MSMR

MEDICAL SURVEILLANCE MONTHLY REPORT FEBRUARY 2022 | Vol. 29 | No. 02

IN THIS ISSUE:

A PUBLICATION OF THE ARMED FORCES HEALTH SURVEILLANCE DIVISION

www.health.mil/MSMR

Diagnosis of Hepatitis C Infection and Cascade of Care in the Active Component, U.S. Armed Forces, 2020

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Hepatitis C virus (HCV) infection rates are rising in the U.S. despite widely available tools to identify and effectively treat nearly all of these cases. This cross-sectional study aimed to use laboratory data to evaluate the prevalence of HCV diagnoses among active component U.S. military service members, describe the characteristics of those diagnosed with HCV, and evaluate the adherence of their care to current standards of practice. All service members in the active component U.S. military between 1 January and 31 December 2020 were included in the study population. The primary outcome was an HCV diagnosis at any time during military service, with secondary outcomes of HCV treatment and sustained virologic response (SVR). The initial case-finding algorithm used laboratory data to identify HCV patients seen in infectious disease and gastrointestinal disease clinics in military treatment facilities (MTFs) (direct care); this was supplemented with additional data to assess and correct for undercounting from cases occurring outside MTFs (purchased care). Thirty active component service members in 2020 had been diagnosed with HCV infection during their military service via direct care, or an estimate of 68 cases after correcting for additional cases from purchased care; this number represents only 12% of the expected number of infections based on previous studies. Of the 30 cases treated via direct care, 28 (93%) received HCV treatment, with 27 of those 28 (96%) achieving SVR. Changes to HCV screening policy for military accessions should be considered in order to effectively identify and treat asymptomatic HCV infections that would otherwise go undetected.

WHAT ARE THE NEW FINDINGS?

Among active component service members with a diagnosis of HCV during military service at MTFs, 93% received appropriate treatment, and 96% of those treated had a documented sustained viral response. However, this study also suggests that only 12% of the expected HCV infections in this population were diagnosed.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Although HCV infection results in a low risk of progression to symptomatic disease during military service, it poses a risk to operational requirements such as the walking blood bank. Recent changes in HCV epidemiology and national guidelines, as well the impact on veterans' health, suggest that HCV screening policies, particularly at accession, should be reevaluated.

During 2013–2016, an estimated 4.1 million U.S. adults were hepatitis C virus (HCV) antibody positive indicating either past or current infection with HCV, while 2.4 million had an active infection based on a positive HCV RNA test.[1] Due to the introduction of novel direct acting antiviral medications (DAAs) in the early 2010s, greater than 90% of cases of chronic HCV infection can be cured prior to progression to advanced liver disease.[2] Despite these recent advancements in treatment, only 49% of those with commercial insurance who are aware of their diagnosis of chronic HCV infection receive treatment,[3] and HCV remains the leading cause of cirrhosis in North America and the second leading cause worldwide.[4]

To better target interventions which promote the control of HCV and monitor its progress, the World Health Organization has developed a consensus HCV cascade of care.[5] This cascade of care depicts how many of those infected with HCV have progressed through the sequence of stages required for effective HCV control, including diagnosis, treatment, and cure. The goal of the cascade of care is to identify the stages at which the greatest numbers of infected individuals are lost to care, in order to target control efforts most effectively and efficiently towards these stages.

It is of concern to the military that HCV rates are increasing in younger, military-aged Americans, largely due to the ongoing opioid epidemic in the U.S.[6,7] Since most chronic HCV infections are asymptomatic, persons infected are often not aware of their underlying condition until it has progressed to advanced liver disease. Because of these factors, as well as the low level of adoption of previous screening recommendations, the Centers for Disease Control (CDC) and U.S. Preventive Services Task Force (USPSTF) recently implemented updated screening policies in 2020 recommending that all persons aged 18 to 79 undergo a one-time screening for HCV infection.[8,9]

Within the U.S. military, HCV infection not only poses risks to health and readiness of those already infected, it

also poses a risk of transmission to previously uninfected service members when utilizing the walking blood bank where whole blood transfusions are given during emergency situations in combat.[10] A prior investigation into the prevalence of chronic HCV infection in a random serum sample of the deployed population between 2007 and 2010 reported a rate of 43 per 100,000 service members.[11] Knowledge of the current epidemiology of HCV infection within the active component U.S. military population is important in informing the Department of Defense (DoD) policies for the screening, diagnosis, and treatment of HCV.

Per current DoD guidelines, applicants for entry into military service are medically disqualified if they display a "history of chronic hepatitis C, unless successfully treated and with documentation of a cure 12 weeks after completion of a full course of therapy."[12] All applicants are required to submit a medical history prior to accession, and each branch has its own system of screening. In 2012, the Navy and Marine Corps updated their accession screening standards to require all new applicants to undergo HCV screening prior to entering military service.[13] The Army and Air Force currently do not require HCV testing at accession.

The objective of this study was to use laboratory surveillance data from the population of U.S. active component service members in 2020 to estimate the period prevalence of HCV diagnosis at any point in time during their military service, to assess associated risk factors for HCV diagnosis, and assess the cascade of HCV care.

