 12 diagnostic categories examined, female soldiers had consistently higher rates than their male counterparts.

What is the impact on readiness and force health protection?

These results emphasize the crucial need for in-theater behavioral health providers to be competent in the delivery of effective, short-term treatments for stress, anxiety, depression, and sleep disruptions. Further, these findings may contribute to the development of new policies and interventions to better prepare, support, and treat soldiers during deployments.

Mental health is a significant concern within the U.S. military, and service members are at substantial risk for developing an array of mental health conditions including anxiety, depression, stress/adjustment issues, and sleep-related disorders.[1,2] Approximately 20% of the active duty population was diagnosed with at least 1 mental health disorder in 2016.[3] Importantly, these mental health issues affect not only force health and readiness but also contribute to the morbidity, hospitalization, and overall attrition of military personnel.[4-6]

To date, most research examining rates of mental health diagnoses in the military has been conducted post-deployment (e.g., Hoge et al.[7]). Despite high rates of mental health disorders after deployment[7,8] (e.g., 7% depression and 11% posttraumatic stress disorder [PTSD] estimated from the Post-deployment Health Assessment[8]), few studies have examined the rates at which service members are diagnosed with a mental health disorder while deployed. Wojcik and colleagues evaluated in-theater diagnoses among soldiers deployed to an overseas contingency operating area between September 2001 and December 2004.[9] The most frequent diagnoses were mood, adjustment, and substance-abuse disorders. White, female, enlisted soldiers were among those at highest risk for nearly all mental health disorders examined in the Wojcik study. However, these rates were assessed only as they related to psychiatric hospitalizations, thus providing insight only into the incidence of diagnoses severe enough to warrant inpatient care. Larson and colleagues also examined in-theater diagnoses and found the most frequently diagnosed disorders were, in descending order, anxiety (including acute stress disorder and PTSD), adjustment, and mood disorders.[10] Their results were limited in that they examined diagnoses across 1 year (January 2006 to February 2007) in a single division (1st Marine Division) deployed to 1 province in Iraq (Al Anbar). However, both of these studies further support the evidence that rates of diagnosis of mental health disorders in the U.S. military population differ by sex[4,11] and racial/ethnic background of the patient.[4]

Deployed service members regularly undergo demanding and stressful experiences that can contribute to mental health difficulties. Furthermore, service members with previous deployments are more frequently utilizing mental health care services in-theater.[9] Using prevalence rates after deployment as a proxy for the mental health status of deployed personnel ignores a wealth of important information about the disease burden and resources necessary to care for deployed service members. A thorough evaluation of in-theater mental health status is vital to understanding force readiness, informing military medical planning, developing prevention efforts, and reducing potential risk. Therefore, this study examines the rates of mental health diagnoses in deployed active duty U.S. soldiers and examines related sociodemographic characteristics.

Methods

Participants

Data were drawn from the Army Analytics Person-Event platform of military personnel datasets, including the Defense Manpower Data Center (DMDC) Contingency Tracking System (CTS), Active Duty Personnel Master files, and medical records from both the Military Health System (MHS) Data Repository and the Theater Medical Data Store (TMDS[10]). The eligible study cohort consisted of 530,404 unique active duty service members in the U.S. Army who were deployed to an overseas contingency operations area between calendar years 2008 and 2013. This calendar timeline was selected to capture years of elevated deployments during contingency operations. This study assessed members of the Army, as this branch has consistently had the greatest number of personnel deployed and the highest percentage of active duty members diagnosed with a mental health condition over the past several years.[3]

Procedures

A CTS deployment event is defined as a service member who is physically located within a designated combat zone/area of operation or a member who has been specifically identified by their service as directly supporting the contingency operation's mission. Overseas contingency operations are military operations designated by the Secretary of Defense in which armed forces are or may become involved in military actions, operations, or hostilities. All deployment event records are included in this study without any restrictions to a specific location and may involve combat or non-combat activities. Deployment records containing a begin date variable and end date variable were used to identify the date of the first deployment and periods of deployment from 1 January 2008 to 31 December 2013. Demographic variables, including military branch of service, were selected from the DMDC Personnel Master file corresponding to the date of first deployment. Encounter information from theater-based medical treatment facilities was retrieved from the TMDS for deployed soldiers identified during the study period. The International Classification of Diseases, 9th Revision[12] (ICD-9) diagnosis codes found in the primary or secondary diagnostic position of the TMDS medical record were used to create 12 different mental health categories for each soldier **(Table 1)**. These categories were developed based on the grouping of diagnoses in the Diagnostic and Statistical Manual of Mental Disorders Fifth Edition (DSM-5)[13] and then cross-referenced with the extant literature on military mental health to eliminate disorders with little relevance (e.g., autism spectrum disorder). To obtain counts of mental health disorders, dichotomous indicators (0: not diagnosed; 1: diagnosed) were set for each calendar year according to these mental health categorization definitions. A case was defined as any documentation of a mental health condition within the calendar year. Therefore, a soldier may appear within multiple diagnostic categories and multiple years.

Data analysis

Summary tables were generated, which captured counts by calendar year for deployment, demographic, and diagnostic variables. The unique number of deployed soldiers and person-years (p-yrs) spent deployed were calculated by calendar year. Due to limitations of the data, diagnostic history could not be determined; thus, the case rates in this report may reflect incident, prevalent, or recurrent mental health disorders based on in-theater diagnostic coding. Due to the low frequency of some disorders, the rates are represented per 10,000 p-yrs and suppressed for groups with less than 20 observations to ensure rate stability.[14] Race/ethnicity data were most affected by this requirement, necessitating the exclusion of many rates due to low counts.

