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Medical Surveillance for Military Readiness

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Guillain-Barré Syndrome Clinical Characteristics and Outcomes Among U.S. Active Component Service Members, 2014–2022

Emily J. Elliott, DO; Shauna L. Stahlman, PhD, MPH; Nora Watson, PhD; Cole Denkensohn, MD; Kaye Sedarsky, MD

An examination of Guillain-Barré Syndrome (GBS) cases among U.S. active component service members from 2014 through 2022 revealed an incidence rate of 1.6 cases per 100,000 person-years. Individuals younger than age 20 years and those in basic training exhibited higher incidence. The type of antecedent event, either illness or immunization, was not associated with higher disability ratings at long-term follow-up. The analysis also quantified morbidity among service members with GBS, finding that 28.0% of cases had a subsequent chronic pain diagnosis, and 28.7% of cases were referred to the medical evaluation board. The need for neuropathic pain medication during the acute phase predicted poorer long-term functional outcomes. Furthermore, electrodiagnostic evidence of axonal or mixed nerve damage correlated with greater disability after 1 year. Although basic trainees had higher incidence, their long-term morbidity was comparable to other groups. These findings underscore the considerable impact that GBS can have on affected military personnel and identify factors associated with long-term complications.

What are the new findings?

There were 1.6 cases of Guillain-Barré syndrome per 100,000 person years among active component U.S. service members from 2014 through 2022. There was no association between persistent disability and associated antecedent event (e.g., infection or immunization). Many patients experienced incomplete recovery, with 28.7% resulting in medical board referrals. Persistent disability was independently associated with chronic pain diagnosis.

What is the impact on readiness and force health protection?

Despite the low incidence rate of the disorder, approximately 29% of U.S. service member GBS cases experienced incomplete recovery that required medical board referral. Service members appear to be at a higher risk for GBS during initial recruit basic training, potentially due to increased exposure to infections and immunization requirements at accession.

Guillain-Barré syndrome (GBS) is an acute immune-mediated polyradiculoneuropathy. GBS stems from an autoimmune response related to an antecedent illness, immunization, or other immune reaction causing damage to myelin (acute inflammatory demyelinating polyneuropathy, or AIDP) or axons (acute motor axonal neuropathy, or AMAN) of the peripheral nerves and ganglia. AIDP is the predominant variant seen in North America.[1]

GBS occurs with an overall worldwide incidence rate (IR) of 0.6–4.0 cases per 100,000 people per year with higher rates reported in North America, 2.2–4.2 cases per 100,000.[2-8] One study from 2009 found a slightly higher incidence of GBS in the active duty U.S. military population compared to the general population.[5] It is more common in men and can affect all age groups.[1]

Mortality due to GBS varies in reported studies, from 2% to 10%, with predictors including advanced age, mechanical ventilation, and cardiopulmonary complications.[1-4,6] Morbidity with severe disability can be seen in upwards of 20% of patients, with predictors including advanced age, mechanical ventilation, preceding diarrheal illness, and high-grade disability in the acute phase.[1-4] Pain is a common symptom upon presentation and can persist long term, significantly affecting quality of life.[9]

Classic clinical presentation of GBS manifests as a progressive ascending muscle weakness with decreased or absent deep tendon reflexes.[6] Patients also present with sensory symptoms, ataxia, lower back pain, and cranial nerve involvement that range in severity.[6] Autonomic dysfunction is also common and can be fatal.[6] Variants include pure motor, pure sensory, Miller Fisher, pharyngeal-brachial, and paraparetic.[6]

There are no specific biomarkers associated with GBS. Diagnosis of GBS is typically based on a thorough history and clinical examination. Certain diagnostic tools may support diagnosis, including cerebrospinal fluid (CSF) analysis, serum antibody testing, magnetic resonance imaging (MRI), and electrodiagnostic studies.

The disease timeline is typically monophasic, with progression over 2 weeks and symptom nadir (i.e., most critically ill point) around 4 weeks after onset.[6] Severity is variable, and up to one-fourth of cases require mechanical ventiliation.[6,8] Close monitoring and early initiation of intravenous immunoglobulins (IVIG) or plasma exchange (PLEX) is essential for accelerating recovery.[7] Uncommonly, acute clinical presentation of GBS can herald another neurological disorder, such as chronic inflammatory demyelinating

polyneuropathy (CIDP) or neurological presentation of other systemic diseases such as lupus or infection.

Antecedent respiratory or gastrointestinal illness can be identified in up to three-fourths of patients presenting with GBS.[1,8,10] *Campylobacter jejuni* is the most common prior infection, with 30% of cases in 1 study demonstrating serological evidence of the infection.[10] Other infectious etiologies include *Mycoplasma pneumonia,* cytomegalovirus, Epstein-Barr virus, hepatitis E virus, Zika, dengue, and influenza.[1,8,10] Asymptomatic infections have also been detected by serological testing, which may suggest higher rates of antecedent illness.[10]

The risk of immunization-related GBS was originally based on the 1976 swine influenza vaccine, but studies investigating influenza immunization after 1976 had mixed results, with most showing no causal relationship.[11] Low, but increased risk of GBS following adenovirus-vectored COVID-19 vaccines was lower than the risk identified with the 1976 influenza vaccine.[12] The same study also found reduced risk of GBS with the messenger RNA (mRNA) COVID-19 vaccines.[12] The U.S. Centers for Disease Control and Prevention (CDC)'s Advisory Committee on Immunization Practices (ACIP) states that GBS is not a precaution for future immunizations, unless it occurred within 6 weeks of receiving a tetanus-toxoid-containing vaccine or an influenza vaccine.[13]

Immunizations are administered upon accession into military service, unless a service member provides prior documentation of prior immunization or serological testing showing presence of antibodies.[14] Immunization administration upon military accession is recommended before or at the beginning of basic training, to help mitigate risk of contagious disease in close quarters environments.[14] Additional immunizations such as yellow fever, Japanese encephalitis, and rabies may be required depending upon travel or area of operation requirements.[14] COVID-19 immunization was mandated for all military members in August 2021; however, the mandate was rescinded in January 2023. Immunizations identified by the CDC of potential concern are influenza and tetanus vaccines, however, other vaccines have also been implicated, including yellow fever and rabies.[15,16]

A previous military population study, of matched case-control design, evaluated the association between GBS and acute gastrointestinal infections and deployment from 1999 through 2007.[5] That 2009 study identified a slightly higher incidence in the military cohort compared to the general population, but it was limited by retrospective database review without medical record review.[5]

The objective of the current study was to describe the incidence, clinical characteristics (including antecedent illness or immunization), clinical course, and electrodiagnostic findings of U.S. active component service members (ACSMs) with clinically confirmed GBS from 2014 through 2022. Due to the timeline chosen for data extraction, it includes 2 years of COVID-19 immunization in addition to yearly influenza immunization. An updated, comprehensive understanding of the clinical characteristics of GBS, its disease course, and their readiness implications will supply health care providers with knowledge that can aid patient education, improve prognostication discussions, and potentially assuage apprehensions about immunizations in relation to GBS risk.

Methods

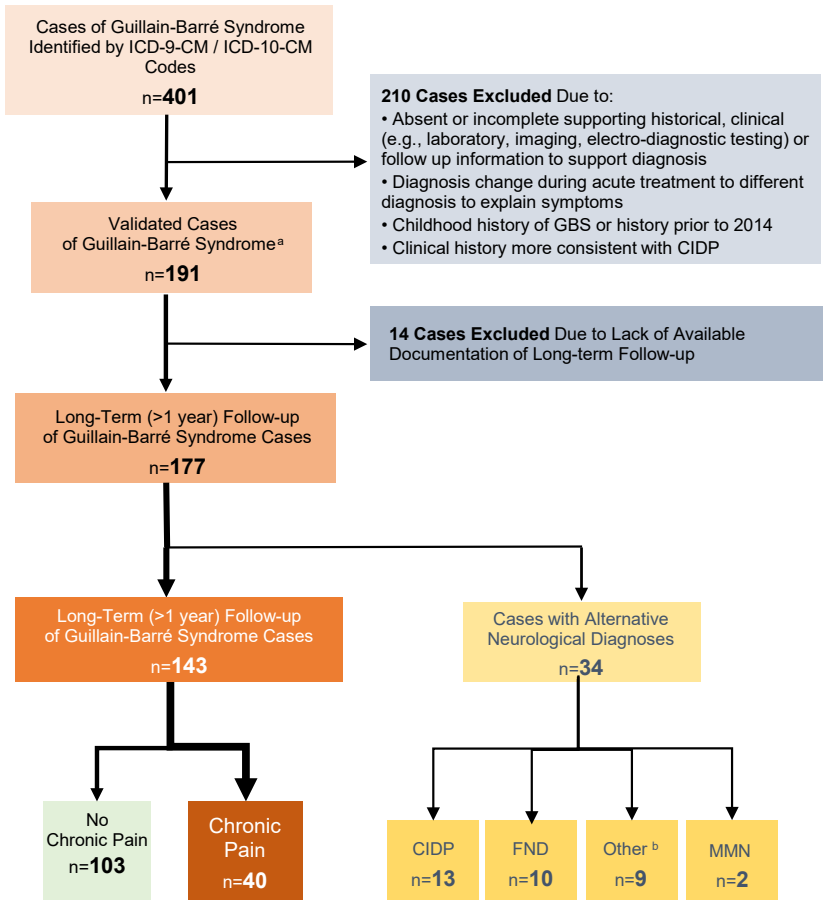
Potential cases of GBS were identified as those with documentation of an International Classification of Diseases, 9th or 10th Revision, Clinical Modification (ICD-9-CM/ICD-10-CM) code (357.0 or G61.0, respectively) in an inpatient or outpatient medical encounter from January 1, 2014 through December 31, 2022 among ACSMs in the U.S. Army, Navy, Marine Corps, Coast Guard, Air Force, or Space Force. The data came from medical records maintained in the Defense Medical Surveillance System (DMSS) that the authors obtained from the Armed Forces Health Surveillance Division (AFHSD) in 2023. DMSS ICD-9-CM/ICD-10-CM code queries included diagnostic positions of 4 digits for outpatient records and 9 digits for inpatient records. The records examined included those from military hospitals and clinics as well as civilian medical facilities if reimbursement was sought through the Military Health System (MHS). The 2014 start date was chosen to capture treatment and prescription data through DMSS. The Walter Reed National Military Medical Center determined this project to be human subject research exempt from institutional board review.

A list of 401 potential cases identified in DMSS was sent to the primary investigator's research team of neurologists and neurology residents for individual record review **(Figure)**. Cases were excluded during individual chart review when the diagnosis code was entered with no other supporting information to confirm diagnosis, or the diagnosis was revised during the acute treatment period. Cases were also excluded if the diagnosis code referenced childhood or prior history of GBS before January 2014.

Following individual chart reviews, 191 cases were identified as acute presentations of GBS. Cases were validated based on a culmination of consistent clinical history, symptoms upon patient presentation, physical examination findings, and treatment choice consistent with GBS diagnosis. Supporting diagnostic evidence including CSF studies, serum antibody testing, lumbar spine MRI findings, and electrodiagnostic testing were also reviewed to aid case validation. Data collected for the 191 identified cases included patient demographics, clinical information, electrodiagnostic testing data, and related case outcomes.

The acute phase of GBS was considered as the time from initial clinical evaluation to either end of acute treatment course, final hospitalization, or acute rehabilitation discharge. Clinical information collected in the acute phase included presence of antecedent illness or prior immunization, timeline of symptom onset, diagnostics (e.g., laboratory, imaging, electrodiagnostic data), primary treatments, pain treatment, hospital care and complications, and disability rating, using the Modified Rankin Scale (MRS), at the most critically ill point (i.e., nadir) of acute presentation. Antecedent illness information was obtained from clinical history and review of clinical notes 30 days prior to presentation, for indications of acute illness appointments or infection treatments. Immunization

FIGURE. Subject Identification Flow Chart for Guillain-Barré Syndrome Cases, U.S. Active Component Service Members, 2014–2022



Abbreviations: ICD-9-CM, International Classification of Diseases, 9th Revision, Clinical Modification; ICD-10-CM, International Classification of Diseases, 10th Revision, Clinical Modification; n, number; GBS, Guillain-Barré syndrome; CIDP, chronic inflammatory demyelinating polyneuropathy; FND, functional neurological disorder; MMN, multifocal motor neuropathy; CSF, cerebrospinal fluid analysis; MRI, magnetic resonance imaging; SLE, systemic lupus erythematosus.

[a] Validated by clinical history with consistent presenting symptoms, physical examination findings, course, treatment choice with resultant GBS diagnosis; supporting evidence included CSF studies, serum antibody testing, lumbar spine MRI findings, and electrodiagnostic testing.

[b] Other diagnoses included SLE, transverse myelitis, and non-inflammatory polyneuropathy.

information was obtained from clinical histories, reviews of medical chart immunization records, and reviews of clinical notes indicating immunization appointments within 30 days preceding patient presentation. Any immunization within 30 days was recorded according to type of immunization and date administered.

Clinical information collected after the acute phase included additional electrodiagnostic study data, time to recovery, chronic pain diagnosis, and long-term follow-up MRS. Electrodiagnostic testing results were classified as normal, demyelinating, or mixed/axonal. Demyelinating cases had isolated demyelinating features that could include prolonged or absent F-waves, prolonged distal latencies, or slowed conduction velocities. Axonal or mixed cases had either axonal features alone or axonal and demyelinating features. Axonal features could include low amplitude action potentials or spontaneous activity on electromyography.

Time to recovery was assessed by patient report of recovery, date returned to full duty, and medical evaluation board (MEB) referrals. MEB information was compared and validated with MEB information provided by the DMSS. Chronic pain diagnosis based on presence of ICD-9-CM or ICD-10-CM code (338.2 or G89) or documentation of chronic pain within the clinical note and was dichotomized as present or not.

During chart reviews, chronic pain diagnosis was included if it could be related to GBS diagnosis in documentation of chronic pain present since acute phase. A diagnosis of chronic pain was included if pain was a new symptom at time of GBS diagnosis and continued at 1 year follow-up or beyond. Cases were not included in the chronic pain category if chronic pain diagnosis was clearly attributable to another injury. Chronic pain diagnosis was independently confirmed by the primary investigator.

MRS determination was based on reviews of neurologists' interpretations of clinical disability reports from histories and documented physical examination findings. If multiple clinical encounters were available after 1 year of follow-up, then the encounter closest to 1 year after the original diagnosis was used to determine MRS. The MRS scale is a disability scale graded from 0 to 6, with 0 indicating no symptoms present, 1 indicating minimal symptoms but ability to complete all usual activities, 2 indicating slight disability but able to perform daily activities without assistance, 3 indicating moderate disability requiring help and unable to walk alone without assistance, 4 indicating moderate severe disability requiring assistance for own bodily needs, 5 indicating severe disability unable to attend own body needs without constant assistance, and 6 indicating death.[17]

All reviewers were trained on proper application of the MRS scale, and a small sampling of cases was provided to the reviewers prior to initiation of review to aid with inter-rater reliability. The primary investigator confirmed complementary assessments with all reviewers of the sample cases provided. A data collection sheet for the acute phase collected medical research council sum score, ventilation requirements, and medical complications during hospitalization, which aided determination of nadir MRS scores. The primary investigator independently confirmed all MRS scores with the data collection sheet and independent review.

The list of confirmed cases was returned to AFHSD for IR calculation. AFHSD used longitudinal personnel data in the DMSS to calculate the rate of clinically confirmed

GBS per 100,000 person-years (p-yrs) of active component service. Person-time was censored at the incident diagnosis date. Person time for recruit basic training was identified using a standard AFHSD algorithm based on time in service, assigned military installation, branch of service, and other factors.

Case characteristics were described and compared by MRS and chronic pain diagnosis as outcomes after 1 year follow-up using Wilcoxon 2-sample tests and Chi-square or Fisher's exact tests. To evaluate potential independent associations of case characteristics with each outcome, multivariable logistic regression models estimated adjusted odds ratios associated with several characteristics selected by the research team based both on their potential clinical relevance and association with the outcome in unadjusted analyses. Further adjustment was avoided to guard against model overfitting and to conform to the traditional minimum number of events per predictor (≥10) in logistic regression. Low variance inflation factors in each model indicated that multi-collinearity was not a concern.