METHODS

This cross-sectional study examined U.S. military service members in the active component between 1 January and 31 December 2020. The primary outcome was prevalent HCV diagnosis at any time during military service, with secondary outcomes of HCV treatment and viral suppression. Potential cases were initially identified by the Navy and Marine Corps Public Health Center (NMCPHC) through active laboratory-based case finding from the active component military population from 1 January 2011 to 31 December 2020 using the Composite Health Care System (CHCS) health level 7 (HL7) laboratory databases. This laboratory-based case-finding algorithm identified positive HCV laboratory results from HCV antibody, RNA, or genotyping tests ordered through Gastroenterology (GI) or Infectious Disease (ID) clinics at fixed military treatment facilities (MTFs). CHCS HL7 data do not include records from shipboard facilities, battalion aid stations, purchased care, or in-theater facilities. Although most of these cases were newly diagnosed, it is likely that many existed prior to accession into military service; given this, it is more accurate to call this a prevalence rather than an incidence study. Purchased care was defined as all care provided outside of (MTFs) by non-military providers but paid for by the military health system. Demographic data and dates of military service were obtained from the Armed Forces Health Surveillance Division's Defense Medical Surveillance System (DMSS). All potential cases identified by laboratory surveillance were verified by chart review using the Armed Forces Health Longitudinal Technology Application (AHLTA) military electronic medical record.

Potential cases met the confirmed case definition for HCV diagnosis if they had a positive HCV RNA laboratory result at any point during their military service, although as mentioned above, laboratory data were only available between 2011 and 2020. Individuals were excluded if they ended military service prior to 1 January 2020. Chart review was systematically performed on all potential cases by 1 of the authors (ML) in June 2021 after an initial validation of 10% of the cases by another of the authors (JM). Chart review consisted of extraction of laboratory data (including HCV RNA, antibody, and genotyping dates and results), medication information (type, dates, and number prescribed), and clinical data (provider assessment of testing indication and source of infection).

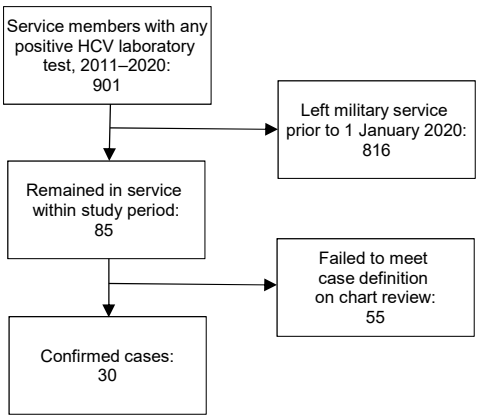
After completing the analysis using the original case-finding algorithm, there were residual concerns that this algorithm had only identified those who had received care in MTFs (direct care), which may have resulted in undercounting cases if they had been diagnosed or treated outside MTFs (purchased care). To assess the magnitude of this undercounting, an additional data query and analysis was performed, this time without restricting to those labs ordered by military GI or ID clinics. To accommodate computing and personnel limitations in data acquisition capabilities, this analysis was restricted to cases initially diagnosed during calendar year 2019 only. A second set of chart reviews of the electronic medical records was performed for all individuals identified in this data query, and these results were used to compare with and correct the results from the original case-finding algorithm.

The size of the population at risk was obtained from the 2019 Annual Demographics Profile published by Military One Source.[14] Prevalence was calculated as prevalent cases of HCV per 100,000 active component service members and prevalence ratios (PRs) were used to assess associations with demographic characteristics. The cascade of care for HCV included HCV diagnosis, receipt of HCV treatment with DAAs, and achievement of SVR after treatment.[5] Measures of frequency were used in the cascade of care analysis. Year of diagnosis was used to assess the impact of the Navy and Marine Corps screening policy implemented in late 2012. To accomplish this, the diagnosis of cases during the period of 2013 to 2020 was compared to the period 2003 to 2012. Stata version 15 (2017, Statacorp LP, College Station, TX) was used for all statistical analysis.

RESULTS

The initial laboratory surveillance data provided by NMCPHC identified 901 potential cases with positive HCV-related tests between 2011 and 2021. However, 816 of those identified had left military service prior to 2020 **(Figure 1)**. After detailed chart review on the remaining

FIGURE 1. Flow chart of participants selected for inclusion in the study.



HCV, hepatitis C virus.

85 subjects, only 30 met the case definition for HCV diagnosis, which included a positive test for HCV RNA. All 30 had 1 or more provider diagnoses of HCV in their medical records. Of the 55 excluded subjects who failed to meet the case definition after chart review, 21 had cured HCV infection as evidenced by a positive HCV antibody test but a negative HCV RNA test result, 1 had a positive HCV antibody but no history of RNA confirmatory testing, 13 had hepatitis B infection, 1 had hepatitis E, and 19 had other hepatic conditions.

The period prevalence of HCV diagnosis occurring during military service at MTFs was 2.3 per 100,000 service members **(Table)**, representing 5.3% of the expected infections (n=570) based on previously estimated prevalence.[11] Diagnosed cases were predominantly male service members and the majority of cases were in the Army. Diagnosed cases showed a bimodal distribution by age with the highest prevalence among those aged 41 or older (5.8 per 100,000) and those aged 26–30 (4.3 per 100,000). Cases were predominantly non-Hispanic White or non-Hispanic Black service members with very few cases among persons from other race/ethnicity groups.

The additional data query for 2019 that included all clinics (not restricted to GI or ID), which was performed to examine completeness of the original case-finding algorithm, revealed 51 unique individuals with positive HCV tests. Of these 51, 14 had already been identified by the original algorithm, 11 who were counted in 2019 and 3 in previous years. Of the remaining 37 individuals which had not been identified previously, 5 were HCV antibody positive but PCR negative, 3 had been diagnosed prior to 2019, and 2 were administrative errors. Of the remaining 27 potential cases, 13 left or were in the process of leaving military service prior to 1 January 2020, which was a criterion for exclusion from the study. The 14 remaining individuals were confirmed HCV cases but had been referred to purchased care, which is why they were not identified by the original algorithm. This suggests that only 44% (11/25) of HCV cases in the active component military are treated in the direct care system and that the original algorithm resulted in undercounting by 56%. After correcting for this undercounting, a revised estimate of 68 cases (12% of expected) was generated, a period prevalence of 5.2 per 100,000. Of note, all 14 of the additional cases missed by the original algorithm were diagnosed and cared for by civilian ID or GI providers, and all 14 also had evidence of treatment in the electronic medical record. It was more difficult to ascertain whether patients referred to purchased care had been cured, as PCR results were sometimes not available after treatment. Nevertheless, 11 of these patients had direct evidence of cure in the medical record, and the other 3 had statements by treating physicians which suggested (but did not confirm) that cure had been achieved.