TABLE 1. ICD-9 diagnostic codes for classification of mental health disorders

Mental health disorder	ICD-9 codes
Schizophrenic disorders, psychosis, and paranoia	295.00 - 295.95; 297.0 - 298.9
Bipolar and mania	296.00 - 296.16; 296.40 - 296.81; 296.89; 301.13
Depressive disorders	296.20 - 296.36; 296.82; 300.4; 311
Anxiety disorders	300.0 - 300.10; 300.20 - 300.3
Post traumatic stress disorder (PTSD)	309.81
Stress reactions, adjustment disorders	308.3 - 309.0; 309.24 -309.28; 309.3 - 309.4; 309.82 - 309.9
Somatic system disorders	300.11; 300.16 - 300.19; 300.7 - 300.89
Personality disorders	301.0; 301.20; 301.22; 301.4 - 301.50; 301.6 - 301.83; 301.89 - 301.9
Sleep disorders	307.40 - 307.47; 307.48
Feeding and eating disorders	307.1; 307.51
Attention deficit hyperactivity disorder/attention deficit disorder	314.00 - 314.01
Alcohol and drug related disorders	291.0 - 292.84; 292.9

ICD-9, International Classification of Diseases, 9th Revision.

Results

Overall findings

There was a case rate of 1,116.6 per 10,000 p-yrs for any mental health disorder. Rates were lowest in 2008 (801.8/10,000 p-yrs) and increased each year until peaking in 2012 (1,427.3/10,000 p-yrs) before decreasing in 2013 (1,014.9/10,000 p-yrs) **(Table 2).**

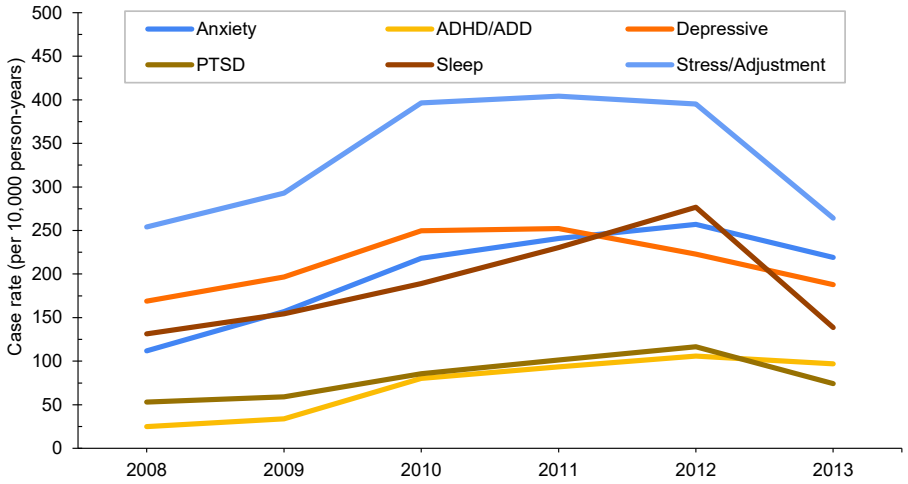
Examination of annual rates for the 12 diagnostic categories revealed that 6-year rates ranged from a low of 1.4/10,000 p-yrs for eating/feeding disorders to a high of 332.6/10,000 p-yrs for stress/adjustment disorders. Diagnostic categories could be roughly divided into those with high (>150/10,000 p-yrs; sleep, anxiety, depression, stress/adjustment), moderate (50-149/10,000 p-yrs; PTSD, ADHD/ADD), low (10-49/10,000 p-yrs; alcohol/drug, personality), and very low (<10/10,000 p-yrs; schizophrenia, bipolar, somatic, eating/feeding) rates. Rates of the 6 most common categories (high/moderate) tended to increase each year from 2008, peaking in 2012, and decreasing slightly in 2013 **(Figure 1)**. The less frequent disorders tended to peak earlier (2009/2010) and have lower rates in ensuing years **(Table 2)**.

Sex and race patterns in diagnostic categories

In each diagnostic category, female soldiers had a greater case rate than their male counterparts **(Figure 2)**. This pattern was apparent in the 6-year rates and also for every annual comparison in which the count of diagnoses was 20 or more. Females demonstrated rates of diagnoses at least twice those of males for anxiety disorders, bipolar/mania, depressive disorders, personality disorders, somatic disorders, and stress reactions. Although some of these differences (e.g., depression, anxiety) reflect differences observed in the broader population,[15,16] some differences stand in striking contrast to relative prevalence rates in the general population. For example, ADHD/ADD is diagnosed more frequently among males in the general population,[17] but the rate among the deployed female soldiers in the present study was almost 50% higher than the rate among males. Similarly, although sex is generally unrelated to the prevalence of personality disorders,[18] female soldiers in this study demonstrated a rate of personality disorder diagnoses almost four times their male counterparts.