The dependent variables were MRS outcome and chronic pain diagnosis at 1 year or greater follow-up. MRS was defined as either 0 (asymptomatic) or greater than 0 (minimally symptomatic to severe disability). Independent variables included use of neuropathic pain treatment in the acute treatment phase, presence of pain in the acute phase, and significant disability (MRS ≥3) during the acute phase. A dichotomized MRS definition of greater than or equal to 3 was based both on observed elevated frequencies of each outcome in this stratum relative to lower MRS scores and by the small cell sizes in several MRS strata, which prevented further evaluation of MRS as an ordinal score in multivariable models. These analyses were performed using R (version 4.0.5).[18]

Results

The DMSS database identified 401 potential GBS cases by ICD-9-CM / ICD-10-CM codes alone **(Figure)**. After individual chart reviews, 191 cases were identified as acute GBS. An IR of 1.6 confirmed GBS cases per 100,000 p-yrs was calculated for ACSMs from 2014 through 2022 **(Table 1)**. Male service members had a slightly higher rate than female service members (1.7 and 1.0 cases per 100,000 p-yrs, respectively). There was a higher IR in those younger than age 20 years, at 3.6 cases per 100,000 p-yrs, and those in basic training recruit status (11.5 cases per 100,000 p-yrs).

An isolated antecedent illness within 30 days of diagnosis was noted in 94 of 191 (49.2%) cases **(Table 2)**. Median time from illness start to diagnosis date was 11 days. Isolated immunization within 30 days of the date of diagnosis was seen in 28 (14.7%) cases. Median time from immunization to date of diagnosis was 15 days. Approximately one-fourth of cases, 46 of 191 (24.1%), had both an antecedent illness and immunization within 30 days of the preceding syndrome presentation.

The most reported symptoms were upper respiratory illness or influenza-like illness, which were seen in 101 (52.8%) cases. COVID infection was only noted in 4 (2.1%) cases. Influenza was the most common immunization received within the preceding 30 days (11.5%). COVID immunization had been received in 9 (4.7%) cases. Among the 28 basic training recruits, 9 of the 28 (32.1%) had a prior illness only, 7 of the 28 (25%) had a previous immunization only, and 12 of the 28 (42.8%) had both a concurrent preceding illness and immunization (data not shown).

Pain was reported during initial patient presentation in 141 of 191 (73.8%) cases **(Table 2)**. Over three-fourths of cases demonstrated no significant disability to moderate disability at the most critical point of initial presentation, ranging from MRS

TABLE 1. Incidence Rate[a] of Guillain-Barré Syndrome, U.S. Active Component Service Members, 2014–2022

Characteristics	No.	Rate
Total	191	1.6
Sex		
Male	171	1.7
Female	20	1.0
Age, *y*		
<20	29	3.6
20–24	55	1.5
25–29	33	1.2
30–34	32	1.7
35–39	19	1.4
40–44	16	2.2
45+	7	1.6
Race and ethnicity		
White, non-Hispanic	76	2.4
Black, non-Hispanic	21	2.3
Hispanic	30	1.6
Other	15	1.5
Unknown	49	1.0
Basic training recruit status		
Yes	28	11.5
No	163	1.4

Abbreviations: No., number; *y*, years.
[a] Per 100,000 person-years.

1 in 40 cases (20.9%), MRS 2 in 71 cases (37.2%), and MRS 3 in 33 cases (17.3%). Almost one-fourth of cases had moderate to severe disability at nadir, with MRS 4 (n=29, 15.2%) or 5 (n=16, 8.4%).

All but 14 patients were hospitalized for monitoring and management **(Table 2)**. The median duration of hospitalization was 7 days (range 2–54 days). Eleven patients received no documented treatment. Most patients received IVIG as primary treatment (n=155, 81.2%). Eleven patients received IVIG in combination with PLEX. Seven patients received PLEX alone, and 7 received steroids alone for primary treatment. Neuropathic pain medication was given to 48.2% (n=92) of patients.

Over half of cases (n=108, 56.5%) received electrodiagnostic testing. Among the 108 cases with electrodiagnostic testing, results were interpreted as normal in 27 cases; evidence of isolated demyelinating features was noted in 53 cases; and 28 cases had axonal or mixed findings **(Table 2)**. Serial electrodiagnostic studies were completed in 45 of 108 (41.6%) cases (data not shown). Follow-up studies were normal in 15 of 45 (33.3%) cases, with median follow-up testing at 51 days (range 7–896 days). Demyelinating features were present in 20 of 45 cases (44.4%), with median follow-up testing at 152 days (range 6–1,063 days). Axonal or mixed features were observed in 10 of 45 cases (22.2%) with median follow-up testing at 122 days (range 19–1,191 days). Five cases had more than 2 serial electrodiagnostic tests completed (4 of 5 were axonal, range 35–1,088 days). One case with primary axonal damage had persistent fibrillation potentials and positive waves more than 1 year after original diagnosis (data not shown).

Following the initial treatment course, 36 patients had recurrent or persistent symptoms without interval improvement after initial hospitalization (data not shown). One case (0.5%) was believed to be recurrence of GBS, 3.5 years after the initial episode. Five cases experienced symptom recrudescence within 90 days, attributed to the initial disease presentation, that were subsequently treated with second rounds of IVIG. Five cases had recurrent symptoms more than 90 days later, without other objective evidence of recurrence, with 1 receiving IVIG treatment again 6 years later.

TABLE 2. Clinical Characteristics of U.S. Active Component Service Members with Guillain-Barré Syndrome, 2014–2022

Clinical Feature	No.	%[a]
Total	191	100
Antecedent clinical event		
Preceding illness only	94	49.2
Preceding immunization only	28	14.7
Both preceding illness and immunization	46	24.1
No preceding illness or immunization	23	12.0
Pain present, acute phase		
Yes	141	73.8
No	50	26.2
Modified Rankin Scale nadir		
MRS 0 (no symptoms)	0	0.0
MRS 1 (no significant disability)	40	20.9
MRS 2 (slight disability)	71	37.2
MRS 3 (moderate disability)	33	17.3
MRS 4 (moderately severe disability)	29	15.2
MRS 5 (severe disability)	16	8.4
Unknown	2	1.0
Hospitalization		
Yes	177	92.7
No	14	7.3
Median duration	7 days (2–54)	
Mechanical ventilation required		
Yes	20	10.4
No	171	89.6
Primary treatment		
IVIG	155	81.2
None	11	5.8
IVIG/PLEX	11	5.8
PLEX	7	3.7
Steroids	7	3.7
Neuropathic pain treatment		
Yes	92	48.2
No	99	51.8
Electrodiagnostic testing completed		
Yes	108	56.5
No	83	43.5
Results of electrodiagnostic testing		
Not completed	83	43.5
Demyelinating	53	27.7
Axonal, mixed	28	14.7
Normal	27	14.1

Abbreviations: No., number; MRS, Modified Rankin Scale; IVIG, intravenous immunoglobulins; PLEX, plasma exchange.
[a] Row percentage calculated from total cases defined with clinical feature.

Long-term follow-up more than 1 year after initial diagnosis was available for 177 cases. Five cases had no clear improvement after acute presentation and continued to report persistent symptoms at long-term follow-up. Following the acute phase, alternative diagnoses (i.e., other than GBS) were made or suspected in 34 cases. Among those 34 cases, CIDP was the ultimate diagnosis in 13 cases; multifocal motor neuropathy was diagnosed in 2 cases; and other neurological disorders were suspected in 19 cases, including 10 cases of functional neurological disorder. Median time to symptom recurrence for CIDP was 33 days, and 130 days for all others with polyphasic presentations.

After excluding the 34 cases with possible alternative long-term diagnoses, there were 143 cases of GBS with more than 1 year of follow-up **(Table 3)**. MRS was extracted from clinical encounters at least 1 year after original diagnosis. During follow-up after 1 year, 73 of 143 (51.0%) cases had returned to baseline, with MRS 0. The outcomes of long-term follow-up for all other cases were distributed from MRS 1 in 46 (32.2%) cases, MRS 2 in 17 (11.9%) cases, MRS 3 in 3 (2.1%) cases, MRS 4 in 3 (2.1%) cases, and MRS 6 in 1 case with death unrelated to GBS.

The average time for return to duty in those with full recovery was 5 months (median 4 months, range 0.5–40 months). Type of antecedent clinical event and recruit status were not associated with higher MRS at 1 year follow-up (p=0.182 and p=0.077, respectively) **(Table 4a)**. Patients with axonal or mixed electrodiagnostic results were more likely to have MRS greater than 0 at 1 year versus patients with demyelinating or normal electrodiagnostic testing (p<0.001) **(Table 4a)**.

Chronic pain associated with GBS diagnosis was seen in 40 (28.0%) of the 143 cases with no other alternative diagnosis at long-term follow-up **(Table 3)**. Chronic pain diagnoses were seen more commonly in patients with MRS greater than 0 at 1 year (p<0.001) **(Table 4a)**. Among the 143 cases at long-term follow-up, MEB was initiated for 41 (28.7%) cases, and 93 cases (65.0%) returned to duty. Twenty-six of the 41 referred for MEB had a chronic pain diagnosis (data not shown).

Of the 40 patients with chronic pain diagnoses, 33 (82.5%) initially required neuropathic pain treatment (p<0.001) **(Table 4b)**. In a multi-variable logistic regression model of relevant clinical characteristics as predictors of MRS outcome and chronic pain diagnosis at long-term follow-up, neuropathic pain treatment was associated with greater risk of MRS greater than 0 (OR 6.8; 95% CI 2.8, 17.7; p<0.001) and resultant chronic pain diagnosis (OR 7.9; 95% CI 2.7, 28.0; p<0.001) independent of reported pain and MRS at nadir **(Table 5)**.

Discussion

This study provides an update on clinical characteristics and outcomes in GBS among a large military cohort. GBS shares an overall similar IR in the U.S. military population when compared to reported rates globally[1,4,7-9] but has a lower incidence when compared to directly to other North American and European cohorts (1.9 to 4.2 per 100,000 p-yrs).[2,7] GBS severity is variable, but there were no fatalities attributable to GBS in this cohort. This lack of mortality may be related to a lower rate of mechanical ventilation (10.4% vs. up to 23% in other studies[3,8]) and an overall healthier and younger active duty military population.

Results of electrodiagnostic testing can be helpful in predicting long-term MRS outcomes, but only slightly more than half of cases in this study had electrodiagnostic testing available for review. This study did not identify a clear role for serial electrodiagnostic testing. Serial testing can be beneficial, however, if the diagnosis is in question or the patient has persistent or recurring

TABLE 3. Outcomes of Long-Term Follow-up of More Than One Year, U.S. Active Component Service Members with Guillain-Barré Syndrome, 2014–2022

	Cases With No Alternative Diagnoses		Total Cases	
Total follow-up cases, after 1 year	143[a]		177[b]	
Modified Rankin Scale, after 1 year	No.	%	No.	%
MRS 0 (no symptoms)	73	51.0	76	43.0
MRS 1 (no significant disability)	46	32.2	62	35.0
MRS 2 (slight disability)	17	11.9	29	16.4
MRS 3 (moderate disability)	3	2.1	5	2.8
MRS 4 (moderately severe disability)	3	2.1	4	2.3
MRS 5 (severe disability)	0	0.0	0	0.0
MRS 6 (deceased)	1[c]	0.7	1	0.5
Return to full duty[d]				
Yes	93	65.0	100	56.5
No	50	35.0	77	43.5
Average time	5 mo.		5 mo.	
Median time	4 mo.		4 mo.	
Chronic pain diagnosis				
Yes	40	28.0	53	30.0
No	103	73.0	124	70.0

Abbreviations: No., number; MRS, Modified Rankin Scale; mo., months; CIDP, chronic inflammatory demyelinating polyneuropathy; FND, functional neurologic disorder; GBS, Guillain-Barré syndrome.
[a]Long-term follow-up cases excluding those with other diagnoses: CIDP, FND, other neurological diagnosis.
[b]14 of original 191 cases had no long-term follow-up documentation.
[c]Did not die from GBS.
[d]Did not return to full duty includes medical board, permanent profile, separated before return to full duty documented.

symptoms. It is notable that 1 axonal case had persistent fibrillation potentials and positive waves in serial electrodiagnostic testing more than 1 year after initial diagnosis; this appears to have captured the natural course of the disease rather than representing a second pathology.

This study quantified morbidity associated with GBS in U.S. ACSMs, as seen in the 28.0% of cases associated with a subsequent chronic pain diagnosis, and in 28.7% of cases referred to the MEB. The 2009 military study reported 20% of service members with continued medical visits related to GBS 1 year post-diagnosis, and other studies report approximately 20% with long-term disability.[4,5] There were similar rates of reported pain in the acute period (~70%) and long-term follow-up period (~25%) compared to a recent civilian cohort.[9] The need for treatment with neuropathic pain medication could be an early indicator for morbidity, as it was independently associated with MRS of greater than 0 at follow-up. This may represent an additional and relatively early clinical feature to consider when determining overall prognosis. Additionally, it may provide an impetus to consider earlier or more aggressive treatment in certain cases. Future prospective studies could provide further clarification.

Determination of the type of GBS, axonal versus demyelinating, can be helpful with understanding associated acute and chronic pain, prognostication, and differentiating GBS from other mimickers.[4,6,9] A recent study highlighted that acute pain may be more pronounced in axonal variants while chronic pain may be associated with demyelinating, however, this was in a cohort of Asian subjects, who typically have higher axonal rates.[9] If there is diagnostic or prognostic uncertainty after the acute phase, electrodiagnostic testing should be pursued.

There was no significant association between type of preceding event (e.g., infection or immunization) and long-term morbidity. Those in basic training recruit status did, however, have a higher incidence when compared to other groups. The recruit population typically receives multiple immunizations upon arrival, and they are also housed in close quarters, increasing potential infection transmissibility. This was reflected in this analysis, as most recruits had a preceding illness or immunization within 30 days of symptom onset. This study was not designed to determine direct causal relationships with immunization.

The main limitation of this study is its retrospective design. While these findings can provide insights, correlation cannot be established. Utilization of medical encounter data is both limited by accuracy of documentation and subject to reporting bias. Cases may be under-reported due to reliance on appropriate ICD-9-CM/ICD-10-CM code placement. Risk factors cannot be assessed with this study design. Antecedent illness and prior immunization data can be incomplete if not documented in clinical notes, or if service members received immunizations out of network without records in MHS medical charts. Evaluating morbidity by using an MRS greater than 0 may over-estimate significant disability.

TABLE 4a. Demographic and Clinical Characteristic Associated with Long-Term[a] Modified Rankin Scale Outcomes

	No Symptoms Indicated per Modified Rankin Scale		Symptoms Indicated per Modified Rankin Scale		*p*-value
Total, *n*	73[b]		70[b]		
	No.	%	No.	%	
Recruit status					0.077
No	61	83.6	66	94.3	
Yes	12	16.4	4	5.7	
Antecedent event					0.182
Illness	33	45.2	41	58.6	
Immunization	9	12.3	9	12.9	
Both	24	32.9	12	17.1	
Neither	7	9.59	8	11.4	
Pain present, acute phase					0.021
No	26	35.6	12	17.1	
Yes	47	64.4	58	82.9	
Neuropathic pain treatment					<0.001
No	57	78.1	23	32.9	
Yes	16	21.9	47	67.1	
Modified Rankin Scale nadir, acute phase					0.027
>3	24	32.9	38	54.3	
0–1	21	28.8	13	18.5	
2	28	38.4	19	27.1	
Chronic pain diagnosis					<0.001
No	72	98.6	31	44.3	
Yes	1	1.39	39	55.7	
Results of electrodiagnostic testing[c]					<0.001
Total, *n*	33[c]		41[c]		
Demyelinating	21	63.6	18	43.9	
Axonal, mixed	1	3.0	18	43.9	
Normal	11	33.3	5	12.2	

Abbreviations: MRS, Modified Rankin Scale; *n*, number; No., number; CIDP, chronic inflammatory demyelinating polyneuropathy; FND, functional neurologic disorder.
[a] Greater than 1 year.
[b] Long-term follow-up cases, excluding those with other diagnoses: CIDP, FND, other neurological diagnosis.
[c] Long-term follow-up cases with electro-diagnostic testing results, excluding cases with other diagnoses: CIDP, FND, other neurological diagnosis.

TABLE 4b. Demographic and Clinical Characteristic Associations with Long-Term Follow-up Presence of Chronic Pain Diagnosis

Chronic Pain Diagnosis	No		Yes		*p*-value
Total, *n*	103[a]		40[a]		
	No.	%	No.	%	
Recruit status					0.236
No	89	86.4	38	95.0	
Yes	14	13.6	2	5.0	
Modified Rankin Scale nadir, acute phase					0.080
>3	39	37.9	23	59.0	
0–1	27	26.2	6	15.4	
2	37	35.9	10	25.6	
Pain present, acute phase					<0.001
No	37	35.9	1	2.5	
Yes	66	64.1	39	97.5	
Neuropathic pain treatment					<0.001
No	73	70.6	7	17.5	
Yes	30	29.4	33	82.5	
Results of electrodiagnostic testing[b]					0.035
Total, *n*	50[b]		23[b]		
Axonal, mixed	9	18.0	10	43.5	
Demyelinating	27	54.0	11	47.8	
Normal	14	28.0	2	8.7	

Abbreviations: No., number; *n*, number; CIDP, chronic inflammatory demyelinating polyneuropathy; FND, functional neurologic disorder.
[a]Long-term follow-up cases, excluding those with other diagnosis: CIDP, FND, other neurological diagnosis.
[b]Long-term follow up cases with electrodiagnostic results, excluding cases with other diagnosis: CIDP, FND, other neurological diagnosis.