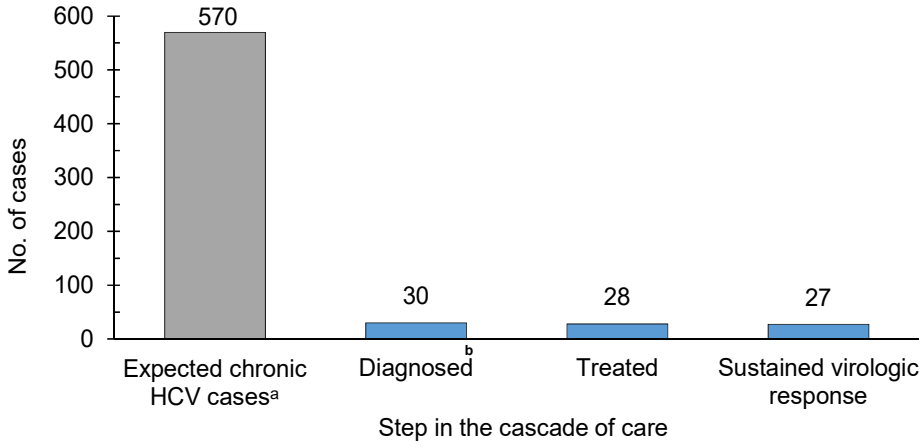
Of the 30 HCV cases diagnosed in direct care, 28 (93%) received appropriate medical therapy **(Figure 2)**. The 2 untreated cases were offered therapy but

TABLE. Prevalent cases and period prevalence rates of HCV during military service at military treatment facilities by selected characteristics, active component, U.S. Armed Forces, 2020

	No.	Total population	Period prevalence[a]	Prevalence ratio
Total	30	1,326,200	2.3	--
Sex				
Male	26	1,101,440	2.5	ref
Female	4	224,760	1.8	0.72
Age at diagnosis (years)				
<26	2	605,942	0.3	ref
26–30	12	280,585	4.3	13.03
31–35	7	195,485	3.6	10.91
36–40	3	140,589	1.4	4.24
41+	6	103,639	5.8	17.58
Race/ethnicity group				
Non-Hispanic White	20	744,770	2.7	ref
Non-Hispanic Black	7	215,601	3.2	1.19
Hispanic/Latino	1	221,554	0.5	0.17
Asian/Pacific Islander	1	73,823	1.4	0.52
American Indian/Alaska Native	0	11,265	0.0	0.00
Other/unknown	1	59,187	1.7	0.63
Service				
Army	20	479,785	4.2	ref
Navy	7	332,528	2.1	0.50
Air Force	1	327,878	0.3	0.07
Marine Corps	2	186,009	1.1	0.26

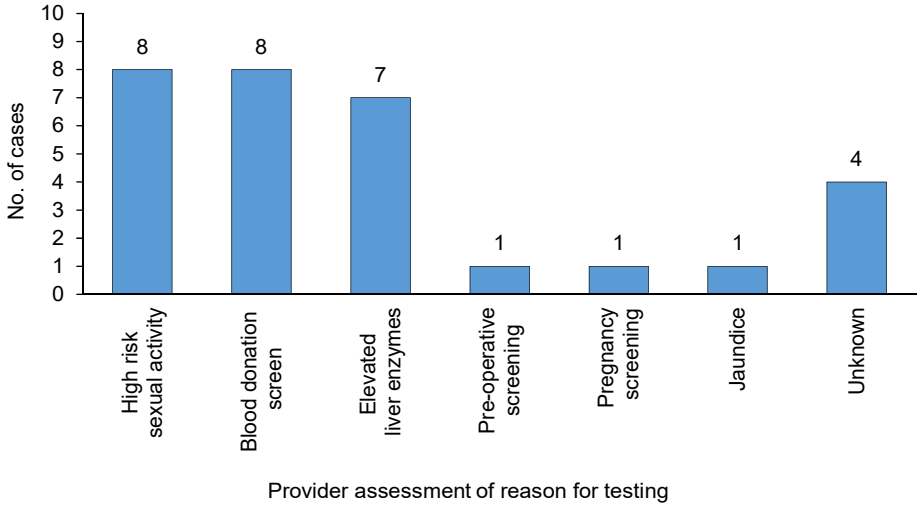
HCV, hepatitis C virus; No., number.
[a]Per 100,000 active component service members.