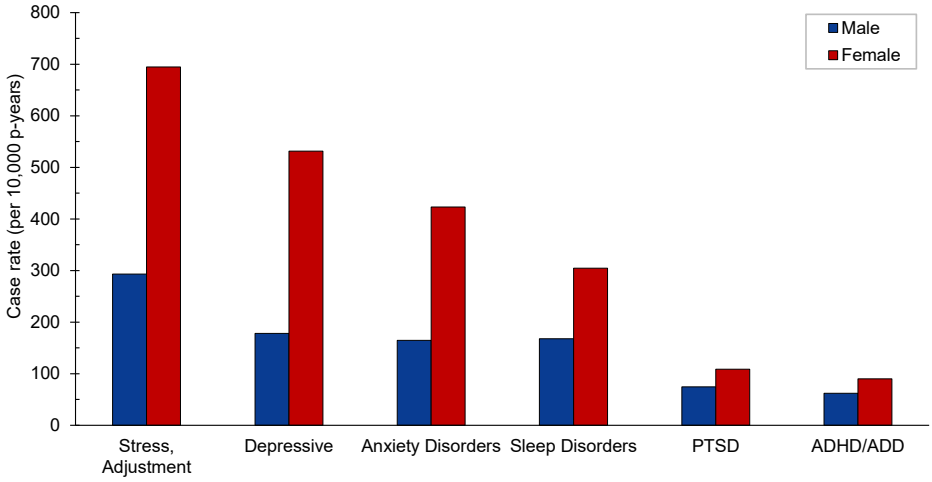
The 6-year annual case rate of nearly all disorders was higher in non-Hispanic White soldiers than soldiers in other race/ethnicity groups. However, schizophrenic disorders, psychosis, and paranoia had a higher rate among Hispanic and Black/African American soldiers. There were no to negligible differences between the rates of somatic and stress-related disorders by race and ethnicity groups. Due to the low rate of feeding and eating disorders, comparative rate assessments by race cannot be made. Additionally, complete rates for individual race/ethnicity groups were available for the most

FIGURE 1. Annual case rates of the most common mental health disorders, deployed soldiers, U.S. Army, 2008-2013



ADHD/ADD, attention deficit hyperactivity disorder/attention deficit disorder; PTSD, post traumatic stress disorder

FIGURE 2. Case rates of the most common mental health disorders by sex, deployed soldiers, U.S. Army, 2008-2013



ADHD/ADD, attention deficit hyperactivity disorder/attention deficit disorder; PTSD, post traumatic stress disorder

TABLE 2. Case rates of mental health disorders by sex and race/ethnicity, deployed soldiers, U.S. Army, 2008-2013

	Total		Alcohol and drug related disorders		Anxiety disorders		ADHD/ADD		Bipolar and mania		Depressive disorders		Feeding and eating disorders	
	No.	Rate[a]	No.	Rate[a,b]	No.	Rate[a]	No.	Rate[a]	No.	Rate[a,b]	No.	Rate[a]	No.	Rate[a,b]
Total	60,295	1,116.6	837	15.5	10,253	189.9	3,503	64.9	413	7.7	11,480	212.6	75	1.4
Sex														
Male	48,216	989.7	737	15.1	8,019	164.6	3,028	62.2	307	6.3	8,673	178.0	NA	NA
Female	12,079	2,287.5	100	18.9	2,234	423.1	475	90.0	106	20.1	2,807	531.6	64	12.1
Race/ethnicity group														
Non-Hispanic White	41,782	1,207.4	611	17.7	7,294	210.8	2,881	83.3	305	8.8	7,902	228.4	58	1.7
Black or African American (non-Hispanic)	9,436	958.6	123	12.5	1,396	141.8	239	24.3	60	6.1	1,858	188.8	7	-
Asian (non-Hispanic)	1,559	801.9	20	10.3	240	123.5	68	35.0	10	-	317	163.1	0	-
Hispanic	6,113	997.0	64	10.4	1,090	177.8	256	41.8	33	5.4	1,126	183.7	10	-
Other	1,405	954.2	NA	NA	233	158.2	59	40.1	5	-	277	188.1	0	-

[a] Case rates are presented per 10,000 person-years.
[b] Rates with less than 20 cases were suppressed.
ADHD/ADD, attention deficit hyperactivity disorder/attention deficit disorder; PTSD, post traumatic stress disorder

TABLE 2 (cont.) Case rates of mental health disorders by sex and race/ethnicity, deployed soldiers, U.S. Army, 2008-2013

	Total		Personality disorders		PTSD		Schizophrenic disorders, psychosis, and paranoia		Sleep disorders		Somatic system disorders		Stress reactions, adjustment disorders	
	No.	Rate[a]	No.	Rate[a,b]	No.	Rate[a]	No.	Rate[a,b]	No.	Rate[a]	No.	Rate[a,b]	No.	Rate[a]
Total	60,295	1,116.6	1,201	22.2	4,207	77.9	411	7.6	9,788	181.3	170	3.2	17,957	332.6
Sex														
Male	48,216	989.7	850	17.5	3,632	74.6	358	7.4	8,181	167.9	131	2.7	14,289	293.3
Female	12,079	2,287.5	351	66.5	575	108.9	53	10.0	1,607	304.3	39	7.4	3,668	694.7
Race/ethnicity group														
Non-Hispanic White	41,782	1,207.4	838	24.2	2,890	83.5	231	6.7	6,741	194.8	111	3.2	11,920	344.5
Black or African American (non-Hispanic)	9,436	958.6	195	19.8	644	65.4	101	10.3	1,545	157.0	30	3.1	3,238	328.9
Asian (non-Hispanic)	1,559	801.9	20	10.3	80	41.2	19	-	261	134.3	4	-	520	267.5
Hispanic	6,113	997.0	125	20.4	473	77.1	51	8.3	957	156.1	20	3.3	1,908	311.2
Other	1,405	954.2	23	15.6	120	81.5	9	-	284	192.9	5	-	371	251.0

[a] Case rates are presented per 10,000 person-years.
[b] Rates with less than 20 cases were suppressed.
ADHD/ADD, attention deficit hyperactivity disorder/attention deficit disorder; PTSD, post traumatic stress disorder

common diagnoses. Rates for all disorders (i.e., anxiety disorders, ADHD/ADD, PTSD, depressive disorders, stress reactions/adjustment disorders) were highest among non-Hispanic White soldiers. Black/African American soldiers had the lowest rates of ADHD/ADD; Asian soldiers had the lowest rates of PTSD and anxiety, depressive, and sleep disorders; and patients with "other" race/ethnicity had the lowest rates of stress reactions/adjustment disorders.