TABLE 5. Multivariable Logistic Regression Model of Clinical Characteristics with Morbidity Outcomes at Long-Term Follow-up (after 1 year)

Characteristic	Odds Ratio	95% CI Lower Limit	95% CI Upper Limit	*p*-value
Modified Rankin Scale, after 1 year				
Neuropathic pain treatment[a]				
Yes	6.8	2.8	17.7	<0.001
No	Reference			
Pain reported, acute phase[a]				
Yes	0.8	0.3	2.3	0.72
No	Reference			
Modified Rankin Scale nadir, >3[a], acute phase				
Yes	1.6	0.8	3.5	0.022
No	Reference			
Chronic pain diagnosis, after 1 year				
Neuropathic pain treatment[a]				
Yes	7.9	2.7	28.0	<0.001
No	Reference			
Pain reported, acute phase[a]				
Yes	5.5	0.8	107.7	0.13
No	Reference			
Modified Rankin Scale nadir, >3[a]				
Yes	1.4	0.55	3.3	0.5
No	Reference			

Abbreviation: CI, confidence interval; >, greater than; MRS, Modified Rankin Scale.
[a]Neuropathic pain treatment defined as identified as present ("Yes" vs. "No"); pain present during acute phase ("Yes" vs. "No"); MRS at nadir greater than or equal to (≥) 3 for significant disability ("Yes" vs. "No").

This study provides an important update on GBS in the active component population of the U.S. military for MHS clinicians and may help guide future research. Given the increased incidence during the recruit training period in this study, it is prudent for health care providers working with populations such as military recruits to consider referral to an appropriate level of care if suspicion of GBS arises, in addition to ensuring appropriate immunization counseling and addressing elements to help mitigate close quarters disease transmissibility. Despite the increased incidence of GBS in recruits, no evidence supported a higher risk of long-term morbidity in the U.S. active component population.

Author Affiliations
Naval Aerospace Medical Institute, Pensacola, FL: LCDR Elliott; Epidemiology and Analysis Branch, Armed Forces Health Surveillance Division, Public Health Directorate, Defense Health Agency, Silver Spring, MD: Dr. Stahlman; Walter Reed National Military Medical Center, Bethesda, MD: Dr. Watson, Dr. Sedarsky; Landstuhl Regional Medical Center, Landstuhl, Germany: MAJ Denkensohn

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References

1. van den Berg B, Walgaard C, Drenthen J, et al. Guillain-Barré syndrome: pathogenesis, diagnosis, treatment and prognosis. *Nat Rev Neurol*. 2014;10(8):469-482. doi:10.1038/nrneurol.2014.121
2. Bragazzi NL, Kolahi AA, Nejadghaderi SA, et al. Global, regional, and national burden of Guillain–Barré syndrome and its underlying causes from 1990 to 2019. *J Neuroinflammation*. 2021;18(1):264. doi:10.1186/s12974-021-02319-4
3. Alshekhlee A, Hussain Z, Sultan B, Katirji B. Guillain-Barré syndrome: incidence and mortality rates in US hospitals. *Neurology*. 2008;70(18):1608-1613. doi:10.1212/01.wnl.0000310983.38724.d4
4. Chiò A, Cocito D, Leone M, et al. Guillain-Barré syndrome: a prospective, population-based incidence and outcome survey. *Neurology*. 2003;60(7):1146-1150. doi:10.1212/01.wnl.0000055091.96905.d0
5. Nelson L, Gormley R, Riddle MS, Tribble DR, Porter CK. The epidemiology of Guillain-Barré syndrome in U.S. military personnel: a case-control study. *BMC Res Notes*. 2009;26(2):171. doi:10.1186/1756-0500-2-171
6. Willison HJ, Jacobs BC, van Doorn PA. Guillain-Barré syndrome. *Lancet*. 2016;388(10045):717-727. doi:10.1016/s0140-6736(16)00339-1
7. Shahrizaila N, Lehmann HC, Kuwabara S. Guillain-Barré syndrome. *Lancet*. 2021;397(10280):1214-1228. doi:10.1016/s0140-6736(21)00517-1
8. Finsterer J. Triggers of Guillain-Barré syndrome: *Campylobacter jejuni* predominates. *Int J Mol Sci*. 2022;23(22):14222. doi:10.3390/ijms232214222
9. Papri N, Mohammed A, Rahman MM, et al. Pain determinants and quality of life in Guillain-Barré syndrome: a prospective cohort study. *BMJ Neurol Open*. 2024;6(2):e000925. doi:10.1136/bmjno-2024-000925
10. Leonhard SE, et al, IGOS Consortium. An international perspective on preceding infections in Guillain-Barré syndrome: the IGOS-1000 cohort. *Neurology*. 2022;99(12):e1299-e1313. doi:10.1212/wnl.0000000000200885
11. Salmon DA, Proschan M, Forshee R, et al. Association between Guillain-Barré syndrome and influenza A (H1N1) 2009 monovalent inactivated vaccines in the USA: a meta-analysis. *Lancet*. 2013;381(9876):1461-1468. doi:10.1016/s0140-6736(12)62189-8
12. Censi S, Bisaccia G, Gallina S, Tomassini V, Uncini A. Guillain-Barré syndrome and COVID-19 vaccination: a systematic review and meta-analysis. *J Neurology*. 2024;271(3):1063-1071. doi:10.1007/s00415-024-12186-7
13. Eiffert SR, Stürmer T, Thorpe CT, et al. Vaccine patterns among patients diagnosed with Guillain-Barré syndrome and matched counterparts in a Medicare supplemental population, 2000–2020. *Vaccine*. 2023;41(39):5763-5768. doi:10.1016/j.vaccine.2023.08.014
14. Headquarters, Departments of the Army, the Navy, the Air Force, and the Coast Guard. Army Regulation 40-562, BUMEDINST 6230.15B, AFI 48-110_IP, CG COMDTINST M6230.4G–Medical Services: Immunizations and Chemoprophylaxis for the Prevention of Infectious Diseases. U.S. Dept. of Defense. Oct. 7, 2013. Accessed Nov. 19, 2025. https://www.med.navy.mil/portals/62/documents/nmfa/nmcphc/root/field%20activities/pages/nepmu6/operational%20support/environmental%20health/bumedinst-6230-15b-immunizations-and-chemoprophylaxis.pdf
15. Staples J, Gershman M, Fischer M, U.S. Centers for Disease Control and Prevention. Yellow fever vaccine: recommendations of the Advisory Committee on Immunization Practices (ACIP). *MMWR Recomm Rep*. 2010;59(rr-7):1-27. Accessed Nov. 19, 2025. https://www.cdc.gov/mmwr/pdf/rr/rr5907.pdf
16. Hemachudha T, Griffin D, Chen W, Johnson R. Immunologic studies of rabies vaccination-induced Guillain-Barré syndrome. *Neurology*. 1988;38(3):375-378. doi:10.1212/wnl.38.3.375
17. Saver JL, Chaisinanunkul N, Campbell BCV, et al, XIth Stroke Treatment Academic Industry Roundtable. Standardized nomenclature for Modified Rankin Scale global disability outcomes: consensus recommendations from Stroke Therapy Academic Industry Roundtable XI. *Stroke*. 2021;52(9):3054-3062. doi:10.1161/strokeaha.121.034480
18. The R Foundation. The R Project for Statistical Computing. Accessed Nov. 19, 2025. https://www.r-project.org

Applying Distinct Approaches to Racial and Ethnic Classification to the Surveillance of Obstetric and Neonatal Outcomes in the U.S. Military, 2010–2021

Celeste J. Romano, MS; Clinton Hall, PhD; Monica Burrell, MPH; Anna T. Bukowinski, MPH; Jackielyn Lanning, MPH; Sandra Maduforo, MPH; Sandra Michelle Magallon, BA; Zeina G. Khodr, PhD; Gia R. Gumbs, MPH; Ava Marie S. Conlin, DO, MPH

Traditional, mutually exclusive approaches to racial and ethnic classification obscure important differences within major demographic groups and among multiracial populations. This study offers a novel examination of obstetric and neonatal outcomes among pregnant U.S. military service members, by applying multiple approaches to racial and ethnic classification and presenting disaggregated data. Overall, 235,608 births were identified among pregnant service members from 2010 through 2021. Inclusion of service members who identified with each racial group, whether alone or in combination with any other group, increased the American Indian or Alaska Native and Native Hawaiian or Pacific Islander birth populations by 209.7% and 94.0%, respectively, when compared to mutually exclusive classifications. Prevalences of obstetric outcomes such as cesarean delivery varied among racial and ethnic groups, particularly Asian and Latino populations, for example, Asian Indian, 36.7%; Filipino, 32.3%; Chinese, 26.5%; Puerto Rican, 30.2%; Mexican, 23.2%; and between distinct multiracial populations. Disaggregated estimates ultimately increased visibility of multiracial and Native service members and elucidated patterns indiscernible in aggregated data. Wider adoption of disaggregated racial and ethnic data methods is needed to improve understanding of health outcomes in the Military Health System.

What are the new findings?

Reporting of non-mutually exclusive racial and ethnic groups as well as disaggregated Asian, Hispanic or Latino, and multiracial populations elucidates important differences in obstetric and neonatal outcomes.

What is the impact on readiness and force health protection?

The collection and reporting of disaggregated racial and ethnic data is crucial to promote understanding of populations of multiracial, Native, and national origins serving in the U.S. military. System improvements in access to and quality of Military Health System obstetric care are needed to address persistent racial disparities and improve force readiness.

Racial and ethnic disparities in adverse obstetric and neonatal outcomes have been widely reported in the U.S. literature.[1-4] Despite concerted efforts to document and attend to disparities, traditional approaches to racial and ethnic classification often obscure important differences within major racial or ethnic groups (e.g., among diverse Asian and Latino populations) and among multiracial populations, resulting in a bias of averages.[5] Additionally, classification methods that restrict racial and ethnic group counts to individuals identifying as single-race and non-Hispanic or Latino lead to significant suppression of American Indian or Alaska Native (AIAN) and Native Hawaiian or Pacific Islander (NHPI) populations: just 23.3% and 39.2% of their national populations, respectively, identified as single-race and non-Hispanic or Latino in the 2020 U.S. Census.[6]

Assessments of racial and ethnic health disparities in the Military Health System (MHS) are limited by many of the aforementioned data concerns.[7-13] A more holistic assessment is crucial given the diversity of the population: in 2022, 26.8% of U.S. military service members identified with a historically racialized group (i.e., AIAN, Asian, Black or African American, NHPI, or multiracial), and 17.3% identified as Hispanic or Latino.[14] The present study used 1) self-reported racial and ethnic data from personnel records and 2) population-level health care claims data to assess the prevalence of obstetric and neonatal outcomes among U.S. service members by disaggregated race and ethnicity. Additionally, prevalence estimates were calculated for each racial and ethnic group using 2 distinct methods of classification: a mutually exclusive and non-mutually exclusive approach.

Methods

Study population

The study population was derived from the U.S. Department of War Birth and Infant Health Research (BIHR) program. The BIHR program is an ongoing surveillance and research effort that identifies live births among military families and captures information on associated pregnancy and infant health outcomes.[15] BIHR data comprise military demographic and personnel data from the Defense Manpower Data Center (DMDC) and administrative medical encounter data from the MHS Data Repository. The data repository includes records for all care paid for by TRICARE, the health care plan for service members, retirees, and their families. Covered care spans medical services received at military and civilian facilities within the U.S. and abroad and is available at no cost to active duty service members and their families.

BIHR data were used to identify all live births occurring from January 2010 through December 2021 among pregnant U.S. military service members. Same-sex multiples were excluded due to difficulties distinguishing their neonatal medical records. The study was approved by the Naval Health Research Center Institutional Review Board (protocol NHRC.1999.0003); informed consent was waived in accordance with criteria set forth by Title 32, Code of Federal Regulations, Part 219.

Measures

Self-reported race and ethnicity data were ascertained from DMDC military personnel records. Values from both the race and ethnicity data fields were considered when assigning race and ethnicity **(Supplementary Table 1)**. The Army and Army Reserve do not allow service members to select multiple categories of race: Multiracial individuals must select a single racial group or "other". Additionally, all service members can report only 1 ethnicity.

Data were categorized using 2 distinct approaches: 1) a mutually exclusive ('alone') and 2) non-mutually exclusive ('alone or in combination') approach. The mutually exclusive ('alone') approach first identified Hispanic or Latino individuals, and subsequently grouped non-Hispanic individuals into 1 of the following racial categories: AIAN, Asian, Black or African American, NHPI, multiracial, or unknown. If service members selected multiple categories, they were classified as multiracial. The non-mutually exclusive approach identified all individuals identifying with each group, whether alone or in combination with any other group (i.e., including people who would otherwise be classified as multiracial or Hispanic or Latino). For example, if an individual's self-reported race was "Black or African American" and ethnicity was "Korean," that individual was categorized as multiracial using the mutually exclusive ('alone') approach, and Black or African American, Asian, and Korean using the non-mutually exclusive ('alone or in combination') approach.

Risk factors (e.g., age) and indicators of socio-economic disadvantage (e.g., educational attainment, military rank) were identified and treated dichotomously: age at delivery (18-19 years vs. ≥20 years; <35 years vs. ≥35 years), educational attainment (bachelor's degree or higher vs. less education), and military rank (officer vs. enlisted).

Three obstetric outcomes were ascertained using International Classification of Diseases, 9th and 10th Revisions (ICD-9/ICD-10), diagnosis codes: cesarean delivery, gestational hypertension, and gestational diabetes **(Supplementary Table 2)**. Cesarean deliveries required notation on either the delivery record or the infant birth record. Gestational hypertension cases required record of associated codes on 1 inpatient or 2 outpatient encounters from 20 weeks estimated gestational age (EGA) to 6 weeks postpartum. Gestational diabetes cases required record of associated codes on 1 inpatient or 2 outpatient encounters from 28 weeks EGA to date of delivery. Cases of pre-existing hypertension and pre-existing diabetes in pregnancy or the year prior to pregnancy were excluded from gestational case definitions. Two neonatal outcomes were also ascertained using ICD-9/ICD-10 diagnosis codes in the infant medical record: pre-term birth (<37 weeks EGA) and low birth weight (<2,500 grams).

Analysis

The proportion of live births among pregnant U.S. service members was calculated for each racial and ethnic group, alone and alone or in combination with any other group, overall and stratified by age, educational attainment, and military rank. Estimates were presented in the style of a heat map, with color gradients from dark green (indicating lowest risk or disadvantage) to dark yellow (indicating greatest risk or disadvantage). The prevalence of each outcome, as well as 95% confidence intervals (CIs), were calculated for each racial and ethnic group, alone and alone or in combination with any other group. Prevalence was not reported when the numerator included less than 11 cases. Secondary analyses examined prevalence among specific, mutually exclusive racial and ethnic identity intersections (e.g., AIAN *and* White). Data management and statistical analyses were performed using SAS Enterprise Guide, version 7.1 (SAS Institute Inc., Cary, NC).

Results

The BIHR program captured 1,353,602 live births among U.S. military families from 2010 through 2021, of which 235,608 occurred to pregnant military service members. Analysis of race and ethnicity as an exclusive classification demonstrated births to White 'alone' pregnant service members comprised the plurality (47.7%), followed by Black or African American 'alone' (22.6%), Hispanic or Latino (16.0%), multiracial (4.1%), Asian 'alone' (3.7%), NHPI 'alone' (1.4%), and AIAN 'alone' (1.3%) **(Table 1)**. When using a non-mutually exclusive racial and ethnic classification approach, the AIAN birth population increased by 209.7% (from 2,985 to 9,245) and the NHPI group increased by 94.0% (from 3,309 to 6,421).