FIGURE 2. HCV cases and cascade of care during military service at military treatment facilities, active component, U.S. Armed Forces, 2020



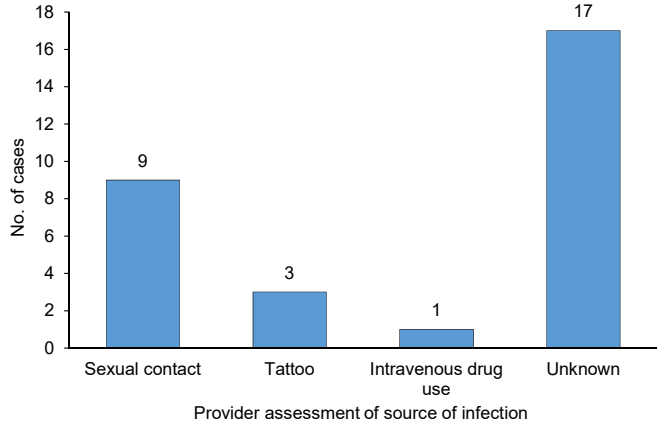
HCV, hepatitis C virus; No., number.
[a]Expected number of HCV infections based on a previously published military prevalence estimate.[11]
[b]After correcting for cases referred to purchased care, the estimate of diagnosed cases was 68.

FIGURE 3. Provider assessment of reasons for testing among HCV cases during military service at military treatment facilities, active component, U.S. Armed Forces, 2020



HCV, hepatitis C virus; No., number.

FIGURE 4. Provider assessments of potential sources of infection among HCV cases during military service at military treatment facilities, active component, U.S. Armed Forces, 2020



HCV, hepatitis C virus; No., number.

elected to defer treatment because of personal considerations. Of note, 1 case who spontaneously cleared without treatment was considered as treated in this analysis. Of the 28 treated, 27 (96%) had confirmed viral suppression on follow-up testing, with 1 case failing to follow up for confirmation of viral suppression after treatment.

Providers documented that nearly all of the HCV diagnoses were discovered by screening of asymptomatic patients **(Figure 3)**. The only symptomatic HCV case was a patient who presented with jaundice.

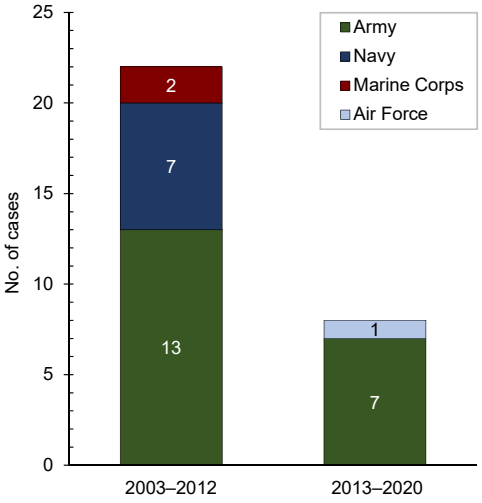
Provider assessment of potential sources of infection showed the majority of cases (n=17; 57%) did not identify a potential source of infection; 30% (n=9) were attributed to sexual contact with an infected individual; and only 3% (n=1) of cases were attributed to intravenous drug use **(Figure 4)**.

None of the cases identified since the 2013 implementation of the accession screening program in the Navy and Marine Corps occurred in either of these branches **(Figure 5)**. All cases of HCV identified after 2013 affected members of the Army and Air Force, which did not implement accession screening.

EDITORIAL COMMENT

Using a laboratory-based case finding algorithm, this study initially identified 30 cases of prevalent HCV diagnoses in the 2020 active component military population occurring at fixed MTFs during the course of their military service. After correcting for cases which were referred to purchased care, the estimate of cases was revised to 68, which was only 12% of the expected number of infections (570) based on a previously established prevalence estimate of 43 per 100,000.[11] This resulted in a corrected 2020 period prevalence of 5.2 diagnoses per 100,000. Of the 30 cases diagnosed at MTFs, 28 (93%) received medical therapy. Of the 28 who received medical therapy, 27 (96%) had attained SVR. The high estimates of HCV treatment and cure were apparently not affected by referral to purchased care. Identified cases were predominantly

FIGURE 5. Comparison of HCV cases identified before and after implementation of HCV accession screening in the Navy and Marine Corps, active component, U.S. Armed Forces



HCV, hepatitis C virus; No., number.

male, and the Army had the highest prevalence among the services. The disease showed a bimodal distribution in age with the highest prevalence in those over 41 and those aged 26–35. Only 3% of cases were symptomatic, and most cases did not have an identified source of transmission.

The estimated prevalence of chronic HCV infection is about 1% in the U.S. population,[1] but the prevalence in the military has been previously estimated to be much lower, at 0.04%.[11] This study reports an even lower HCV prevalence of 5.2 diagnoses per 100,000 service members, or 0.005%, identified at any time during their military service. The bimodal age distribution of HCV cases was similar to patterns seen in the general U.S. population.[15] Roughly 50% of those with chronic HCV infection in the general population are aware of their diagnosis,[16] compared to the much lower estimate of 12% in the active military in this study. In contrast, whereas only 49% of those with commercial insurance who are aware of their diagnosis received treatment,[3] 93% of service members diagnosed in MTFs received treatment. Additionally, attributed sources of infection appear to be vastly different in the military compared to the civilian population. However, this difference is likely due to a substantial reporting bias within the military population; illicit drug use is a punishable offense under military law, as is failure to disclose such use at time of accession into military service.

Strengths of this study include a large enumerated population and a detailed chart review of all subjects of interest in order to verify case results. However, several limitations should be considered when interpreting these findings. Most importantly, these estimates likely underestimate the true prevalence of HCV infection in the military due to the lack of asymptomatic screening in the Army and Air Force, as well as those Navy and Marine Corps service members who entered service prior to the implementation of accession screening for HCV infection in 2012.