Editorial Comment

The present study reports case rates of psychiatric disorders among U.S. Army personnel deployed to an overseas contingency operation area from 2008 through 2013. These rates were based on in-theater diagnostic codes, and thus represent incident, prevalent, or recurrent disease. Results highlight several important aspects regarding psychiatric disorders among military personnel. The most common disorders (>180/10,000 p-yrs) were stress/adjustment, depression, anxiety, and sleep. In contrast, the study found very low case rates (<10/10,000 p-yrs) of psychosis, bipolar, somatic, and eating disorders. These findings provide vital information in regards to the training and deployment of mental health providers and support assets into theater. Specifically, deploying mental health clinicians need to be trained and competent in the delivery of effective, short-term treatments for stress, anxiety, depression, and sleep disruptions. Future studies may examine the incidence of in-theater diagnoses, as well as the mental health and career trajectories of service members who receive in-theater diagnoses.

Consistent with the current findings, a previous study found rates of adjustment disorders, PTSD, anxiety, depression, and personality disorders to be higher among female recruits attending basic training;[19] however, there were no noted differences between males and females in rates of alcohol abuse/dependence, schizophrenia, or other psychoses in this earlier study.[19] The authors noted that the lack of difference in substance disorders may have been due to the stringent requirements against alcohol use during basic training.[19] Among active duty service members receiving care from or reimbursed by the Military Health System between 2000 and 2011, female service members were diagnosed with adjustment, personality, depressive, and anxiety disorders at a higher rate than their male counterparts.[20] In contrast to the current study's findings, these researchers found that males were diagnosed more frequently with PTSD and alcohol/substance abuse. As in the current study, adjustment and depressive disorders were among the two most frequently diagnosed mental health disorders[20] and reasons for mental health hospitalizations[21] among service members in the active component of the U.S. Armed Forces. As noted above, some estimates suggest 7% of service members have depression and 11% experience PTSD following deployments.[8] The observed rates of PTSD (0.8%) and depression (2.1%) in the present study were much lower.

As in prior studies of military medical records,[20] adjustment disorders were diagnosed at a greater rate than other disorders. The case rate of stress/adjustment disorders (332.56/10,000 p-yrs or 3.3%) in the present sample is strikingly high given that estimates of adjustment disorder in the general population tend to be around 1%.[22] It is likely that these rates reflect the high stress conditions inherent in deployments. However, it is possible some of these diagnoses may be given as a proxy for other diagnoses such as PTSD.[23] However, an adjustment disorder diagnosis may be given prior to these diagnoses[23] to reflect the acute period of stress experienced during a deployment, as adjustment disorder diagnoses are only appropriate for the 6-month period following the stressor. In addition to the potential stress of combat operations, it is likely some of these cases reflect difficulties in adjusting to deployment away from family and support systems as well as stress associated with problems "on the home front." Additional research into the nature and reactions to different stressors while deployed is warranted. Further, better understanding of the stressors leading to significant adjustment problems could provide insight into the potential challenges of providing care to these service members when they return from deployment.

The present finding that female soldiers had 2.3 times the rate of diagnoses compared to male soldiers, considering all diagnostic groups and years, necessitates further study. Previous studies have found higher rates of psychiatric diagnosis among female service members,[4,11] but the present results are notably different. For example, research indicates that male service members utilized more mental health services in proportion to their total outpatient and inpatient encounters for the middle (17.0%) and last 6 months (35.6%) of service compared to females (15.1% and 32.4%, respectively).[24] Also, previous research found female service members were hospitalized for adjustment disorder, PTSD, depression, and bipolar disorder at higher rates, but male service members were hospitalized at greater rates for alcohol and substance use/abuse disorders.[21] In the present study female soldiers had a 25% greater rate of diagnosis with alcohol/substance use disorders than male soldiers. Similarly, when considering the general population, the DSM-5 suggests that ADHD is 1.6 times more likely to be diagnosed in male adults than in female adults,[13] but the observed rates of ADHD/ADD were nearly 45% times higher among female soldiers than their male counterparts. The findings from this study are consistent with those of Williams and colleagues[25] who found female service members were medically evacuated from theater for a mental health reason at a rate 64% greater than that of their male counterparts. Understanding the reasons for the variability in rates in the deployed setting is critical to enhancing support for important sections of the DOD workforce, as close to 17% of the active duty DOD workforce identify as female.[26]

The nature of the present data suggest several possibilities for this difference that should be explored. First, deployed female soldiers may actually experience more mental health problems than their male peers. Among female service members, combat stress, military sexual trauma, family separation, and reintegration post-deployment are significant stressors[27] that contribute to MH disorders.[28-30] Second, female soldiers may be more likely than their male counterparts to seek help for mental health issues, an idea consistent with findings that female service members are more likely to receive MH care.[31] Similarly, among active duty combat veterans screening positive for PTSD, major depressive disorder (MDD), or generalized anxiety disorder (GAD), women and veterans of color, compared to men and White veterans, were more interested in receiving care.[32] Finally, health care providers may be more likely to psychiatrically diagnose deployed female soldiers compared to male soldiers due to sex-based biases. Implicit biases among

primary care physicians resulted in female patients receiving less accurate diagnoses, made with less confidence, and less appropriate treatment recommendations than male patients.[33] Addressing these possibilities would require unique policy, training, and clinical interventions.