Service members identifying as AIAN, Black or African American, and NHPI (both alone and alone or in combination) had higher proportions of pregnant service members younger than age 20 years at delivery and lower proportions of those

TABLE 1. Births to Pregnant Military Service Members by Disaggregated Race and Ethnicity, U.S. Department of Defense Birth and Infant Health Research Program, 2010–2021 (n=235,608)

	Exclusive Classification of Race and Ethnicity		Non-Exclusive Classification of Race and Ethnicity[a]		
Race and Ethnicity	No.	%	No.	%	Percentage Increase[b]
American Indian or Alaska Native	2,985	1.3	9,245	3.9	209.7
Asian	8,666	3.7	13,263	5.6	53.0
Asian Indian	210	0.1	431	0.2	105.2
Chinese	525	0.2	558	0.2	6.3
Filipino	2,165	0.9	2,694	1.1	24.4
Japanese	150	0.1	238	0.1	58.7
Korean	591	0.3	674	0.3	14.0
Vietnamese	291	0.1	322	0.1	10.7
Other Asian descent	4,734	2.0	8,346	3.5	76.3
Black or African American	53,226	22.6	60,913	25.9	14.4
Hispanic or Latino	—	—	37,751	16.0	—
Mexican	—	—	9,773	4.1	—
Puerto Rican	—	—	3,046	1.3	—
Cuban	—	—	336	0.1	—
Other Hispanic or Latino descent	—	—	24,596	10.4	—
Native Hawaiian or Pacific Islander	3,309	1.4	6,421	2.7	94.0
Chamorro or Guamanian	159	0.1	185	0.1	16.4
Other Native Hawaiian or Pacific Islander descent	3,150	1.3	6,236	2.6	98.0
White	112,361	47.7	144,266	61.2	28.4
Multiracial	9,619	4.1	—	—	—
Unknown	7,691	3.3	7,691	3.3	—

Abbreviation: No., number

[a]Non-exclusive classification by race and ethnicity creates a unique count of births within each distinct grouping; thus, birth totals for each race and ethnicity grouping do not sum to total number of births, and percentages do not sum to 100.

[b]Represents percentage increase from each racial and ethnic group alone to each racial and ethnic group alone or in combination.

who completed a bachelor's degree and of officer rank in relation to other groups **(Table 2)**. Patterns were variable among Asian and Latino ethnic groups. Pregnant Filipino service members had lower proportions of college graduates and officers compared with other Asian ethnic groups. Mexican service members demonstrated higher proportions of pregnant service members younger than age 20 years at delivery and lower proportions of those with college education and of officer rank in relation to Cuban and Puerto Rican service members.

The overall prevalence of cesarean delivery, gestational hypertension, and gestational diabetes among all live births was 27.5% (95% CI 27.4, 27.7), 13.4% (95% CI 13.3, 13.6), and 7.3% (95% CI 7.2, 7.4), respectively **(Figure 1)**. As a mutually exclusive group, Black or African American service members had a high prevalence of cesarean delivery (31.9%; 95% CI 31.5, 32.3) and gestational hypertension (15.5%; 95% CI 15.2, 15.8), but a low prevalence of gestational diabetes (6.4%; 95% CI 6.2, 6.7). The prevalence of each outcome varied across Asian alone ethnic groups, but skewed below the overall estimate for gestational hypertension, ranging from 6.7% (95% CI 4.5, 8.8) among Chinese service members to 11.9% (95% CI 10.6, 13.3) among Filipino service members. For gestational diabetes, the prevalence among Asian 'alone' ethnic groups skewed above the overall estimate, ranging from 13.4% (95% CI 12.5, 14.4) for the 'other' Asian descent population to 18.6% (95% CI 15.5, 21.8) for Korean service members. Among Hispanic and Latinos, Puerto Rican and Cuban service members had high prevalences of cesarean delivery (30.2%; 95% CI 28.6, 31.9 and 34.2%; 95% CI 29.2, 39.3, respectively) compared with the overall prevalence and that among Mexican service members (23.2%; 95% CI 22.3, 24.0); however, gestational diabetes was less prevalent among Cuban service members (5.1%, 95% CI 2.7, 7.4) than Mexican service members (8.4%; 95% CI 7.9, 9.4). Gestational diabetes was higher among AIAN alone service members (9.8%; 95% CI 8.8, 10.9) compared to the population inclusive of multiracial and Hispanic or Latino individuals (8.1%; 95% CI 7.5, 8.7). The prevalence of all obstetric outcomes was low among White service members.

TABLE 2. Proportion (%) of Pregnant Military Service Members with Selected Characteristics by Disaggregated Race and Ethnicity, Department of Defense Birth and Infant Health Research Program, 2010–2021 (n=235,608)[a]

	Exclusive Classification of Race and Ethnicity				Non-Exclusive Classification of Race and Ethnicity			
Race and Ethnicity	Age <20 Years	Age ≥35 Years	College Education or Higher	Sponsor Officer Rank	Age <20 Years	Age ≥35 Years	College Education or Higher	Sponsor Officer Rank
American Indian or Alaska Native	1.9	6.8	10.8	7.4	1.7	5.2	11.6	8.0
Asian	0.8	14.3	36.7	25.9	0.9	12.7	31.8	23.3
Asian Indian	1.4	15.7	47.1	26.2	1.9	9.7	27.6	15.5
Chinese	0.4	18.5	49.0	25.0	0.4	19.2	48.7	26.3
Filipino	1.0	13.5	28.2	17.2	1.0	12.5	26.2	17.2
Japanese	0.0	13.3	30.7	28.0	0.4	13.4	29.8	30.7
Korean	0.5	19.0	44.0	38.6	0.4	18.4	43.5	39.3
Vietnamese	0.7	16.2	34.7	29.6	0.6	16.5	35.1	30.7
Other Asian descent	0.8	13.5	38.2	28.2	1.0	11.8	31.7	23.7
Black or African American	1.6	8.8	16.1	7.9	1.6	8.4	15.9	7.9
Hispanic or Latino	—	—	—	—	2.1	6.8	13.3	7.9
Mexican	—	—	—	—	3.2	5.4	7.4	4.4
Puerto Rican	—	—	—	—	2.0	8.8	17.5	8.3
Cuban	—	—	—	—	2.7	8.9	20.5	16.4
Other Hispanic or Latino descent	—	—	—	—	1.7	7.1	15.1	9.1
Native Hawaiian or Pacific Islander	1.8	6.4	12.4	7.9	1.4	7.3	15.7	11.0
Chamorro or Guamanian	1.3	10.1	10.1	7.5	2.2	10.8	9.7	8.1
Other Native Hawaiian or Pacific Islander descent	1.8	6.3	12.5	7.9	1.4	7.2	15.8	11.1
White	1.3	9.4	27.6	23.2	1.5	8.5	24.3	19.8
Multiracial	1.4	6.3	17.1	13.5	—	—	—	—
Unknown	1.0	20.3	22.4	41.4	1.0	20.3	22.4	41.4

[a]Color gradient ranges from dark green (indicating lowest risk or disadvantage among estimates) to dark yellow (indicating greatest risk or disadvantage among estimates).

Overall prevalence of pre-term birth and low birth weight was 8.4% (95% CI 8.3, 8.5) and 5.0% (95% CI 4.9, 5.1), respectively **(Figure 2)**. Black or African American service members had higher prevalences of pre-term birth (alone 11.0%; 95% CI 10.7, 11.3) and low birth weight (alone 8.0%; 95% CI 7.8, 8.2) relative to several other racial and ethnic groups. Prevalence estimates among Asian 'alone' and Hispanic or Latino ethnic groups revealed wide variations among both neonatal outcomes, although corresponding CIs were widened for some groups, due to smaller sample sizes. For example, pre-term birth ranged from 6.7% (95% CI 4.5, 8.8) among Chinese service members to 11.9% (95% CI 7.5, 16.3) among Asian Indian service members, and low birth weight ranged from 3.2 (95% CI 1.7, 4.8) among Chinese service members to 7.1 (95% CI 3.7, 10.6) among Asian Indian service members. Hispanic or Latino service members had lower prevalences of pre-term birth (7.9%; 95% CI 7.6, 8.1) and low birth weight (4.7%; 95% CI 4.5, 4.9) than the overall estimate, but prevalence was elevated among Puerto Rican service members (pre-term birth 10.1%; 95% CI 9.0, 11.1; low birth weight 5.8%; 95% CI 5.0, 6.6). The inclusion of multiracial and Hispanic or Latino individuals in estimates for AIAN and NHPI groups, as is reflected in the non-mutually exclusive groupings, resulted in a disproportionate increase in cases of adverse neonatal outcomes, although CIs overlapped.

Outcome prevalences also differed at racial and ethnic identity intersections **(Table 3)**. Black or African American 'alone', Black or African American and other Hispanic descent, Filipino, and White and Puerto Rican service members had higher estimates of several adverse outcomes. In contrast, service members who identified as White 'alone', White and other Hispanic descent, White and Mexican, and Other Hispanic descent 'alone' frequently had lower estimates. Despite similar population sizes, there were also differences in the prevalences of cesarean delivery and gestational diabetes for AIAN 'alone' versus AIAN and White service members.

Discussion

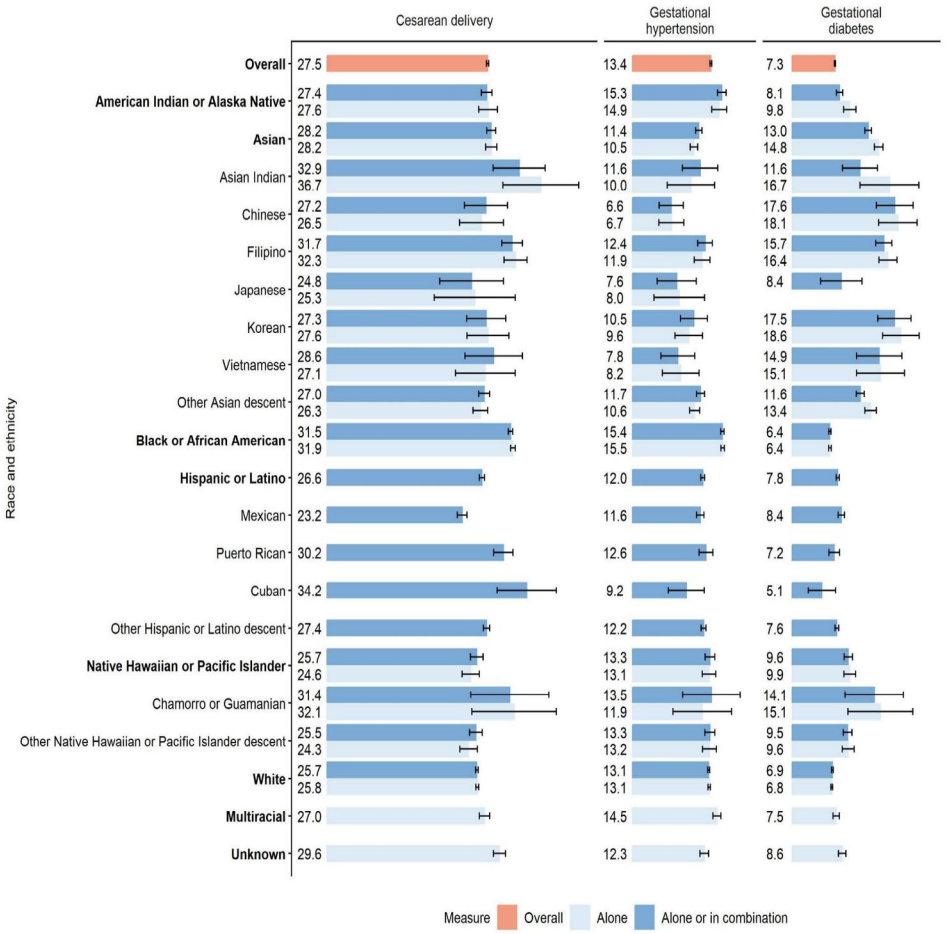
This study reported the prevalence of selected obstetric and neonatal outcomes among U.S. service members by disaggregated race and ethnicity, revealing varying prevalence within and across racial and ethnic groups. Furthermore, we identified differences between distinct multiracial groups and by using mutually exclusive versus non-mutually exclusive classification structures. These differences are especially important for AIAN and NHPI service members, who are very likely to additionally identify as another race or ethnicity.

We add to a limited body of racial health disparities research conducted among pregnant U.S. military service members. The prevalence of pre-term birth among Black or African American service members was lower than that previously reported using 2003-2014 data (11.0% vs. 11.5%), while low birth weight was more prevalent in the present study (8.0% vs. 7.7%).[15] Prevalence of both neonatal outcomes, as well as of cesarean delivery and gestational hypertension, remained higher among Black or African American service members compared with all other major racial and ethnic groups. These findings underscore the continued relevance of disparities previously identified for neonatal mortality, severe maternal morbidity, and pregnancy-related mortality, and counter suggestions that comprehensive health coverage alone eliminates health disparities.[8-10, 16]

Disaggregation of the population identifying as Asian or Pacific Islander elucidated marked differences for each group overall and across specific ethnic groups. For low birth weight, overall estimates were 4.1% among NHPI alone service members and 5.2% among Asian alone service members, whereas the aggregated estimate using data from 2003-2014 was 4.9%.[15] Differences were also pronounced for gestational diabetes, with Asian alone service members having a 49.5% increased risk compared with NHPI alone service members. Findings parallel prior work documenting higher risk for gestational diabetes among Asian populations compared with other major racial and ethnic groups, as well as uniquely high risk among Asian Indian, Vietnamese, and Filipino ethnic groups.[17,18] We also noted prevalence estimates for Chinese and Korean service members that were higher than typically reported[17,18]; this finding may reflect differences between civilian and active duty populations related to place of birth, childhood socio-economic status, education, and age at delivery. Observed differences among Asian ethnic groups provide further justification for acknowledgment of aggregation as a potential fallacy.[5]

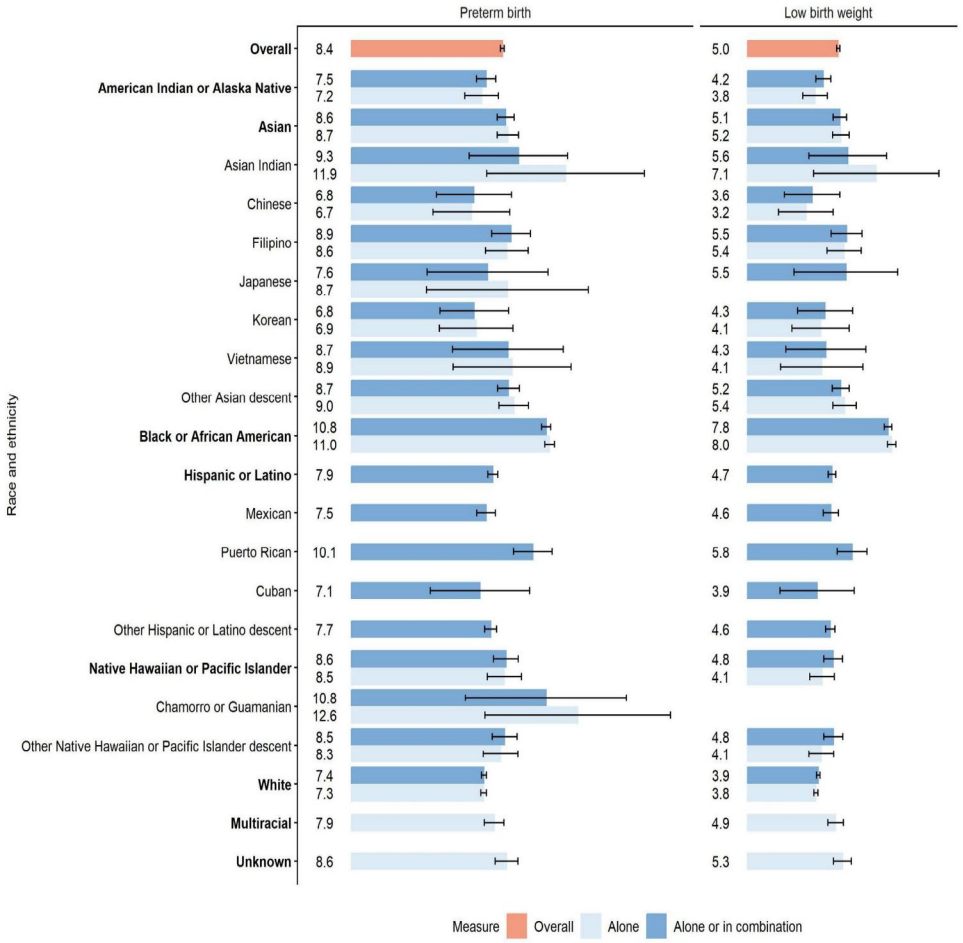
More inclusive, non-mutually exclusive definitions of race and ethnicity proved particularly effective for capturing births among AIAN and NHPI service members, as the numbers of births attributed to these populations increased by 209.7% and 94.0%, respectively, if compared to a mutually exclusive approach. Although meaningful differences in estimates between mutually exclusive and non-mutually exclusive groups were difficult to ascertain due to wide CIs, with the exception of gestational diabetes, point estimates were consistently higher among the NHPI 'alone or in combination' population, indicating greater risk for multiracial NHPI populations. For AIAN service members, gestational diabetes was higher among those identifying as AIAN alone. Prior work has shown the AIAN 'alone' population experienced increased economic disadvantage and decreased life expectancy relative to the multiracial AIAN population,[19,20] whereas the multiracial AIAN population experienced increased depression and mental distress.[21] Our findings of disparate estimates by multiracial identity,

FIGURE 1. Prevalence (per 100 live births) and 95% Confidence Intervals for Obstetric Outcomes Among Pregnant U.S. Service Members by Disaggregated Race and Ethnicity, Department of Defense Birth and Infant Health Research Program, 2010–2021[a]



[a]Prevalence estimates not calculated when numerator included less than 11 cases.