Restricting laboratory surveillance of HCV to only those specimens which were ordered through ID and GI clinics since 2011 also resulted in underestimates. While the evaluation and treatment of HCV infection is generally restricted to these clinics, it is possible that some patients were diagnosed and treated in primary care clinics at MTFs or that some were diagnosed prior to 2011. The initial algorithm used to obtain these data was generated empirically by NMCPHC because 1) it was believed that most active component cases were treated in MTFs, and 2) the data available for assessing direct care was thought to be much more complete and of higher quality than that available for purchased care. However, due to concerns regarding the completeness of case capture from the original case-finding algorithm, an additional analysis of cases referred to purchased care was performed. This analysis suggested that only 44% of HCV cases were, in fact, diagnosed and treated in the direct care system. Although the data in the electronic medical records from purchased care were less complete and more difficult to access, sufficient documentation was available to assess the outcomes in this study. Nevertheless, the potential for misclassification of outcomes is greater in cases treated by purchased care compared to those treated by direct care due to the more limited data available.

Additionally, the NMCPHC algorithm does not include laboratory data from facilities which implemented the new electronic health record for the Military Health System, MHS GENESIS. The effect of this error is expected to be small because GENESIS was not implemented until late 2017 and had been less than 10% implemented by the end of 2020.[17] In contrast, this study's use of period prevalence during the service members' military service may not be comparable to the point prevalence estimate from Brett-Major et al.

Although most laboratories currently perform reflex PCR testing for all positive HCV antibody tests, it is possible some service members had a positive HCV antibody test at a time when no PCR testing capability existed and thus never had a confirmatory PCR test. It should also be considered that the estimate of the total number of military HCV infections is based on a serosurvey among those with combat deployments from 2007 through 2010; therefore, this estimate may not be fully comparable to that obtained from the active component military population in 2020.

Another limitation was the potential for misclassification bias regarding potential exposures that result in HCV infection. High risk behaviors that can lead to HCV infection, such as intravenous drug use, are not permitted the Armed Forces and those who may have a history of such use may be reluctant to disclose this or other high-risk behaviors for fear of reprisal. While these concerns are present in the civilian population, they are likely heightened among military members because of additional legal consequences of reporting high risk behaviors. Finally, these results are not generalizable to populations outside of the U.S. military.

Given the recent changes in CDC and USPSTF recommendations for screening of nearly all adults aged 18–79 and the increasing incidence of HCV infection in younger individuals in the U.S. population, it is reasonable for the Army and Air Force to revisit their policies regarding accession screening. Comparison of identified HCV diagnoses before and after the Navy and Marine Corps implemented universal accession screening revealed that no cases were identified in those branches since this policy was initiated. This finding supports the argument that most HCV infections actually exist at time of entry into military service and that very few cases are identified after accession or occur during military service.

Another case for HCV screening is that it would mitigate the potential risk that HCV transmission poses to military operational requirements like the walking blood bank.[18] Results of this study suggest that 88% of HCV infections are unrecognized and such persons pose the risk of HCV transmission if their blood is used for transfusions. HCV also poses risks to soldiers and health care workers rendering care in a combat environment where universal precautions cannot always be ensured. There is one case report of HCV transmission resulting from emergency tranfusion during deployment, a rate of 2.1 per 1,000 persons.[18]

The counterargument against HCV screening within the U.S. military is that this population is at low risk for infection and for progression to symptomatic disease, both of which were demonstrated in this study. It is also noteworthy that the CDC recommendation for universal screening for HCV infection includes a caveat that it is not explicitly recommended in settings where the prevalence is less than 0.1%, although screening "may occur at the provider's discretion."[9] The low expected prevalence of HCV infection at time of entry into service suggests that the initiation of screening would not result in a large impact on recruiting and, in fact, any recruits found to have HCV infection could be cured in a few months resulting in eligibility to enter the military service.

Future studies should review all HCV testing conducted within the Armed Forces (not just those ordered from ID or GI clinics) which would help to validate these results. Additionally, incidence studies would be helpful in determining rates of new infections, instead of prevalent diagnoses, as well as provide a more complete view of risk factors associated with infection.

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Disclaimer: The views expressed in this article are those of the authors and do not necessarily reflect the official policy of the Department of Defense or the U.S. Government.

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A New Approach to Categorization of Ocular Injury Among U.S. Armed Forces

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This report describes a new approach to categorizing ocular injury using Military Health System data, the application of an algorithm to a dataset, and the verification of the results using an audit of clinical data. Based on health care encounter data, an algorithm was developed to systematically document the occurrence of specific complications and medical procedures in the 12 months following initial ocular injuries. The injuries were classified into 1 of 2 groups: "uncomplicated injury" with no complications or medical procedures and "complicated injury" with complications and/or medical procedures. Injuries in the latter group were further classified by severity into low, moderate, and high strata based on a ranking of complications and medical procedures. From 2016 through 2019, 12,664 complicated ocular injuries and 49,016 uncomplicated injuries were identified among active duty U.S. military members. The vast majority (84%) of complications were concurrent or occurred within 30 days following the injury. The 3 most common complications (orbital floor fracture, iridocyclitis and recurrent corneal erosion) accounted for 52% of complications. These findings underscore the importance of accurate classification of complex ocular injuries to inform studies in multiple areas including injury prevention, the development of clinical guidelines, and health services research.

WHAT ARE THE NEW FINDINGS?

The Vision Center of Excellence (VCE) developed a classification algorithm that uses longitudinal data (including diagnoses of complications and medical procedures related to the initial ocular injury) to more accurately classify ocular injuries sustained by U.S. service members. The results of the algorithm's classification were verified through medical record review.

WHAT IS THE IMPACT ON READINESS AND FORCE HEALTH PROTECTION?