Due to small case counts for some disorders, it was not possible to examine rates for individual race/ethnicity groups; rates were presented for the 6 most frequently diagnosed disorders for which the data permitted computation of all race/ethnicity groups. Non-Hispanic White soldiers were consistently diagnosed at greater rates than all other race/ethnicity groups, consistent with previous studies of military medical records.[21,34]

Though the ability to analyze data from all Army personnel deployed to contingency operation areas during a 6-year period represents a notable strength of the current study, the reliance on medical record data from theater-based military treatment clinics and hospitals also creates some challenges. First, because the rates used in the present study require that a soldier seek treatment and have a mental health diagnosis coded into TMDS to be considered a case, it is inevitable that the case rate identified in the present study underestimates the actual rate of psychiatric illness. Although clinical diagnoses provide benefits relative to self-reported symptoms, the data offer no means to assess the validity of the diagnoses made or that diagnoses were reliably entered into the system and therefore available for analysis. Second, the diagnostic categories used in the present study are based on the ICD-9, which was in use within the military health care system at the time the data were collected. Results may differ with other diagnostic frameworks (e.g., DSM-5, ICD-10/11). Finally, the use of archived medical record data limits our ability to examine factors that may contribute to the reported results. This examination of rates defines a case as any documentation of a mental health condition within the calendar year in the primary or secondary diagnostic position, consistent with Hepner and colleagues.[35] This definition was selected so that these rates may be as inclusive as possible. However, future studies may consider using other definitions with a more stringent criteria to increase confidence in the accuracy of the diagnosis (e.g., one primary inpatient diagnosis or two primary outpatient diagnoses documented within 30 days of each other[34]).

Despite the limitations inherent in working with archived medical records and unvalidated diagnoses, the present results provide vital insight into the mental health issues that arise and require treatment during deployments—conditions that providers should be prepared to diagnose and treat in the context of ongoing contingency operations. These rates provide a general framework for understanding case rates of mental health disorders among soldiers deployed into combat. Future studies should consider important demographic, psychological health, and calendar factors such as operations tempo that may influence rates of disorders. Additionally, future studies would be strengthened by consideration of preexisting diagnostic status, which the present study was unable to examine. A more comprehensive understanding of the causes of the apparent differences across demographic groups will contribute to the development of new approaches and policies to better prepare, support, and treat soldiers during overseas deployments.

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Brief Report: Pediatric Vaccine Completion and Compliance Among Infants Born to Female Active Duty Service Members, 2006–2016

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Rotavirus gastroenteritis is the leading cause of diarrhea-associated morbidity and mortality among children under age 5 worldwide.[1] RotaTeq vaccine was approved in 2006 for the prevention of rotavirus gastroenteritis in infants 6 to 32 weeks of age, followed by Rotarix in 2008. However, vaccination coverage for children aged 19–35 months remained well below 50% in the United States (U.S.) in 2009 and rose to only 73% in 2017.[2] In contrast, vaccination coverage for inactivated polio virus (IPV) and diphtheria, tetanus, and acellular pertussis (DTaP), two longstanding and highly trusted pediatric vaccines, averaged 93% and 84%, respectively, between 2009 and 2017.[2] Even when vaccine acceptance is high, degree of delay is of concern: A national study of children born between 2004 and 2008 reported that 49% were undervaccinated for at least 1 day before age 24 months.[3]

There is a paucity of published research on recent pediatric vaccine coverage among military beneficiaries. A 2015 study identified military children as potentially at risk for lower vaccination rates than their civilian counterparts: 28% of military dependents vs 21% of all other children aged 19–35 months had not completed the recommended immunization series.[4] Notably, this study relied on data reported by primary care providers. As military beneficiaries are more likely to move and may access care at both military and civilian facilities, the information provided by a single provider may be incomplete. No prior study of military beneficiaries has examined timeliness of pediatric vaccinations relative to the recommended age of vaccination.

The present study used the Military Health System (MHS) immunization registry and medical encounter data to assess: 1) rotavirus vaccine coverage relative to IPV and DTaP vaccines and 2) trends in pediatric undervaccination among a population of infants born to female active duty service members.

Methods

Department of Defense Birth and Infant Health Research (BIHR) program data were used to identify infants born to female active duty service members from 2006 through 2016.[5] The BIHR program is an ongoing population-based surveillance and research effort that identifies and follows infants born to military families (i.e., TRICARE beneficiaries). BIHR data consist of military demographic and personnel data from the Defense Manpower Data Center and the Defense Enrollment Eligibility Reporting System, and administrative medical encounter data from the MHS Data Repository. Same-sex multiple births are excluded from BIHR data due to difficulty distinguishing their neonatal medical records. Infants included in the present study were required to be enrolled in TRICARE within the first 12 months of life and then continuously enrolled until 24 months of age.

Immunization status was principally assessed using the MHS immunization database, which is populated with immunizations given at military clinics. These data were supplemented with immunizations identified using Current Procedural Terminology codes (90680, 90681, 90713, 90696, 90697, 90698, 90723, 90700) in outpatient health care records from military clinics and civilian facilities. Completion of rotavirus (2 doses), IPV (3 doses), and DTaP (4 doses) vaccination was assessed by 24 months of age. Vaccine compliance was assessed by additionally applying the Advisory Committee on Immunization Practices childhood immunization schedule **(Table 1)**.[6] Doses received early were not considered, while those received after the recommended vaccination window were recorded as delayed and not compliant. Due to limited information on vaccine product in the MHS database, the 2 dose Rotarix requirement (vs the 3 dose RotaTeq requirement) was applied for rotavirus vaccine completion and compliance.

Service member (sponsor) factors of interest included age at delivery (18–24, 25–29, 30–34, or 35+ years), race and ethnicity (American Indian or Alaska Native, Asian or Pacific Islander, Hispanic, non-Hispanic Black, non-Hispanic White, or other/unknown), marital status (married or unmarried/unknown), military rank (enlisted or officer), service branch (Air Force, Army, Coast Guard, Marine Corps, or Navy), and deployment within 24 months postpartum (yes or no). Health care factors of interest included birth location (civilian facility or military clinic), primary well-child care location (according to the location of the majority of care, either at civilian facilities or military clinics), change of well-child care location (by catchment area) before age 24 months (yes or no), and infant enrollment type (TRICARE Prime or other).