FIGURE 2. Prevalence (per 100 live births) and 95% Confidence Intervals for Neonatal Outcomes Among Pregnant U.S. Service Members by Disaggregated Race and Ethnicity, Department of Defense Birth and Infant Health Research Program, 2010–2021[a]



[a]Prevalence estimates not calculated when numerator included less than 11 cases.

therefore, contribute further nuance to awareness of Native health in the U.S.

There are some notable limitations with military personnel race and ethnicity data that affected this work. First, in the Services overall, only 1 ethnic identity could be reported; and in the Army and Army Reserve (which accounted for nearly 40% of all births in this cohort), soldiers could not report identity with multiple racial groups. Consequently, the multiracial population was under-estimated. Second, although self-reported, these records remain subject to data entry and administrative errors. Finally, detailed ethnicity is available only for Asian and Hispanic or Latino groups, hampering understanding of diversity among White, Black or African American, and NHPI service members.

The approach to this work, through the presentation of estimates for mutually exclusive and non-mutually exclusive racial and ethnic groups, as well as specific groups comprising a significant proportion of the population, mirrors recommendations in the 2024 Office of Management and Budget guidance for the maintenance, collection, and presentation of racial and ethnic data.[22] Our findings underscore that a singular, mutually-exclusive approach to racial and ethnic classification is insufficient for understanding racial health disparities: It disproportionately obscures AIAN and NHPI populations and homogenizes multiracial populations.[23,24] As the U.S. population is increasingly multiracial,[25] disaggregation will only grow more pertinent. Ultimately, while application of multiple approaches to racial and ethnic classification may not always be feasible, researchers should consider the implicit biases or assumptions reflected in their selected approach.[26] Greater attention to the collection and reporting of disaggregated racial and ethnic health data will improve understanding of health outcomes within and beyond the MHS.[13]

Author Affiliations
Deployment Health Research Department, Naval Health Research Center, San Diego, CA: Ms. Romano, Dr. Hall, Ms. Burrell, Ms. Bukowinski, Ms. Lanning, Ms. Maduforo, Ms. Magallon, Dr. Khodr, Ms. Gumbs, Dr. Conlin; Leidos, Inc., San Diego, CA: Ms. Romano, Dr. Hall, Ms. Burrell, Ms. Bukowinski, Ms. Lanning, Ms. Maduforo, Ms. Magallon, Dr. Khodr, Ms. Gumbs

Disclaimer
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TABLE 3. Prevalence (per 100 Live Births) and 95% Confidence Intervals for Neonatal and Obstetric Outcomes by Specific Racial and Ethnic Intersections, Department of Defense Birth and Infant Health Research Program, 2010–2021[a]

	Population		Cesarean Delivery			Gestational Hypertension			Gestational Diabetes		
Race and Ethnicity	No.	%	Prevalence	95% CI Lower Limit	95% CI Upper Limit	Prevalence	95% CI Lower Limit	95% CI Upper Limit	Prevalence	95% CI Lower Limit	95% CI Upper Limit
White	112,361	47.7	25.8	25.5	26.0	13.1	12.9	13.3	6.8	6.6	6.9
Black or African American	53,226	22.6	31.9	31.5	32.3	15.5	15.2	15.8	6.4	6.2	6.7
White and other Hispanic descent	15,092	6.4	25.8	25.1	26.5	12.3	11.7	12.8	7.3	6.9	7.7
Unknown[b]	7,691	3.3	29.6	28.5	30.6	12.3	11.6	13.0	8.6	7.9	9.2
White and Mexican	7,225	3.1	22.6	21.7	23.6	12.2	11.4	12.9	8.1	7.5	8.7
Other Hispanic descent[c]	4,377	1.9	31.5	30.1	32.9	9.6	8.7	10.4	9.0	8.1	9.8
Asian[d]	3,683	1.6	27.3	25.9	28.8	11.3	10.3	12.4	13.9	12.8	15.0
Native Hawaiian or Pacific Islander[d]	3,150	1.3	24.3	22.8	25.8	13.2	12.0	14.4	9.6	8.6	10.6
American Indian or Alaska Native	2,985	1.3	27.6	26.0	29.2	14.9	13.6	16.2	9.8	8.8	10.9
American Indian or Alaska Native and White	2,824	1.2	25.1	23.5	26.7	15.3	13.9	16.6	7.6	6.6	8.6
Black or African American and other Hispanic descent	2,211	0.9	29.0	27.1	30.9	14.4	13.0	15.9	6.5	5.4	7.5
Filipino	2,165	0.9	32.3	30.4	34.3	11.9	10.6	13.3	16.4	14.8	18.0
Mexican[c]	2,042	0.9	24.5	22.6	26.4	9.1	7.8	10.3	9.8	8.6	11.1
White and Puerto Rican	1,647	0.7	29.1	26.9	31.3	12.1	10.6	13.7	6.0	4.9	7.2
Black or African American and White	1,331	0.6	26.4	24.1	28.8	14.7	12.8	16.6	4.6	3.5	5.0

	Population		Pre-Term Birth			Low Birth Weight		
Race and Ethnicity	No.	%	Prevalence	95% CI Lower Limit	95% CI Upper Limit	Prevalence	95% CI Lower Limit	95% CI Upper Limit
White	112,361	47.7	7.3	7.2	7.5	3.8	3.7	3.9
Black or African American	53,226	22.6	11.0	10.7	11.3	8.0	7.8	8.2
White and other Hispanic descent	15,092	6.4	7.2	6.8	7.6	4.2	3.8	4.5
Unknown[b]	7,691	3.3	8.6	8.0	9.2	5.3	4.8	5.8
White and Mexican	7,225	3.1	7.6	7.0	8.2	4.7	4.2	5.2
Other Hispanic descent[c]	4,377	1.9	8.0	7.2	8.8	4.5	3.9	5.1
Asian[d]	3,683	1.6	9.2	8.3	10.2	5.6	4.9	6.3
Native Hawaiian or Pacific Islander[d]	3,150	1.3	8.3	7.3	9.2	4.1	3.4	4.8
American Indian or Alaska Native	2,985	1.3	7.2	6.3	8.2	3.8	3.1	4.4
American Indian or Alaska Native and White	2,824	1.2	6.9	6.0	7.9	3.8	3.1	4.5
Black or African American and other Hispanic descent	2,211	0.9	10.4	9.1	11.6	7.6	6.5	8.8
Filipino	2,165	0.9	8.6	7.5	9.8	5.4	4.4	6.3
Mexican[c]	2,042	0.9	7.8	6.6	8.9	4.6	3.7	5.5
White and Puerto Rican	1,647	0.7	9.0	7.6	10.4	5.4	4.3	6.5
Black or African American and White	1,331	0.6	8.2	6.7	9.7	5.0	3.9	6.2

Abbreviations: No., number.

[a]Color gradient ranges from dark green (indicating lowest risk or disadvantage among estimates) to dark yellow (indicating greatest risk or disadvantage among estimates). Racial and ethnic identity intersections comprising less than 0.5% of the population (<1,178) were omitted for brevity.

[b]No specified race or ethnicity.

[c]No specified race.

[d]No specified ethnicity.

References

1. Creanga AA, Bateman BT, Kuklina EV, Callaghan WM. Racial and ethnic disparities in severe maternal morbidity: a multistate analysis, 2008–2010. *Am J Obstet Gynecol.* 2014;210(5):435e1-435e8. doi:10.1016/j.ajog.2013.11.039
2. Grobman WA, Parker CB, Willinger M, et al. Racial disparities in adverse pregnancy outcomes and psychosocial stress. *Obstet Gynecol.* 2018;131(2):328-335. doi:10.1097/aog.0000000000002441
3. Pollock EA, Gennuso KP, Givens ML, Kindig D. Trends in infants born at low birthweight and disparities by maternal race and education from 2003 to 2018 in the United States. *BMC Public Health.* 2021;21(1):1117. doi:10.1186/s12889-021-11185-x
4. Martin JA, Osterman M. National Vital Statistics Reports: Shifts in the Distribution of Births by Gestational Age: United States, 2014–2022. U.S. Centers for Disease Control and Prevention. 2024. Accessed Nov. 21, 2024. https://www.cdc.gov/nchs/data/nvsr/nvsr73/nvsr73-01.pdf
5. Gee GC, Chien J, Sharif MZ, Penaia C, Tran E. East is east...or is it? Racialization of Asian, Middle Eastern, and Pacific Islander persons. *Epidemiol Rev.* 2023;45(1):93-104. doi:10.1093/epirev/mxad007
6. U.S. Census Bureau. Hispanic or Latino, and Not Hispanic or Latino by Race. U.S. Dept. of Commerce. 2020. Accessed Feb. 19, 2024. https://data.census.gov/table/decennialdhc2020.p9?q=racean dethnicity&g=010xx00us&y=2020
7. Hall C, Bukowinski AT, McGill AL, et al. Racial disparities in prenatal care utilization and infant small for gestational age among active duty US military women. *Matern Child Health J.* 2020;24(7):885-893. doi:10.1007/s10995-020-02941-3
8. Hall C, Romano CJ, Bukowinski AT, et al. Severe maternal morbidity among women in the U. S. military, 2003–2015. *Am J Perinatol.* 2024;41(2):150-159. doi:10.1055/s-0041-1740248
9. Romano CJ, Hall C, Bukowinski AT, Gumbs GR, Conlin AMS. Pregnancy-associated and pregnancy-related deaths in the United States military, 2003–2014. *Am J Obstet Gynecol.* 2022;227(3):508e1-508e9. doi:10.1016/j.ajog.2022.04.020
10. Hamilton JL, Shumbusho D, Cooper D, et al. Race matters: maternal morbidity in the Military Health System. *Am J Obstet Gynecol.* 2021;224(5):512e1-512e6. doi:10.1016/j.ajog.2021.02.036
11. Ranjit A, Andriotti T, Madsen C, et al. Does universal coverage mitigate racial disparities in potentially avoidable maternal complications? *Am J Perinatol.* 2021;38(8):848-856. doi:10.1055/s-0040-1701195
12. Williams VF, Oh GT, Stahlman S, Shell D. Diabetes mellitus and gestational diabetes, active and reserve component service members and dependents, 2008–2018. *MSMR.* 2020;27(2):8-17. Accessed Jan. 20, 2026. https://www.health.mil/reference-center/reports/2020/02/01/medical-surveillance-monthly-report-volume-27-number-2
13. Mancuso JD, Young J, Rusiecki J, et al. Advancing health equity in the US military. *J Health Dispar Res Pract.* 2023;16(1):3.
14. Office of the Deputy Assistant Secretary of Defense for Military Community and Family Policy. 2022 Demographics: Profile of the Military Community. U.S. Department of Defense. Accessed Jan. 20, 2026. https://www.militaryonesource.mil/data-research-and-statistics/military-community-demographics/archive
15. Bukowinski AT, Conlin AMS, Gumbs GR, et al. Department of Defense Birth and Infant Health Registry: select reproductive health outcomes, 2003–2014. *MSMR.* 2017;24(11):39-49. Accessed Jan. 20, 2026. https://www.health.mil/reference-center/reports/2017/01/01/medical-surveillance-monthly-report-volume-24-number-11
16. Vereen RJ, Nestander M, Haischer-Rollo G, et al. Neonatal mortality and disparities within the Military Health System. *J Perinatol.* 2023;43:496-502. doi:10.1038/s41372-022-01598-w
17. Bane S, Abrams B, Mujahid M, et al. Risk factors and pregnancy outcomes vary among Asian American, Native Hawaiian, and Pacific Islander individuals giving birth in California. *Ann Epidemiol.* 2022;76:128-135e9. doi:10.1016/j.annepidem.2022.09.004
18. Pu J, Zhao B, Wang EJ, et al. Racial/ethnic differences in gestational diabetes prevalence and contribution of common risk factors. *Paediatr Perinat Epidemiol.* 2015;29(5):436-443. doi:10.1111/ppe.12209
19. Huyser KR, Takei I, Sakamoto A. Demographic factors associated with poverty among American Indians and Alaska natives. *Race Soc Probl.* 2014;6:120-134. doi:10.1007/s12552-013-9110-1
20. Burnette J, Gregg M. How much did Native American life expectancy drop during COVID-19? *Econofact*. Jan. 31, 2023. Accessed Feb. 19, 2024. https://econofact.org/how-much-did-native-american-life-expectancy-drop-during-covid-19
21. Asdigian NL, Bear UR, Beals J, Manson SM, Kaufman CE. Mental health burden in a national sample of American Indian and Alaska Native adults: differences between multiple-race and single-race subgroups. *Soc Psychiatry Psychiatr Epidemiol.* 2018;53(5):521-530. doi:10.1007/s00127-018-1494-1
22. U.S. Office of Management and Budget. Statistical Policy Directive No. 15: Standards for Maintaining, Collecting, and Presenting Federal Data on Race and Ethnicity. Updated Nov. 14, 2025. Accessed Jan. 20, 2026. https://spd15revision.gov
23. Quint J, Matagi C, Kaholokula JK. The Hawai'i NHPI data disaggregation imperative: preventing data genocide through statewide race and ethnicity standards. *Hawaii J Health Soc Welf.* 2023;82(10 suppl 1):67-72.
24. Urban Indian Health Institute. Toolkit: Best Practices for American Indian and Alaska Native Data Collection. Updated Aug. 26, 2020. Accessed Feb. 19, 2024. https://www.uihi.org/resources/best-practices-for-american-indian-and-alaska-native-data-collection
25. Jones N, Marks R, Ramirez R, Ríos-Vargas M. Improved Race and Ethnicity Measures Reveal U.S. Population Is Much More Multiracial: 2020 Census Illuminates Racial and Ethnic Composition of the Country. U.S. Census Bureau, U.S. Dept. of Commerce. Aug. 12, 2021. Accessed Feb. 19, 2024. https://www.census.gov/library/stories/2021/08/improved-race-ethnicity-measures-reveal-united-states-population-much-more-multiracial.html
26. Lam-Hine T, Forthal S, Johnson CY, Chin HB. Asking multicrit questions: a reflexive and critical framework to promote health data equity for the multiracial population. *Milbank Q.* 2024;102(2):398-428. doi:10.1111/1468-0009.12696

SUPPLEMENTARY TABLE 1. Race and Ethnicity Values Reported to Defense Manpower Data Center

Race		Ethnicity	
Value	Description	Value	Description
1	American Indian or Alaska Native	AA	Asian Indian
2	Asian	AB	Chinese
3	Black or African American	AC	Filipino
4	Native Hawaiian or Other Pacific Islander	AD	Guamanian
5	White	AF	Japanese
100	American Indian or Alaska Native, Asian	AG	Korean
101	American Indian or Alaska Native, Asian, Black or African American	AI	Vietnamese
102	American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander	AJ	Other Asian descent
103	American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White	AK	Mexican
104	American Indian or Alaska Native, Asian, Black or African American, White	AL	Puerto Rican
105	American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander	AM	Cuban
106	American Indian or Alaska Native, Asian, Native Hawaiian or Other Pacific Islander, White	AN	Latin American with Hispanic descent
107	American Indian or Alaska Native, Asian, White	AO	Other Hispanic descent
108	American Indian or Alaska Native, Black or African American	AP	Aleut
109	American Indian or Alaska Native, Black or African American, Native Hawaiian or Other Pacific Islander	AQ	Eskimo
110	American Indian or Alaska Native, Black or African American, Native Hawaiian or Other Pacific Islander, White	AR	U.S. or Canadian Indian tribes
111	American Indian or Alaska Native, Black or African American, White	AS	Melanesian
112	American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander	AT	Micronesian
113	American Indian or Alaska Native, Native Hawaiian or Other Pacific Islander, White	AU	Polynesian
114	American Indian or Alaska Native, White	AV	Other Pacific Island descent
115	Asian, Black or African American	BG	Other
116	Asian, Black or African American, Native Hawaiian or Other Pacific Islander	BH	None
117	Asian, Black or African American, Native Hawaiian or Other Pacific Islander, White	ZZ	Unknown
118	Asian, Black or African American, White		
119	Asian, Native Hawaiian or Other Pacific Islander		
120	Asian, Native Hawaiian or Other Pacific Islander, White		
121	Asian, White		
122	Black or African American, Native Hawaiian or Other Pacific Islander		
123	Black or African American, Native Hawaiian or Other Pacific Islander, White		
124	Black or African American, White		
125	Native Hawaiian or Other Pacific Islander, White		
999	Other, Declined to respond, Identification pending		