Ocular injuries present an ongoing threat to readiness and retention of service members. Robust surveillance methods are needed to account for non-specific and often inconsistent diagnosis coding in electronic health records. The increased accuracy of classification of ocular injuries provides critical data to inform prevention and treatment initiatives

Ocular injuries have the potential to negatively impact the readiness and retention of U.S. service members and incur a significant cost to the Military Health System (MHS).[1] The availability of large administrative/billing data sources provides the opportunity to surveil the burden and trend of ocular injuries. It is a challenge, however, to categorize ocular injuries based on electronic health record (EHR) data because coded diagnoses may be non-specific and inconsistent in resource-constrained settings, such as an emergency room or a primary care clinic. Ocular injuries frequently involve more than 1 anatomic structure, and have been described in multiple publications as complex injuries.[2–4] Surveillance of ocular injuries in the U.S. Armed Forces is conducted by the Tri-service Vision Conservation and Readiness Program of the Army Public Health Center and the Armed Forces Health Surveillance Division which identifies cases based on initial diagnoses in administrative health records.[5]

The Vision Center of Excellence (VCE) was established by congressional mandate in 2008 as a center of excellence in the prevention, diagnosis, mitigation, treatment, and rehabilitation of military eye injuries.[6] The VCE developed the military ocular injury case definition in support of multiple initiatives, including improved utilization of the Defense and Veterans Eye Injury and Vision Registry (DVEIVR). This registry contains information to track diagnoses, interventions/treatments, and follow-up for each case of significant eye injury sustained by a member of the U.S. Armed Forces while serving on active duty. The DVEIVR permits accurate ocular injury burden reporting and estimation of health care burden across the MHS. To improve the accuracy of classification of ocular injuries in the MHS, the VCE developed a novel approach to characterizing ocular injury that uses information on multiple diagnoses and procedures from MHS administrative data. This approach allows classification of ocular injuries by their severity and can be used for multiple types of initiatives including monitoring trends and targeting significant ocular injuries in the U.S. military members. The objective of this study was to provide accurate

information on the type and severity of ocular injuries to inform strategic planning for medical readiness, resource allocation, and prevention programs.

METHODS

Ocular injury data were obtained by applying the VCE case definition for ocular injury to the Military Health System Management and Analysis Reporting Tool (M2), a longitudinal administrative data warehouse that contains electronic medical records of hospitalization and ambulatory medical encounters in both military medical treatment facilities (direct care) and civilian facilities (purchased care). Additional data on ocular injuries documented in deployed settings were obtained from the Theater Medical Data Store (TMDS). Health care records of both active component and activated guard/reserve service members were captured based on beneficiary category in the M2 and included in these analyses. Guard and reserve service members receive the same care entitlements as those in the active component if they were on active duty for more than 30 days, or may qualify for