Completion and compliance were calculated annually (2006–2016), overall, and by sponsor and health care characteristics. For calculations by sponsor and health care characteristics, rotavirus vaccine was required among infants born after 2008. All data management and descriptive statistical analyses were conducted using SAS, Version 9.4 (SAS Institute, Inc.).

TABLE 1. Criteria used to evaluate compliance with childhood vaccination schedule and calculate days undervaccinated[a]

Vaccination dose	Recommended age per ACIP (months)	Minimum acceptable age (days)	Minimum acceptable interval between doses (days)	Age when under-vaccination count initiated[b] (days)
Rotavirus[c]				
Dose 1	2	38		93
Dose 2	4	66	24	154
Dose 3	6	94	24	215
IPV				
Dose 1	2	38		93
Dose 2	4	66	24	154
Dose 3	6–18	94	24	580
DTaP				
Dose 1	2	38		93
Dose 2	4	66	24	154
Dose 3	6	94	24	215
Dose 4	15–18	361	179	580

[a]Criteria based on Glanz, 2016[6]
[b]The latest age a child can receive the first dose of Rotavirus, IPV, and DTaP vaccines on time per the ACIP schedule is 92 days.
[c]Rotavirus vaccine should not be administered past age 252 days.
ACIP, Advisory Committee on Immunization Practices

Results

Overall, 103,522 infants were identified for vaccination assessment. Rotavirus vaccine completion increased from 2007 (the first full year after vaccine approval) to 2016 (2007: 65.0%, 2016: 92.4%; **Figure**); however, the rate of uptake slowed after 2009 and completion never achieved levels of IPV, which remained consistently high throughout the study time frame (2006: 87.0%, 2016: 95.2%). After 2007, vaccine completion was lowest for DTaP (2008: 76.5%, 2016: 85.5%), and DTaP compliance only reached 62.3% in 2016. Low DTaP compliance was due in large part to 14.5% of infants not receiving the fourth dose of the vaccine and another 8.6% with no previous delays in vaccination receiving the fourth dose after age 15-18 months. For infants born between 2014 and 2016, approximately 40% remained undervaccinated for at least 1 day before age 24 months, and 12.5% were undervaccinated for more than 6 months.

Vaccination coverage varied by select sponsor and health care characteristics, particularly for incomplete vaccination status **(Table 2)**. Infants born to older service members, service members of officer rank, and service members who did not deploy within 24 months postpartum were more likely to be completely vaccinated without delays (35+ vs 18–24 years: 58.1% vs 46.7%; officer vs enlisted: 62.3% vs 49.8%; not deployed vs deployed: 53.2% vs 45.0%). Asian or Pacific Islander service members had the highest rate of infant non-delayed vaccine completion (54.7%), followed by non-Hispanic White and Hispanic service members (52.7% and 52.5%, respectively). Non-Hispanic Black and American Indian or Alaska Native service members had the lowest rates of non-delayed vaccine completion (49.8% and 46.4%, respectively). Infants born to service members in the Army were more likely to complete all

FIGURE. Percentage of infants born to active duty service members who complete and are compliant with pediatric vaccine recommendations, by vaccine series, and overall, Department of Defense Birth and Infant Health Research program data, 2006-2016 (n=103,522)

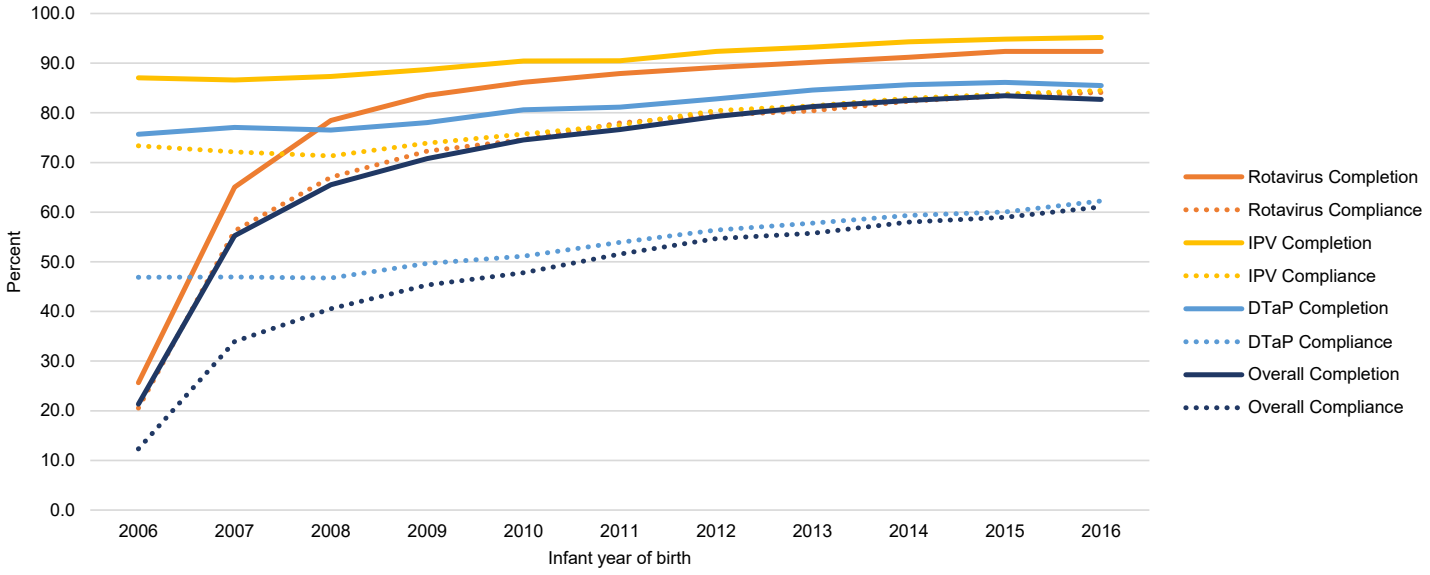

TABLE 2. Frequency and percentage of infants with complete, non-delayed; complete, delayed; and incomplete vaccination status at 24 months of age, by sponsor and health care characteristics, Department of Defense Birth and Infant Health Research program data, 2006–2016