SUPPLEMENTARY TABLE 2. Case Definitions for Neonatal and Obstetric Outcomes Obtained from Administrative Medical Encounter Data

Variable	Codes	Case Definition
Cesarean delivery	**ICD-9:** V[30-37,39].01, 649.8x, 669.7x, 763.4, 74.[0,1,2,4,99]	Any diagnosis or procedure code on a delivery record or any diagnosis code on an infant birth record
	ICD-10: Z38.[01,31,62,64,66,69], O82.x, P03.4x, O75.82, 10D00Z[0,1,2]	
Gestational hypertension	**ICD-9:** 642.[3,4,5,6]x	One inpatient encounter or 2 outpatient encounters, on different days, from 20 weeks' gestation through 6 weeks postpartum (excluding pre-existing hypertension cases, see below)
	ICD-10: O13.x-O15.x	
Pre-existing hypertension	**ICD-9:** 401.x-405.x	Any diagnosis during the year prior to pregnancy or during pregnancy up to 20 weeks gestation
	ICD-10: I10.x-I13.x, I15.x	
	ICD-9: 642.[0,1,2]x	Any diagnosis during pregnancy up to 20 weeks gestation
	ICD-10: O10.x	
Gestational diabetes	**ICD-9:** 648.8x	One inpatient encounter or 2 outpatient encounters, on different days, from 24 weeks gestation through date of delivery (excluding pre-existing diabetes cases, see below)
	ICD-10: O24.4x	
Pre-existing diabetes	**ICD-9:** 249.x, 250.x	Any diagnosis during year prior to pregnancy or during pregnancy up to 24 weeks gestation
	ICD-10: E08.x, E09.x, E10.x, E11.x, E13.x	
	ICD-9: 648.0x	Any diagnosis during pregnancy up to 24 weeks gestation
	ICD-10: O24.[0,1,3,8,9]x	
Pre-term birth	**ICD-9:** 765.[0,1], 765.2[1-8], 766.2[1,2], 765.29, 645.[1,2], 644.2[0,1]	Any diagnosis during the delivery hospitalization or in the first 28 days of the infant's life
	ICD-10: P07.2[0-6], P07.3[0-9], P08.[21,22], Z3A.[18-42,49], O48.[0,1], O60.1[0,3,4]x[0-9], O60.2[0,2,3]x[0-9], O60.12	
Low birth weight	**ICD-9:** 764.xx, 765.xx, 766.[0,1]	Earliest assigned diagnosis during infant's first 28 days of life; if 2 or more codes assigned, lowest weight prioritized
	ICD-10: P05.xx, P07.xx, P08.[0,1]	

Case Report

An Atypical Ross River Virus Infection in an Australian Army Service Member

Melissa Graham, MPhil; Brian Vesely, PhD; Cielo Pasay, PhD; Wenjun Liu, PhD

Arboviral diseases, transmitted by arthropods such as mosquitoes, represent a significant and ongoing threat to the health, readiness, and mission capability of U.S. military personnel deployed in endemic regions.[1,2] Ross River virus (RRV), an alphavirus transmitted by mosquitoes, is endemic to Australia and causes an average of 5,000 cases annually.[3] RRV is also endemic as well as epidemic in many South Pacific Islands including Papua New Guinea, Solomon Islands, Fiji, American Samoa, New Caledonia, and Cook Islands.[4] These countries are frequent locations for U.S. military training and joint operations **(Figure 1)**.

RRV is not a new threat to U.S. military operations. In 1997, an outbreak of RRV-related epidemic polyarthritis (EPA) occurred among 19 U.S. Navy personnel during a joint exercise at the Shoalwater Bay Training Area in Queensland.[5] A pre- and post-deployment serum survey of 2,500 U.S. marines deployed to Australia on 6-month training rotations confirmed RRV sero-conversion, indicating RRV local transmission during training deployments.[6]

U.S. military presence in the South Pacific has increased recently, with several multi-national, joint exercises in response to strategic pressures arising from the expansion of China's southwestern Pacific military presence. More than 35,000 military personnel, including Australian and U.S. forces, and representatives from over 19 nations took part in Exercise Talisman Sabre 2025, the largest military exercise ever held in Australia and the first in Papua New Guinea.[7]

RRV is the most frequently reported arboviral disease in Australia, with approximately over 63,000 cases recorded in Queensland alone from 1993 to 2020.[8,9] The ecology of RRV is complex: Over 40 mosquito species have been identified as potential vectors, and more than 18 wild and domestic animal species are suspected as amplifying hosts or reservoirs.[10] These factors contribute to unpredictable and seasonal RRV outbreaks. RRV is particularly prevalent in the Northern Territory and Queensland, where human cases are reported year-round.[11]

Although some RRV infections are asymptomatic or sub-clinical (approximate symptomatic-to-asymptomatic ratio 1:3), symptomatic cases can develop into EPA, a debilitating condition characterized by joint inflammation. Additional symptoms, such as rash, low-grade fever, malaise, myalgia, lymphadenopathy, headache, depression, and fatigue, may accompany EPA.[12-14] Atypical presentations have been reported, including cases with prolonged or relapsing symptoms, absence of rash or arthritis, neurological involvement, or unusual laboratory findings.

While most symptomatic RRV patients recover within 4–6 weeks, some experience persistent joint or muscle pain and fatigue for months to several years. In a 1996 study of long-term symptomatic cases, at 15 months 51% of respondents still had joint pain, and 45% had persistent tiredness and lethargy[15]; these symptoms were still common up to 30 months after infection. Joint pain is the most common and persistent symptom, with the 4 most common joints affected being ankles (75%), wrist (72%), knees (66%) and fingers (66%). While other affected joints had much lower incidences (4-47%).[16] Such cases can pose diagnostic challenges, particularly in military or deployment settings where other vector-borne or febrile illnesses are also possible.

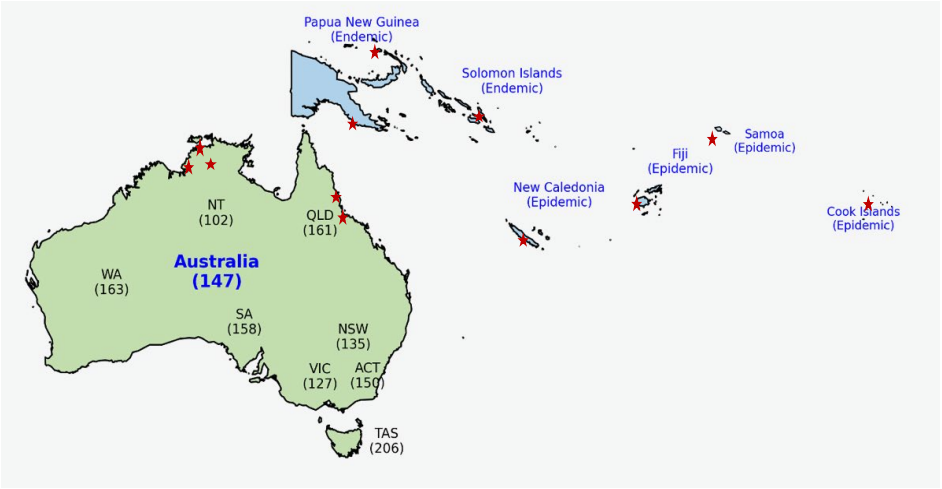
The pathogenesis of persistent arthritis remains unclear, although persistent infection of synovial macrophages has been documented for other alphaviruses.[17] RRV-induced arthritis is characterized by inflammatory infiltrates comprised largely of mononuclear cells. Characterization of those infiltrates suggests that monocytes/macrophages are a major constituent of the infiltrate, while immune-histological studies of synovial biopsy samples have also identified $CD4^+$ and $CD8^+$ T lymphocytes within inflammatory infiltrates.[18,19]

Symptoms similar to EPA may occur after infection with Barmah Forest virus (BFV), chikungunya virus (CHIKV), Epstein-Barr virus, Rubella virus, and Parvovirus B19. BFV co-circulates with RRV in Australia with approximately 1,600 cases annually.[20] Currently, there is no specific antiviral treatment or vaccine for RRV. Clinical management primarily targets symptom relief.

In accordance with the Australian Health Department, definitive laboratory diagnosis of RRV infection requires specific laboratory evidence, including virus isolation or detection of viral RNA (ribonucleic acid) by RT-PCR (reverse transcription-polymerase chain reaction) in serum collected within 6 days of illness onset. Alternatively, diagnosis may be based on serological evidence, such as seroconversion or a greater than or equal to 4-fold increase in immunoglobulin G (IgG) titre, provided there is no corresponding change in antibody levels to BFV. Detection of RRV-specific immunoglobulin M (IgM) in the absence of anti-CHIKV IgM or anti-BFV IgM is also considered confirmatory evidence.

Due to serological cross-reactivity among alphaviruses, particularly BFV and CHIKV, serological diagnosis must be carefully interpreted. Alphavirus-specific IgM antibodies usually last 1–3 months, with levels generally falling subsequently.[21]

FIGURE 1. Endemic and Epidemic Countries of Ross River Virus[a] and Major Locations of Routine Personnel Training and Visits[b] by U.S. Australian and U.S. Armed Forces, with Rates per 100,000 for Australian States and Territories, 2024[c,d]



Abbreviations: NT, Northern Territory; QL, Queensland; WA, Western Australia; SA, Southern Australia; NSW, New South Wales; VIC, Victoria; ACT, Australian Capital Territory; TAS, Tasmania; HMAS, His Majesty's Australian Ship; RAAF, Royal Australian Air Force; Int'l, International; RAMSI, Regional Assistance Mission to Solomon Islands.

[a] Since 1979.

[b] Stars (*) indicate locations routinely used by Australian and U.S. military personnel for training, visits, and transit, based on information from official Australian Defence websites, news releases, and widely cited reference sources. Locations include Australia: Shoalwater Bay (QLD), Lavarack Barracks (Townsville), Larrakeyah/HMAS Coonawarra (Darwin), Bradshaw Field (Top End), RAAF Base Tindal (Katherine); Papua New Guinea: Lombrum Naval Base (Manus), Jacksons Int'l (Port Moresby), Momote/Manus airfield area (logistics/training hub); Solomon Islands: Honiara/Henderson Field (Honiara Int'l), former Camp RAMSI site of regional missions; Fiji: Queen Elizabeth Barracks (Nabua/Suva), Nadi (Nadi Int'l Airport) main transit hub; American Samoa: Pago Pago/Tafuna (Pago Pago Int'l Airport) for exercises and coordination (U.S. Coast Guard, partner activities); New Caledonia: Nouméa/La Tontouta (main airport, French military presence); Cook Islands: Rarotonga/Avarua (Rarotonga Int'l Airport) primary transit gateway.

[c] Australian National Communicable Disease Surveillance Dashboard, https://nindss.health.gov.au/pbi-dashboard

[d] No current RRV data available for Papua New Guinea nor Solomon Islands.

Within 2 weeks of an elevated virus-specific IgM response, a virus-specific IgG level usually becomes detectable, with IgG levels persisting for a long period, likely providing lifelong protection.[22]

We report here an atypical RRV infection in 2024 in an Australian Army service member. The study was approved by the Australian Departments of Defence and Veterans' Affairs Human Research Ethics Committee (protocol DDVA HREC P204-20). This report serves to promote awareness among medical corps and force health protection officers for consideration of deployment-related RRV disease in differential diagnosis of patients with fever, arthralgia, or rash who have recently deployed to, or conducted exercises in Australia.

Case Presentation

During a routine pre- and post-deployment serological screening program, a concerning seroconversion was identified in an Australian Defence Force (ADF) service member who had recently returned from a 3-week deployment to Papua New Guinea in late April and early May 2024. The pre-deployment serum sample, collected in early February 2024, was negative for anti-RRV IgG/M and neutralizing antibodies (NAb). The post-deployment serum, however, collected in early May 2024, was positive for both anti-RRV IgG/M and NAb, at a dilution of 1 : 320. Negative serology for anti-BFV NAb ruled out cross-reactivity and supported a definitive RRV infection.

Clinical questioning confirmed strict adherence to mosquito bite prevention measures while deployed, including sleeping indoors with screened windows, wearing a permethrin-treated uniform, and consistent use of mosquito repellent. As a result, she sustained few mosquito bites in Papua New Guinea.

Further investigation revealed that the service member resided in a known RRV hotspot in Brisbane, Queensland—an area with ongoing community transmission. The service member recalled significant mosquito exposure in early February (~15 bites per day), 2 months prior to deployment, and developed monoarthritis in the right wrist on February 13th. Imaging studies (x-ray and ultrasound) found no structural injury, and blood examination was negative for rheumatoid factors or other arthritic markers. MRI (magnetic resonance imaging) in March confirmed right wrist joint inflammation-joint effusion/synovitis **(Figure 2a)**.

Despite the service member's background as a laboratory scientist and personal request for RRV testing, her general practitioner dismissed the possibility of RRV infection due to monoarticular involvement.

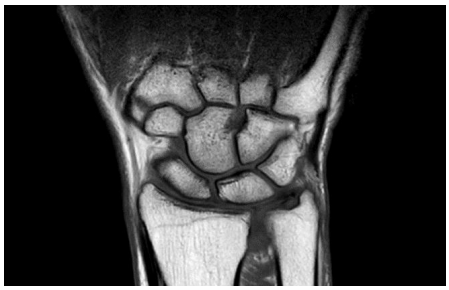
The service member's symptoms persisted—with manageable pain—until approximately October 2024. Some residual discomfort continued until April 2025, largely triggered by over-use. Follow-up pathology testing for rheumatoid and other arthritic markers was again negative. Additional MRI in April 2025 confirmed mild synovitis **(Figure 2b)**, and corticosteroid injection was administered.

Based on timing, exposure history and serological data, we concluded that the infection likely occurred at the service member's home in Queensland rather than during overseas deployment.

Discussion

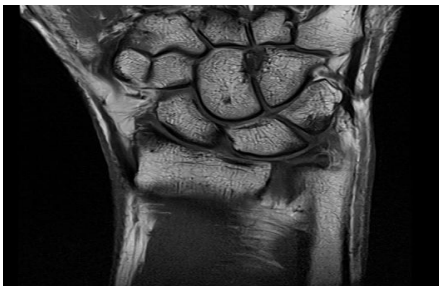
Queensland is the Australian state most affected by RRV, consistently reporting over 1,000 cases annually. A record-breaking number of mosquito samples tested positive for RRV during the 2023-2024 mosquito season (November–April), which coincided with a high number of human RRV cases. Samples from more than 1,225 mosquito traps were tested,

FIGURE 2a. 2024 MRI Image of Ross River Virus-Infected Australian Service Member's Right Wrist, Indicating Capsulosynovitis



2024 MRI of wrist shows increased joint fluid and thickening of joint lining (synovium) in multiple wrist joints, particularly at distal radioulnar, radioscaphoid, and pisotriquetral joints. Inflammation of tendon sheaths (tenosynovitis) evident in flexor pollicis longus (thumb flexor) and flexor carpi radialis (wrist flexor) tendons. Mild inflammatory changes also present along several tendons on dorsal aspect of wrist (extensor compartments 2, 3, 4, 6).

FIGURE 2b. 2025 MRI Image of Ross River Virus-Infected Australian Service Member's Right Wrist, Indicating Capsulosynovitis



2025 MRI of wrist demonstrates capsulosynovial thickening (up to 5 mm) on dorsal aspect of wrist, overlying articulations between proximal and distal carpal rows. Mild inflammation also noted around tendon that extends fingers (extensor digitorum tendon).

Abbreviation: MRI, magnetic resonance imaging.

with 116 traps yielding positive results, the highest number since 2016, when the current surveillance program began. In the first 4 months of 2024, 2,065 human RRV cases were reported in Queensland, the highest total since the 2019-2020 season. In the second week of March 2024, weekly cases peaked at 333, with over 50% in Southeast Queensland, where incidence was 2.4 times higher than the 5-year average.[23]

As the Indo-Pacific area becomes a defining theater of 21st century strategic competition, northern Australia, including Queensland and the Northern Territory, has emerged as a crucial area for U.S. force presence and deterrence.[24] U.S. military personnel who are deployed to regions where RRV is endemic, including northern Australia, Papua New Guinea, or the Solomon Islands, may be at risk of infection even during short-term exercises or visits. Exposure risk is influenced not only by location but also by timing, duration, and type of activities during deployment.