FIGURE. Vision Center of Excellence algorithm for classifying ocular injuries

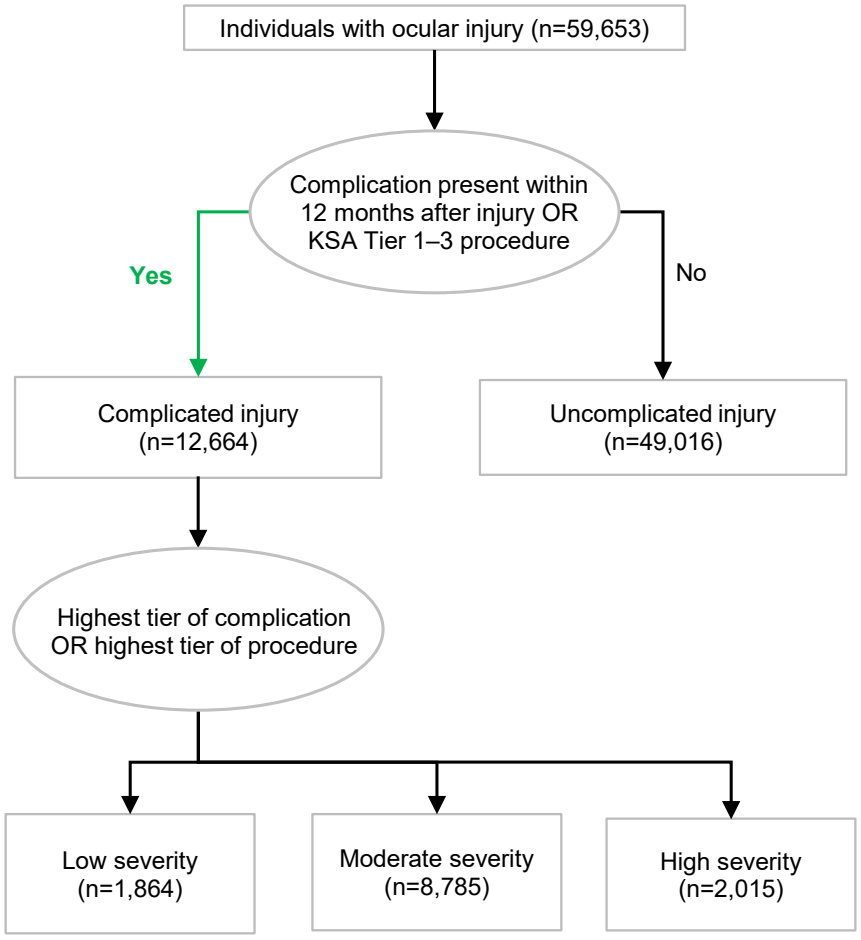

TABLE 1. ICD-10 diagnosis codes for ocular injuries

Code group	ICD-10 codes[a]
Hemorrhage of orbit	H05.23*
Hyphema	H21.0*
Contusion of eyelid and periocular area	S00.10X*;S00.11X*;S00.12X*
Other and unspecified superficial injuries of eyelid and periocular area	S00.201*;S00.202*;S00.209*;S00.211*;S00.212*;S00.219*;S00.251*;S00.252*;S00.259*;S00.261*;S00.262*;S00.269*;S00.271*;S00.272*;S00.279*
Laceration without foreign body of eyelid and periocular area	S01.101*;S01.102*;S01.109*;S01.111*;S01.112*;S01.119*;S01.121*;S01.122*;S01.129*;S01.131*;S01.132*;S01.139*;S01.141*;S01.142*;S01.149*;S01.151*;S01.152*;S01.159*
Fracture of orbital roof	S02.121*;S02.122*;S02.129A*;S02.129*
Fracture of orbital floor	S02.30X*;S02.31X*;S02.32X*
Fracture of medial orbital wall	S02.831*;S02.832*;S02.839*
Fracture of lateral orbital wall	S02.841*;S02.842A*;S02.849*
Fracture of orbit, unspecified	S02.85XA;S02.85XB;S02.85XD*;S02.85XG*;S02.85XK*;S02.85XS*
Injury of eye and orbit	S05.00X*;S05.01X*;S05.02X*;S05.10X*;S05.11X*;S05.12X*;S05.20X*;S05.21X*;S05.22X*;S05.30X*;S05.31X*;S05.32X*;S05.40X*;S05.41X*;S05.42X*;S05.50X*;S05.51X*;S05.52X*;S05.60X*;S05.61X*;S05.62X*;S05.70X*;S05.71X*;S05.72*;S05.8X1*;S05.8X2*;S05.8X9*;S05.90X*;S05.91X*;S05.92X*
Foreign body on external eye	T15.00X*;T15.01X*;T15.02X*;T15.10X*;T15.11X*;T15.12X*;T15.80X*;T15.81X*;T15.82X*;T15.90X*;T15.91X*;T15.92X*

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

Line of Duty Care if injured while on active duty for fewer than 30 days.

The classification algorithm **(Figure)** developed by the VCE used multiple criteria including 320 International Classification of Diseases, 10th Revision (ICD-10) diagnosis codes for ocular injuries **(Table 1)**, 332 ICD-10 diagnosis codes for potential complications **(Table 2)**, and 1,543 Procedural Classification System (PCS) and ICD Current Procedural Terminology (CPT) codes for outpatient procedures associated with ocular injuries **(Table 3)** to assess and classify the severity of the injuries.

Of note, the complications include conditions with potential impacts on readiness and retention, such as corneal ulcers, retinal breaks, and orbital fractures. The included list of procedures was based on the results of the ophthalmology knowledge, skills, and abilities (KSA) workgroup. This ad hoc workgroup, consisting of military ophthalmologists with deployment experience, reviewed outpatient ophthalmic procedures and developed a tiered system to determine readiness to deploy based on the number of procedures performed in the military treatment facilities. The VCE mapped CPT codes to ICD-10 PCS codes to ensure capture of procedures conducted in inpatient settings. As a result, individuals with a KSA tier of 1, 2, or 3 were classified by the algorithm as complicated injury if not already identified as such based on complications **(Figure).**

All encounter data in the M2 and the TMDS that included diagnoses of ocular injuries or complications for active duty members were collected from 2016 through 2020. Data were line-based, and each line represented 1 visit (direct care) or 1 claim (purchased care). Data from different care locations were consolidated into 1 comprehensive dataset to accommodate all variables and visit dates were used to assess temporality of encounters. The algorithm was then applied to identify the presence of the pre-specified injuries, complications, and medical procedures for each individual during the 12 months following the initial injury date. Those injured individuals without complications and no medical procedures corresponding to KSA tier 1 through 3 were classified as having suffered an uncomplicated injury; otherwise, individuals were classified as having a complicated injury. For those individuals with uncomplicated injury, if 60 days passed after the date of the injury without a subsequent health care encounter for an uncomplicated ocular injury, then an encounter for an uncomplicated injury after the 60-day period would be counted as a newly incident uncomplicated injury. For complicated injuries, the severity level was further categorized as low, moderate, or high based on the highest rank of presented complications **(Table 2)** or prescribed medical procedures **(Table 3)**. Of note, complicated injuries were not subject to an incidence rule like that for uncomplicated injuries; an individual was assumed to sustain only 1 complicated injury during the study period. Complicated injuries with complications only, medical procedures only, or both were counted. For complications, the number of different complication types for each individual was determined; for individuals with more than 1 type of complication, all complications were included **(Figure)**. Based on the incidence rule, individuals may suffer from multiple uncomplicated injuries but only one complicated injury was counted

TABLE 2. ICD-10 diagnosis codes for ocular injury complications

Strata	Complication type	ICD-10 codes[a]
High	Corneal ulcer	H16.*;H16.1*;H16.2*;H16.3*;H16.7*;H16.31*
	Traumatic cataract	H26.10*;H26.109;H26.11*;H26.12*;H26.13*
	Other lens trauma	T85.22X*;T85.29X*;H27.10;H27.11*;H27.12*;H27.13*
	Choroidal rupture	H31.32*
	Retinal detachment	H33.*;H33.1*;H33.2*;H33.3*;H33.4*;H33.5*
	Retinal break	H33.30*;H33.31*;H33.32*;H33.33*
	Macular hole	H35.34*
	Traumatic glaucoma	H40.30X*;H40.31X*;H40.32X*;H40.33X*
	Vitreous hemorrhage	H43.1*
	Optic nerve injury	S04.011*;S04.012*;S04.019*
	Choroidal hemorrhage	H31.30*;H31.31*
	Endophthalmitis	H44.*
	Orbital hemorrhage	H05.23*
	Avulsion of eye	S05.70X*;S05.71X;S05.72X
Moderate	Corneal opacity	H17.0*,H17.1*
	Recurrent corneal erosion	H18.83*
	Hypopyon	H20.5*
	Hyphema	H21.*
	Angle recession	H21.55*
	Orbital roof facture	S02.121*;S02.122*;S02.129*
	Orbital floor fracture	S02.30X*;S02.31X*;S02.32X*
	Orbital medial fracture	S02.831*;S02.832*;S02.839*
	Orbital lateral fracture	S02.841*;S02.842*;S02.849*
	Orbital fracture unspecified	S02.85X*
Low	Keratitis	H16.10*;H16.8;H16.9
	Iridocyclitis	H20.0*;H20.1*;H20.2*;H20.4*;H20.9
	Iridodialysis	H21.53*;
	Iris sphincter tear	H21.56*
	Retinal hemorrhage	H35.6*
	Retinal edema	H35.81