Characteristic	Total[a]		Vaccination status[b]					
			Complete, non-delayed vaccination		Complete, delayed vaccination		Incomplete vaccination	
	No.	%	No.	%	No.	%	No.	%
Total	103,522	100.0	53,653	51.8	27,005	26.1	22,864	22.1
Age at infant birth								
18–24 years	39,897	38.5	18,617	46.7	10,736	26.9	10,544	26.4
25–29 years	32,684	31.6	17,339	53.1	8,522	26.1	6,823	20.9
30–34 years	20,687	20.0	11,742	56.8	5,172	25.0	3,773	18.2
35+ years	10,254	9.9	5,955	58.1	2,575	25.1	1,724	16.8
Race and ethnicity								
American Indian or Alaska Native	2,191	2.1	1,016	46.4	573	26.2	602	27.5
Asian or Pacific Islander	6,988	6.8	3,820	54.7	1,772	25.4	1,396	20.0
Hispanic	15,932	15.4	8,362	52.5	4,313	27.1	3,257	20.4
Non-Hispanic Black	27,685	26.7	13,785	49.8	7,762	28.0	6,138	22.2
Non-Hispanic White	47,032	45.4	24,783	52.7	11,679	24.8	10,570	22.5
Other/Unknown	3,694	3.6	1,887	51.1	906	24.5	901	24.4
Marital status								
Married	79,095	76.4	41,650	52.7	20,411	25.8	17,034	21.5
Unmarried/Unknown	24,427	23.6	12,003	49.1	6,594	27.0	5,830	23.9
Military rank								
Enlisted	86,469	83.5	43,036	49.8	23,264	26.9	20,169	23.3
Officer	17,053	16.5	10,617	62.3	3,741	21.9	2,695	15.8
Service branch								
Air Force	33,655	32.5	16,931	50.3	9,111	27.1	7,613	22.6
Army	35,152	34.0	19,377	55.1	9,301	26.5	6,474	18.4
Coast Guard	2,619	2.5	1,076	41.1	545	20.8	998	38.1
Marine Corps	6,910	6.7	3,600	52.1	1,627	23.5	1,683	24.4
Navy	25,186	24.3	12,669	50.3	6,421	25.5	6,096	24.2
Deployment within 24 months postpartum								
No	86,120	83.2	45,820	53.2	21,906	25.4	18,394	21.4
Yes	17,402	16.8	7,833	45.0	5,099	29.3	4,470	25.7
Infant birth location								
Civilian facility	31,903	30.8	15,900	49.8	8,196	25.7	7,807	24.5
Military clinic	71,619	69.2	37,753	52.7	18,809	26.3	15,057	21.0
Primary well-child care location								
Civilian facilities	18,156	17.5	8,934	49.2	3,773	20.8	5,449	30.0
Military clinics	85,366	82.5	44,719	52.4	23,232	27.2	17,415	20.4
Change of well-child care location								
No	40,250	38.9	21,082	52.4	9,753	24.2	9,415	23.4
Yes	63,272	61.1	32,571	51.5	17,252	27.3	13,449	21.3
Infant enrollment type								
TRICARE Prime	102,476	99.0	53,285	52.0	26,857	26.2	22,334	21.8
Other	1,046	1.0	368	35.2	148	14.1	530	50.7

[a] Results presented as a column percentage.
[b] Results presented as a row percentage.

vaccinations on time relative to other service branches (55.1%), while infants born to Coast Guard branch members were the least likely to have complete, non-delayed vaccination (41.1%). Infants who primarily received care at military clinics versus civilian facilities were more likely to experience delays in vaccination (27.2% vs 20.8%), but less likely to be incomplete with their vaccinations at 24 months (20.4% vs 30.0%). Vaccination coverage was similar by marital status, infant birth location, and change of well-child care location. Although sample size was small, incomplete vaccination appeared more likely among infants enrolled in other types of TRICARE versus those enrolled in TRICARE Prime.

Editorial Comment

Rotavirus vaccination of infants born to active duty service members commenced in 2006, following RotaTeq approval. By 2009, rotavirus vaccine completion among these military dependents had surpassed that observed nationally for children aged 19-35 months (83.5% vs 43.9%). Although the gap had narrowed by 2016, the infants in this study continued to exhibit higher vaccine completion (92.4% vs 74.1%).[2] IPV and DTaP vaccine series completion began below national rates but achieved comparable levels by 2012, with coverage exceeding national rates after 2013.[1] Despite overall improvements in vaccine series completion, incomplete and delayed vaccination remained prevalent for DTaP and varied by select characteristics: some differences paralleled national findings (e.g., by maternal age and race and ethnicity);[2,4,7] others were distinct to the active duty population (e.g., by military rank, service branch, and deployment status).