U.S. military personnel are subject to insect-borne diseases and pest threats that can adversely affect their health and compromise important missions, whether deployed in combat operations, engaged in humanitarian relief, or conducting training. Malaria, as well as flaviviruses such as dengue and West Nile virus, and alphaviruses such as RRV, BFV and CHIKV, along with sandfly fever, scrub typhus, and several tick-borne diseases, continue to pose a significant threat to forces worldwide. The largest outbreak of RRV infection ever recorded, in the Pacific from 1979 to 1980, demonstrates the epidemic potential of the virus.[25]

The experience of Zika virus outbreaks since 2015 and the explosive CHIKV outbreak in China 2025 underscores the serious threat posed to global health by the potential for previously obscure arboviruses to shift from their historical cycles of transmission.[26,27] This risk is amplified within a mobile population such as the U.S. military.

A further risk is the potential for RRV to be exported to other countries through asymptomatic infected individuals, whether military personnel or civilians. RRV-viraemic travelers have been linked to the spread and epidemics with RRV in the Asia-Pacific region before.[28] This risk is of particular concern for the U.S., given the presence of mosquitoes known to be RRV vectors.[4,29]

Australia remains a key partner of the U.S. in joint training operations, with an estimated 2,500 U.S. marines and sailors rotating annually through northern Australia. Additionally, in 2024, approximately 656,000 U.S. citizens traveled to Australia for recreational purposes, highlighting the potential for both military and civilian exposure to these endemic arboviruses. Enhanced surveillance, diagnostic capacity, and medical awareness of RRV, preventive measures during and after deployment must be prioritized in both the U.S. Military Health System and joint force health support planning.

This case underscores the need for heightened clinical awareness among military medical providers. U.S. service members presenting with febrile illness or joint pain after deployment to Australia should be evaluated for RRV as part of a comprehensive differential diagnosis of vector-borne diseases. Because exposure risk may extend beyond deployment sites, both deployment and travel locations should be considered when developing differential diagnoses, which should include arboviruses not endemic to Australia, such as CHIKV, dengue, and Zika virus (ZIKV). A high index of suspicion based on travel location and seasonality is needed to ensure RRV is included in the differential diagnosis.

The U.S. Department of Defence Insect Repellent System is an effective mechanism for protecting military personnel from pests and insect-borne diseases.[30] Preventive measures—including the use of DEET (diethyltoluamide)-based repellents, wearing long-sleeved uniforms, and treating uniforms with permethrin—remain critical to force health protection. In addition, medical staff must be aware of the local disease ecology and incorporate arboviral infections into pre-deployment briefings and post-deployment health assessments.

Author Affiliations
Australian Defense Force Malaria and Infectious Disease Institute, Gallipoli Barracks, Enoggera, Queensland, Australia: CAPT Graham, Dr. Liu, Dr. Pasay; QIMR-Berghofer Medical Research Institute, Brisbane, Queensland: CAPT Graham, Dr. Pasay; Walter Reed Army Institute of Research Engineering and Scientist Exchange Program, Enoggera: MAJ Vesely

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Disclaimer

The opinions and assertions contained herein are the private views of the authors authors and are not to be construed as official, nor as reflecting true views of the Australian Department of Defence or the Department of the Army. The investigators have adhered to the policies for protection of human subjects as prescribed in AR 70–25. Research data were derived from an approved Australian Department of Defence and Department of Veterans' Affairs Human Research Ethics Committee Institutional Review Board protocol, DDVA HREC 204-20. The data are included in the manuscript. The study protocol was approved by the Australian departments of Defence and Veterans' Affairs Human Research Ethics Committee Institutional Review Board in compliance with all applicable regulations governing the protection of human and animal subjects..

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This report has been reviewed by the Walter Reed Army Institute of Research. There is no objection to its publication.

References

1. Kizu J, Graham M, Izuagbe R, et al. Potential high arbovirus exposure in INDOPACOM during U.S. service member deployment or exercises in Papua New Guinea. *MSMR.* 2025;32(8):9-17. Accessed Nov. 12, 2025. https://www.health.mil/news/articles/2025/08/01/msmr-papua-new-guinea-arboviruses
2. Wellington T, Fraser JA, Kuo HC, Hickey PW, Lindholm DA. The burden of arboviral infections in the Military Health System 2012–2019. *Am J Trop Med Hyg.* 2023;108(5):1007-1013. doi:10.4269/ajtmh.22-0684
3. Proboste T, Bista D, Clark NJ, et al. Ascertainment of community exposure sites to Ross River virus during the 2020 outbreak in Brisbane, Australia. *J Infect Dis.* 2025;231(3):e501-e510. doi:10.1093/infdis/jiae578
4. Yuen KY, Bielefeldt-Ohmann H. Ross River virus infection: a cross-disciplinary review with a veterinary perspective. *Pathogens.* 2021;10(3):357. doi:10.3390/pathogens10030357
5. Hueston L, Yund A, Cope S, et al. Ross River virus in a joint military exercise. *Commun Dis Intell.* 1997;21(14):193. doi:10.33321/cdi.1997.21.40
6. Bell MG, Liu W, Hulsey WR, Schully KL. Low risk for Ross River virus infection in expeditionary forces training in Australia demonstrated by a serological survey of Marine rotational force–Darwin, 2012–2018. *MSMR.* 2023;30(9):11-16. Accessed Nov. 12, 2025. https://www.health.mil/reference-center/reports/2023/09/01/msmr-september-2023-volume-30-issue-9
7. Australian Government Dept. of Defence. Exercise Talisman Sabre 2025. Apr. 23, 2025. Accessed Nov. 12, 2025. https://www.defence.gov.au/news-events/releases/2025-04-23/exercise-talisman-sabre-2025
8. Australian Centre for Disease Control. National Notifiable Diseases Surveillance System (NNDSS) Public Datasets. Updated Dec. 2, 2025. Accessed Jan. 20, 2026. https://www.cdc.gov.au/resources/collections/nndss-public-datasets?utm_source=health.gov.au&utm_medium=callout-auto-custom&utm_campaign=digital_transformation
9. Qian W, Hurst C, Glass K, Harley D, Viennet E. Spatial and temporal patterns of Ross River virus in Queensland, 2001–2020. *Trop Med Infect Dis.* 2021;6(3):145. doi:10.3390/tropicalmed6030145
10. Suhrbier A, La Linn M. Clinical and pathologic aspects of arthritis due to Ross River virus and other alphaviruses. *Curr Opin Rheumatol.* 2004;16(4):374-379. doi:10.1097/01.bor.0000130537.76808.26
11. Qian W, Glass K, Harley D, Viennet E, Hurst C. Unpacking Ross River virus trends in Queensland: regional insights and predictive modeling. *iScience.* 2025;28(10):113446. doi:10.1016/j.isci.2025.113446
12. Liu W, Kizu JR, Le Grand LR, et al. Localized outbreaks of epidemic polyarthritis among military personnel caused by different sublineages of Ross River virus, northeastern Australia, 2016–2017. *Emerg Infect Dis.* 2019;25(10):1793-1801. doi:10.3201/eid2510.181610
13. Harley D, Sleigh A, Ritchie S. Ross River virus transmission, infection, and disease: a cross-disciplinary review. *Clin Microbiol Rev.* 2001;14(4):909-932. doi:10.1128/cmr.14.4.909-932.2001
14. Selden SM, Cameron AS. Changing epidemiology of Ross River virus disease in south Australia. *Med J Aust.* 1996;165(6):313-317. doi:10.5694/j.1326-5377.1996.tb124989.x
15. Westley-Wise VJ, Beard JR, Sladden TJ, Dunn TM, Simpson J. Ross River virus infection on the north coast of New South Wales. *Aust N Z J Public Health.* 1996;20(1):87-92. doi:10.1111/j.1467-842x.1996.tb01343.x
16. Harley D, Bossingham D, Purdie DM, Pandeya N, Sleigh AC. Ross River virus disease in tropical Queensland: evolution of rheumatic manifestations in an inception cohort followed for six months. *Med J Aust.* 2002;177(7):352-355. doi:10.5694/j.1326-5377.2002.tb04836.x
17. Malvy D, Ezzedine K, Mamani-Matsuda M, et al. Destructive arthritis in a patient with chikungunya virus infection with persistent specific IgM antibodies. *BMC Infect Dis.* 2009;9:200. doi:10.1186/1471-2334-9-200
18. Soden M, Vasudevan H, Roberts B, et al. Detection of viral ribonucleic acid and histologic analysis of inflamed synovium in Ross River virus infection. *Arthritis Rheum.* 2000;43(2):365-369. doi:10.1002/1529-0131(200002)43:2<365::aid-anr16>3.0.co;2-e
19. Fraser JR, Cunningham AL, Clarris BJ, Aaskov JG, Leach R. Cytology of synovial effusions in epidemic polyarthritis. *Aust N Z J Med.* 1981;11(2):168-173. doi:10.1111/j.1445-5994.1981.tb04226.x
20. Liu W, Kizu JR, Matley DR, et al. Circulation of 2 Barmah Forest virus lineages in military training areas, Australia. *Emerg Infect Dis.* 2020;26(12):3061-3065. doi:10.3201/eid2612.191747
21. Zaid A, Burt FJ, Liu X, et al. Arthritogenic alphaviruses: epidemiological and clinical perspective on emerging arboviruses. *Lancet Infect Dis.* 2021;21(5):e123-e133. doi:10.1016/s1473-3099(20)30491-6
22. Kistner O, Barrett N, Bruhmann A, et al. The preclinical testing of a formaldehyde inactivated Ross River virus vaccine designed for use in humans. *Vaccine.* 2007;25(25):4845-4852. doi:10.1016/j.vaccine.2007.01.103
23. Queensland Dept. of Health. Record-breaking Ross River Virus Detections in Queensland Mosquitoes. Press release. Apr. 30, 2024. Accessed Nov. 12, 2025. https://www.news.com.au/technology/science/animals/ross-river-virus-detected-in-record-number-of-queensland-mosquitoes/news-story/b8c008d2b75c1fe244f62f43858ac8d0
24. Dziedzic S. Andrew Hastie calls for 'transparency' about US military's growing presence in Australia. *Australian Broadcasting Corporation News.* Jun. 23, 2024. Accessed Nov. 12, 2025. https://www.abc.net.au/news/2025-06-24/hastie-demands-answer-about-us-militarys-growing-presence/105451834
25. Aaskov JG, Mataika JU, Lawrence GW, et al. An epidemic of Ross River virus infection in Fiji, 1979. *Am J Trop Med Hyg.* 1981;30(5):1053-1059. doi:10.4269/ajtmh.1981.30.1053
26. Zhang Y, Zhang Y, Fang Z, Ni S. China's chikungunya virus outbreak is a wake up call. *Nature.* 2025;645(8079):41. doi:10.1038/d41586-025-02794-2
27. Barreto Santana LM, Andrêssa de Moura I, Ramos Tanaka YM, de Oliveira França RF. Zika virus: a review of biology, clinical impacts, and coinfections. *Viruses.* 2025;17(5):637. doi:10.3390/v17050637
28. Lau C, Weinstein P, Slaney D. Imported cases of Ross River virus disease in New Zealand: a travel medicine perspective. *Travel Med Infect Dis.* 2012;10(3):129-134. doi:10.1016/j.tmaid.2012.04.001
29. Claflin SB, Webb CE. Ross River virus: many vectors and unusual hosts make for an unpredictable pathogen. *PLoS Pathog.* 2015;11(9):e1005070. doi:10.1371/journal.ppat.1005070
30. Defense Health Agency. DoD Insect Repellent System. U.S. Dept. of Defense. Updated Sep. 22, 2025. Accessed Nov. 12, 2025. https://ph.health.mil/topics/entomology/pur/pages/dod-insect-repellent-system.aspx

Surveillance Snapshot

Chikungunya in Military Health System Beneficiaries, 2020–2024

Shauna L. Stahlman, PhD, MPH; Kiara D. Scatliffe-Carrion, MPH; Charles E. McCannon, MD, MPH

Chikungunya is a mosquito-borne viral disease that can cause severe joint pain, fever, and other short- or long-term symptoms.[1] Chikungunya is endemic to tropical and subtropical regions, with cases and outbreaks recorded in more than 100 countries.[2] The U.S. Food and Drug Administration (FDA) recently approved 2 chikungunya vaccines: a live-attenuated vaccine called IXCHIQ in November 2023, and a virus-like particle vaccine called VIMKUNYA in February 2025.[3] These vaccines are recommended for those traveling to high-risk areas. The FDA recently suspended the U.S. license for IXCHIQ in August 2025, however, citing vaccine safety concerns.[4]

This analysis was conducted to answer questions from military health leadership about the risk of chikungunya infection to service members and their families. The analysis employed data published in prior *MSMR* articles[5-7] to provide case counts for all Military Health System (MHS) beneficiaries from 2020 through 2024. Data were drawn from the Defense Health Agency's Disease Reporting System internet (DRSi), and were confirmed via medical chart review.

Ten cases of chikungunya virus disease among MHS beneficiaries were documented from 2020 through 2024 **(Table)**. Five cases were recorded in service members, 3 among family members (all spouses), and 2 in other beneficiary types (i.e., not service members or dependents). One case was acquired while on deployment to multiple locations in Southeast Asia; no other cases were related to official travel or deployment. Most cases were related to unofficial travel.

Polyarthralgia, or pain in multiple joints, was the most documented symptom (n=7). Other commonly reported symptoms included fever, rash, and myalgia. Two cases had long-term symptoms (i.e., lasting longer than 12 weeks), and 2 cases were hospitalized. No cases had evidence of prior chikungunya vaccination in their medical records.

The small number of cases, hospitalizations, and evidence of long-term symptoms reported in the past 5 years suggest that risk of chikungunya virus disease to MHS beneficiaries is small. Use of standard preventive measures including personal protective equipment and vaccination should, however, continue to be encouraged when indicated for service members and other beneficiaries traveling to high-risk areas.