The present work adds to the literature on childhood vaccination among military dependents. Findings corroborate prior vaccine completion estimates of 84.0–85.7% for 24-month-old military dependents;[8,9] however, there were also stark gaps between vaccine completion and compliance. Differences by demographic characteristics indicate the need for improved communication between providers and parents, while those by primary care location underscore the need for improved data and information flow between civilian and military health care providers.[10] Relatively low vaccine completion rates among infants born to Coast Guard and deployed sponsors may be related to unique barriers to coordinated care for these infants, including fragmented care and childcare challenges associated with living in remote or geographically isolated areas.[10-12] Recent evidence suggests vaccine hesitancy may be increasing in the U.S.,[13] including within the MHS: parental hepatitis B vaccination refusal rates for infants born in the MHS increased from 2014 to 2018, despite a concurrent increase in vaccination coverage.[14] Provider-parent communication about vaccine significance and safety, and provider attention to access-related barriers are therefore increasingly important for vaccine series compliance.

In this study, detailed infant vaccination records and continuous TRICARE enrollment enabled ascertainment of timing and type of vaccination. Although capture of vaccination status is therefore presumed close to comprehensive, it is possible that some vaccinations, e.g., those received at civilian inpatient facilities, were not documented in the immunization record. This may in part explain higher incompletion rates among infants whose well-child care visits were predominantly at civilian facilities. As rotavirus measurement did not account for the fact that the RotaTeq vaccine requires a third dose, true coverage (i.e., receipt of all rotavirus doses in the series) may also be lower than reported here.

Military providers should continue to promote rotavirus vaccination alongside vaccination for IPV and DTaP, and ensure infants return for a care visit during the 15- to 18-month age window in order to remain compliant with the DTaP series. Additional work is needed to understand the causes of delayed vaccination and identify opportunities for delay prevention.

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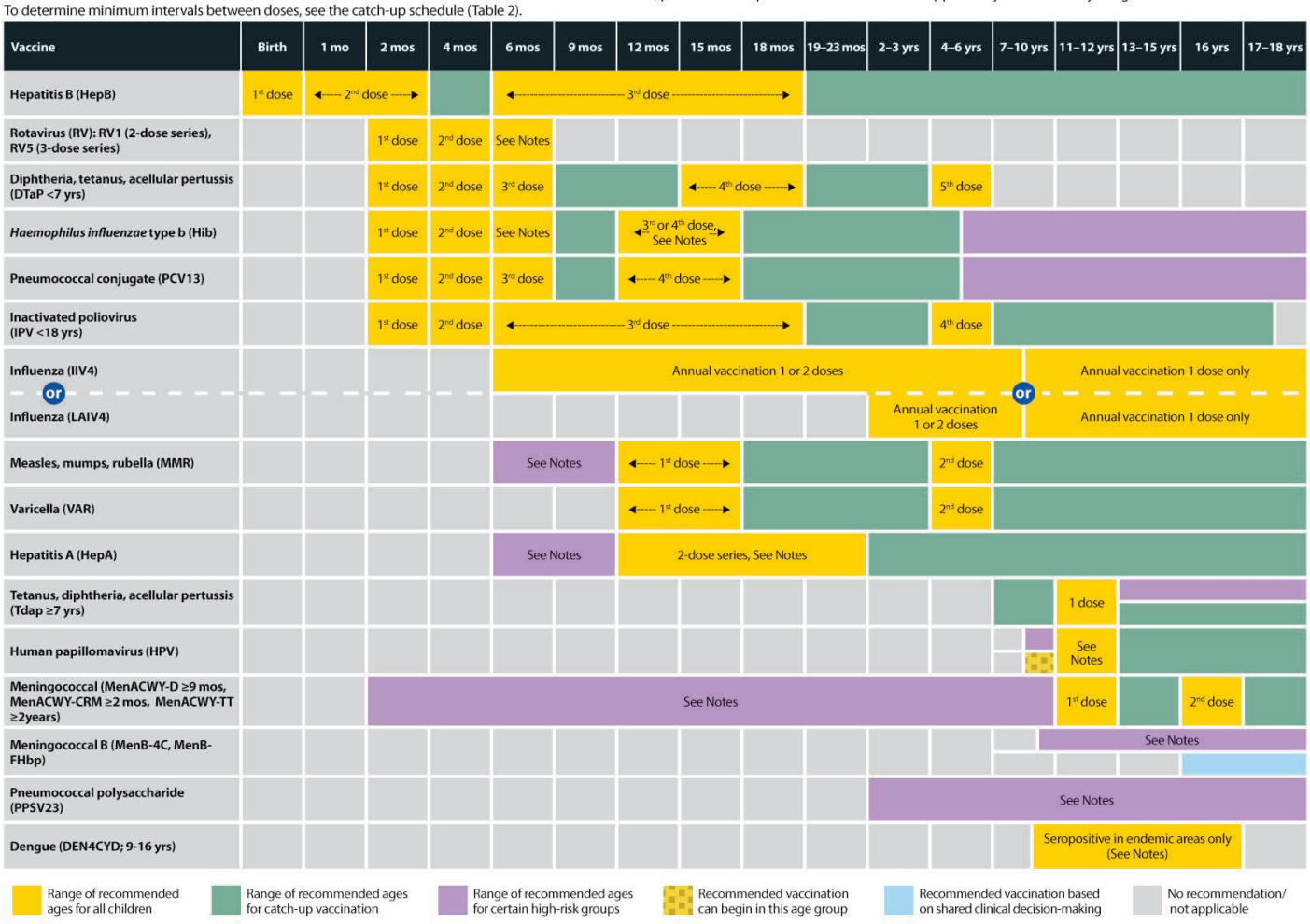
Recommended Child and Adolescent Immunization Schedule for ages 18 years or younger, United States, 2022

These recommendations must be read with the notes that follow. For those who fall behind or start late, provide catch-up vaccination at the earliest opportunity as indicated by the green bars.
To determine minimum intervals between doses, see the catch-up schedule (Table 2).



https://www.cdc.gov/vaccines/schedules/downloads/child/0-18yrs-child-combined-schedule.pdf

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