Authors' Affiliation
Defense Health Agency, Public Health Directorate, Armed Forces Health Surveillance Division, Epidemiology and Analysis Branch, Silver Spring, MD: Dr. Stahlman; Defense Health Agency, Defense Centers for Public Health–Aberdeen, MD: Ms. Scatliffe-Carrion, Dr. McCannon

REFERENCES

1. U.S. Centers for Disease Control and Prevention. Chikungunya Virus. U.S. Dept. of Health and Human Services. Accessed Oct. 3, 2025. https://www.cdc.gov/chikungunya/index.html
2. U.S. Centers for Disease Control and Prevention. Areas at Risk for Chikungunya. U.S. Dept. of Health and Human Services. Accessed Oct. 3, 2025. https://www.cdc.gov/chikungunya/data-maps/index.html
3. U.S. Centers for Disease Control and Prevention. Chikungunya Vaccine Information for Healthcare Providers. U.S. Dept. of Health and Human Services. Accessed Oct. 3, 2025. https://www.cdc.gov/chikungunya/hcp/vaccines/index.html
4. U.S. Food and Drug Administration. FDA Update on the Safety of Ixchiq (Chikungunya Vaccine, Live), August 2022, 2025. U.S. Dept. of Health and Human Services. Accessed Oct. 3, 2025. https://www.fda.gov/vaccines-blood-biologics/safety-availability-biologics/fda-update-safety-ixchiq-chikungunya-vaccine-live
5. O'Donnell FL, Fan M, Stahlman S. Surveillance for vector-borne diseases among active and reserve component service members, U.S. Armed Forces, 2016-2020. *MSMR*. 2021;28(2):11-15. Accessed Nov. 18, 2025. https://www.health.mil/reference-center/reports/2021/02/01/medical-surveillance-monthly-report-volume-28-number-02
6. O'Donnell FL, Stahlman S, Fan M. Surveillance for vector-borne diseases among active and reserve component service members, U.S. Armed Forces, 2010–2016. *MSMR*. 2018;25(2):8-15. Accessed Nov. 18, 2025. https://www.health.mil/reference-center/reports/2018/01/01/medical-surveillance-monthly-report-volume-25-number-2
7. Stahlman SL, Langton RS. Surveillance snapshot: chikungunya in service members of the U.S. Armed Forces, 2016–2022. *MSMR*. 2023;30(12):11. Accessed Nov. 18, 2025. https://www.health.mil/news/articles/2023/12/01/msmr-chikungunya

TABLE. Chikungunya Cases, Military Health System Beneficiaries, 2020–2024

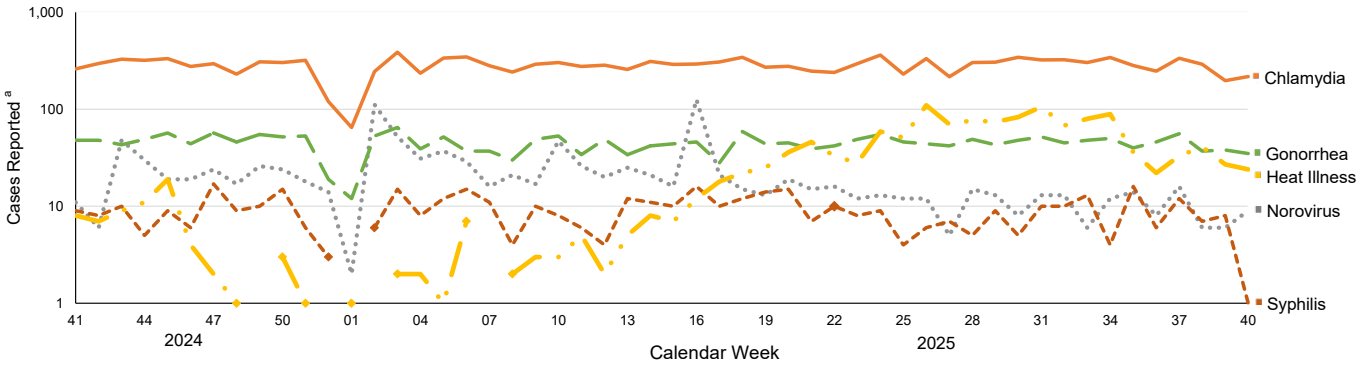
Year of Onset	Beneficiary Type	Location of Travel	Deployment-related	Hospitalized[a]	Long-Term Symptoms[b]	Short-Term Symptoms (summarized)
2020	Family member (spouse)	Costa Rica	No	No	Yes	Fever, polyarthralgia, rash
2020	Other	Niger	No	N/A	N/A	N/A
2020	Other	Cameroon	No	N/A	N/A	N/A
2022	Navy active duty	Brazil	No	Yes	Yes	Fatigue, myalgia, rash, polyarthralgia
2022	Army National Guard	Mexico	No	No	No	Rash, polyarthralgia, myalgia, gait disturbance
2023	Air Force active duty	Indonesia	No	No	No	Influenza-like symptoms, headache, polyarthralgia
2023	Family member (spouse)	Guatemala	No	No	No	Rash, polyarthralgia
2023	Navy active duty	Southeast Asia (multiple countries)	Yes	No	No	Fever, headache, polyarthralgia
2024	Family member (spouse)	No travel around time of diagnosis	No	Yes	No	Rash, polyarthralgia, swollen lymph nodes
2024	Army active duty	Chad	No	No	No	Patient also had malaria; fever, headache, myalgias, nausea, vomiting, dysuria

Abbreviation: N/A, not available.
[a] Hospitalization likely related to chikungunya.
[b] Long-term symptoms defined as symptoms lasting longer than 12 weeks likely due to chikungunya.

Reportable Medical Events at Military Health System Facilities Through Week 40, Ending October 4, 2025

Matthew W. R. Allman, MPH; Anthony R. Marquez, MPH; Katherine S. Kotas, MPH; Kiara D. Scatliffe-Carrion, MPH

TOP 5 REPORTABLE MEDICAL EVENTS[a] BY CALENDAR WEEK, U.S. ACTIVE COMPONENT SERVICE MEMBERS, OCTOBER 6, 2024–OCTOBER 4, 2025



[a]Cases are shown on a logarithmic scale.

Abbreviation: RMEs, reportable medical events.

Note: There were 0 reported heat illness cases during weeks 49 and 52 of 2024, and during weeks 2 and 7 of 2025. There were 0 reported syphilis cases during week 1 of 2025.

Reportable Medical Events (RMEs) are documented in the Disease Reporting System internet (DRSi) by health care providers and public health officials throughout the Military Health System (MHS) for monitoring, controlling, and preventing the occurrence and spread of diseases of public health interest or readiness importance. These reports are reviewed by each service's public health surveillance hub. The DRSi collects reports on over 70 different RMEs, including infectious and non-infectious conditions, outbreak reports, 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 reported in these tables are considered provisional and do not represent conclusive evidence until case reports are fully validated.

Total active component cases reported per week are displayed for the top 5 RMEs for the previous year. Each month, the graph is updated with the top 5 RMEs, and is presented with the current month's (September 2025) top 5 RMEs, which may differ from previous months. COVID-19 is excluded from these graphs due to changes in reporting and case definition updates in 2023.

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

Authors' Affiliation: Defense Health Agency, Disease Epidemiology Branch, Defense Centers for Public Health–Aberdeen

References

1. Armed Forces Health Surveillance Division. Armed Forces Reportable Medical Events. Accessed Feb. 28, 2024. https://health.mil/reference-center/publications/2022/11/01/armed-forces-reportable-medical-events-guidelines
2. Defense Manpower Data Center. Department of Defense Active Duty Military Personnel by Rank/Grade of Service. Accessed Feb. 28, 2024. https://dwp.dmdc.osd.mil/dwp/app/dod-data-reports/workforce-reports
3. Defense Manpower Data Center. Armed Forces Strength Figures for January 31, 2023. Accessed Feb. 28, 2024. https://dwp.dmdc.osd.mil/dwp/app/dod-data-reports/workforce-reports
4. Navy Medicine. Surveillance and Reporting Tools–DRSI: Disease Reporting System Internet. Accessed Feb. 28, 2024. https://www.med.navy.mil/navy-marine-corps-public-health-center/preventive-medicine/program-and-policy-support/disease-surveillance/drsi

TABLE. Reportable Medical Events, Military Health System Facilities, September 2025[a]

Reportable Medical Event[b]	Active Component[c]					MHS Beneficiaries[d]
	September 2025	August 2025	YTD 2025	YTD 2024	Total 2024	September 2025
	No.	No.	No.	No.	No.	No.
Amebiasis	0	0	13	9	15	0
Arboviral diseases, neuroinvasive, non-neuroinvasive	0	0	1	4	4	1
Babesiosis	0	1	1	0	0	0
Brucellosis	0	0	0	1	1	0
COVID-19-associated hospitalization, death	1	7	31	38	41	17
Campylobacteriosis	29	29	249	260	326	23
Chikungunya virus disease	0	0	0	0	1	0
Chlamydia trachomatis infection	1,145	1,321	11,263	12,375	16,097	141
Cholera, O1, O139	0	0	0	2	3	0
Coccidioidomycosis	3	3	18	43	53	0
Cold weather injury[e]	4	1	284	136	174	N/A
Cryptosporidiosis	8	5	56	70	82	2
Cyclosporiasis	0	8	22	10	11	1
Dengue virus infection	0	2	8	11	12	0
E. coli, Shiga toxin-producing	5	8	54	67	93	3
Ehrlichiosis, anaplasmosis	0	0	1	1	1	0
Giardiasis	11	12	84	79	98	3
Gonorrhea	191	197	1,735	2,195	2,823	21
H. influenzae, invasive	0	0	2	3	3	0
Heat illness[e]	134	307	1,305	1,188	1,276	N/A
Hepatitis A	0	0	1	6	7	0
Hepatitis B, acute, chronic[f]	9	7	61	87	108	3
Hepatitis C, acute, chronic	4	1	20	32	35	1
Influenza-associated hospitalization[g]	0	1	49	40	54	2
Lead poisoning, pediatric[h]	N/A	N/A	N/A	N/A	N/A	8
Legionellosis	0	0	1	4	5	3
Leishmaniasis	0	0	1	0	0	0
Leprosy	0	0	0	1	2	0
Listeriosis	0	0	1	0	0	0
Lyme disease	8	10	84	86	101	11
Malaria	5	11	29	16	21	1
Meningococcal disease	1	0	2	0	2	0
Mpox	1	2	7	12	14	0
Mumps	0	0	2	0	0	0
Norovirus infection[i]	41	46	886	380	654	50
Pertussis	1	3	37	20	39	12
Rabies post-exposure prophylaxis (PEP)	49	68	471	477	637	56
Q fever	0	0	1	2	3	0
Salmonellosis	24	17	129	116	160	28
Schistosomiasis	0	0	0	0	1	0
Shigellosis	1	8	30	42	53	3
Spotted fever rickettsiosis	4	3	28	19	22	3
Syphilis[j]	33	45	355	475	587	7
Toxic shock syndrome	0	0	0	2	2	0
Trypanosomiasis	1	0	2	3	5	0
Tuberculosis	0	1	7	4	6	1
Tularemia	0	0	2	1	1	0
Typhoid fever	0	0	0	1	1	0
Typhus fever	1	1	7	1	2	0
Varicella	2	0	12	12	18	8
Zika virus infection	0	0	0	1	1	0
Total case counts	1,716	2,125	17,352	18,332	23,655	409

Abbreviations: MHS, Military Health System; YTD, year-to-date; No., number; N/A, not applicable; *E, Escherichia*; *H., Haemophilus*; RMEs, reportable medical events; DRSi, disease reporting system internet; DCPH-A, Defense Centers for Public Health, Aberdeen.

[a] RMEs submitted to DRSi as of Dec. 11, 2025. RMEs were classified by date of diagnosis or, where unavailable, date of onset. Monthly comparisons are displayed for the periods Aug. 1, 2025–Aug. 31, 2025 and Sep. 1, 2025–Sep. 30, 2025. YTD comparison is displayed for the period Jan. 1, 2025–Sep. 30, 2025 for MHS facilities. Previous year counts are provided as: previous YTD, Jan. 1, 2024-Sep. 30, 2024; total 2024, Jan. 1, 2024–Dec. 31, 2024.

[b] RME categories with 0 reported cases among active component service members and MHS beneficiaries for the periods covered were not included in this report.

[c] Services included in this report include the Army, Navy, Air Force, Marine Corps, Coast Guard, and Space Force, including personnel classified as active duty, cadet, midshipman, or recruit in DRSi.

[d] Beneficiaries included individuals classified as retired and family members (including spouse, child, other, unknown). National Guard, reservists, civilians, contractors, and foreign nationals were excluded from these counts.

[e] Only reportable for service members.

[f] Observed decrease in hepatitis B cases from 2024 to 2025 may be attributed, in part, to updated case validation process.

[g] Influenza-associated hospitalization is reportable only for individuals younger than age 65 years.

[h] Pediatric lead poisoning is reportable only for children ages 6 years or younger.

[i] DCPH-A is closely monitoring norovirus, due to 133% increase in DRSi reports for norovirus YTD 2025 (n=886) versus YTD 2024 (n=380).

[j] Observed decrease in syphilis cases from 2024 to 2025 may be attributed, in part, to updated case validation process that began Jan. 2024.

Letter from the Editor in Chief

Thank you for being one of the many *MSMR* readers in 2025. *MSMR*'s mission is to publish operationally relevant, timely, and descriptive epidemiological articles that provide accurate data on topics vital to the health, safety, and resilience of the U.S. Armed Forces. As a product of the Armed Forces Health Surveillance Division (AFHSD), within the Public Health Directorate (PHD) of the Defense Health Agency (DHA), *MSMR* is a peer-reviewed journal published each month on health.mil that is also indexed on PubMed and archived on PubMed Central (PMC).

The *MSMR* role, supporting the combined missions of AFHSD, PHD, and DHA, remains vital. The need for appropriate database utilization, information synthesis, and methodologically valid analysis remains the 'gold standard' of epidemiological surveillance and medical knowledge development. *MSMR* continuously strives for timeliness with careful deliberation, relevance with objectivity, and scientific validity focused on force readiness, force health protection, and force resilience.

Although we publish *MSMR* for both warfighter readiness as well as military and civilian public health surveillance, planning, and response—with many individuals and organizations both within and outside DHA to thank—it is our readers such as you who are in our thoughts when we assemble, edit, and publish each issue. 2025 has truly been a high water mark for *MSMR* due to increased content, particularly in special topical issues, and significantly enhanced readership metrics.

MSMR published three special issues in 2025, which enhanced *MSMR* focus on unique military readiness and force health protection concerns. Our 30th anniversary issue in April featured 10 articles covering many operationally important topics including, but not limited to, historical highlights, influenza modeling, global pathogen surveillance, HIV testing, in addition to the annual malaria case update. In May, *MSMR* published a military women's health and readiness issue, which also included 10 reports, covering a breadth of topics from infertility and contraception trends to military women's health and readiness research and female warfighter performance in extreme environments.

MSMR's third special issue, in September, presented our annual review of illnesses and injuries within the active, reserve, and Guard components of the U.S. Armed Forces in addition to its Military Health System (MHS) beneficiaries. The issue examined numbers and trends in hospitalization and ambulatory visits, deployment morbidity burdens, selected medical evacuations and telehealth usage by the active component members. Publishing morbidity burdens for the entire MHS in one issue provides our readers with a valuable reference document of recent case numbers and trends.

Rigorous data collection, exacting analysis, manuscript writing and review, and painstaking submission for publication is hard work, and we appreciate and heartily thank each author in 2025 for their scholarship and dedication. The *MSMR* editorial staff deeply appreciates the quality and operational value of every submission. Our manuscript submissions in 2025 increased by nearly two-thirds, and those increased submissions resulted in greater *MSMR* content, providing our readers with even more accurate, timely, and clear epidemiological reporting.

We also heartily thank our subject matter expert reviewers. Our external reviewers provide robust assessments and insightful comments informed by their professional knowledge and years of expertise that assist our authors' refinement of their manuscripts. For each original manuscript submitted, our double-blind peer review process involves two independent subject matter experts who contribute clinical and professional perspectives, enhanced analyses, and additional editorial rigor that improves the quality of *MSMR* reporting.

MSMR began archiving on PMC in January 2024, enabling free, open, permanent access to our peer-reviewed content. Over the past two years, readership of *MSMR* content on PMC has steadily grown, expanding our impact within the international scientific community. The *MSMR* online 'hit' rate on PMC was 50% higher in 2025 compared to 2024.

Our reach and readership continue to increase as the appetite for high quality, evidence-based, military health-specific information continues to grow. The Department of War public health community is focused on collecting, publishing, and applying the increasing knowledge base to positively influence health awareness and outcomes. *MSMR*'s advances in 2025 are the result of hard work by the *MSMR* staff in concert with the excellent manuscripts submitted by public health investigators and researchers, not only from the various DHA organizations, but civilian and international contributors as well. *MSMR* staff works in collaboration with DHA PHD staff to more broadly share the findings that result from the substantial medical data available within DHA and the MHS.

Each *MSMR* issue comes together over the course of months, beginning with manuscript submission by our authors, comprehensive internal review by our editors, external review by external subject matter experts, painstaking responses and revisions by the authors, meticulous copy editing, and publishing on health.mil, indexing on PubMed, and archiving on PMC. We could not accomplish our mission to publish this operationally relevant journal without our authors, reviewers and, of course, our readers. Many thanks to you all!

Our plans for 2026 are robust. We will continue to increase our published content, and aim to publish earlier within the month, to increase the timeliness of our reporting. To return to my first Letter form the Editor's Desk, published in January 2024, our mission and dedication remain firm and unchanged. I wrote then and reiterate, "In the most recent Armed Forces Health Surveillance Division (AFHSD) Annual Report, *MSMR* is referred to as the "premiere medical peer-reviewed journal published by the AFHSD and Defense Health Agency (DHA)," which provides "evidence-based estimates of the incidence, distribution, impact and trends of illness and injury among U.S. military service members and associated populations." *MSMR* has a distinguished legacy of excellence and professional rigor. As we begin our 31st year, the *MSMR* staff is honored to pick up and carry that standard further. *MSMR* continues to be vigilant and undaunted by the continued high stakes role of public health but successes of 2025 position us well to continue to serve "those who serve" in 2026.

Very Respectfully,
Robert Johnson, MD, MPH, MBA
Col (ret) USAF
Editor-in-Chief
Medical Surveillance Monthly Report

Thank You to MSMR External Reviewers

The editor-in-chief of *MSMR*, its contributing editors, and production staff would each like to extend appreciation and gratitude to the subject matter experts who served as peer reviewers of manuscripts that were published in *MSMR* in 2025. External reviewers commit valuable time and effort that is sincerely appreciated by the *MSMR* team. Their informed insights, careful analyses, and thoughtful critiques supported the continuance of the *MSMR* mission: monthly, evidence-based estimates of the incidence, distribution, impacts, and trends of health-related conditions among U.S. service members.

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