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

TABLE 3. CPT and PCS codes used to classify ocular injury severity

Strata	KSA tier	CPT/ICD-10 PCS grouping	Code type	Code set
High	1	Globe trauma	CPT	65275;6528*;65930;66680
			ICD-10 PCS	08Q(0XZZ,1XZZ,23ZZ,33ZZ,6XZZ,7XZZ,8XZZ,9XZZ,C3ZZ,D3ZZ)
High	2	Retinal vitreous - surgical	CPT	67027;6526*;65810,6622*;66850;67036;67039;6704*;6710*;67110;67113;67115;6712*;6725*;67218
			ICD-10 PCS	08943*;08953*;089A0*;089A3*;089B0*;089B3*;089E3*;089F3*;089G3*;089H3*;08B43*;08B53*;08BA0*;08BA3*;08BB0*;08BB3*;08BE3*;08BF3*;08C43ZZ; 08C4XZZ;08C53ZZ;08C5XZZ;08CA0ZZ;08CA3ZZ;08CAXZZ;08CB0ZZ;08CB3ZZ;08CBXZZ;08CE3ZZ;08CEXZZ;08CF3ZZ;08CFZZ;08CG3ZZ;08CGXZZ;08CH3ZZ;08CHXZZ;08F43ZZ;08F4XZZ;08F53ZZ;08F5XZZ;08N23ZZ;08N33ZZ;08N43ZZ;08N53ZZ;08N6XZZ;08N7XZZ;08NA0ZZ;08NA3ZZ;08NB0ZZ;08NB3ZZ;08NE3ZZ;08NF3ZZ;08NG3ZZ;08NH3ZZ;08P001Z;08P031Z;08P071Z;08P081Z;08P0X1Z;08P101Z;08P131Z;8P171Z;08P181Z;08Q43ZZ;08Q53ZZ;08QA0ZZ;08QA3ZZ;08QB0ZZ;08QB3ZZ;08QE3ZZ;08QF3ZZ;08QG3ZZ;08QH3ZZ;08R43*;08R53*;08R6X*;08R7X*;08RA0*;08RA3*;08RB0*;08RB3*;08RG3*;08RH3*;08SG3ZZ;08SH3ZZ;08T43ZZ;08T53ZZ;08UE0*;08UE3*;08UF0*;08UF3*;08UG0*08UG3*;08UH0*;08UH3*
High	2	Oculoplastic & orbit - orbit	CPT	15576;15731;15760;15770;21275;21386;21387;2139*;6509*;6510*;6511*;65125;6513*;65140;6515*;65175;6740*;67412;67413;67414;67420;67430;6744*;67450;67550;67560;67570;67599;67346;31239;68500;68505;68520;68540;68550;68720;68745;68750
			ICD-10 PCS	081X0*;081X3*;081Y0*;081Y3*;0850XZZ;0851XZZ;085V0ZZ;085V3ZZ;085W0ZZ;085W3ZZ;089V0*;089V3*;089W0*;089W3*;08B00*;08B03*;08B0X*;08B10*;08B13*;08B1X*;08BV0*;08BV3*;08BW0*;08BW3*;08BX0*;08BX3*;08BX7*;8BX8*;08BY0*;08BY3ZZ;08BY7*;08BY8*;08BY8ZZ;08QV0ZZ;08QV3ZZ;08QW0ZZ;08QW3ZZ;08QX0ZZ;08QX3ZZ;08R00*;08R03*;08R10*;08R13*;08RX0*;08RX3*;08RX7*;08RX8*;08RY0*;08RY3*;08RY7*;08RY8*;08SV0ZZ;08SV3ZZ;08SW0ZZ;08SW3ZZ;08T0XZZ;08T1XZZ;08TV0ZZ;08TV3ZZ;08TW0ZZ;08TW3ZZ;08TX0ZZ;08TX3ZZ;08TX7ZZ;08TX8ZZ;08TY0ZZ;08TY3ZZ;08TY7ZZ;08TY8ZZ;08U00*;08U03*;08U10*;08U13*;08UX0*;08UX3*;08UX7*;08UX8*;08UY0*;08UY3*;08UY7*;8UY8*;0N5P0ZZ;0N5P3ZZ;0N5P4ZZ;0N5Q0ZZ;0N5Q3ZZ;0N5Q4ZZ;0N8P0ZZ;0N8P3ZZ;0N8P4ZZ;0N8Q0ZZ;0N8Q3ZZ;0N8Q4ZZ;0N9P0*;0N9P3*;0N9P4*;0N9Q0*;0N9Q3*;0N9Q4*;0NBP0*;0NBP3*;0NBP4*;0NBQ0*;0NBQ3*;0NBQ4*;0NCP0ZZ;0NCP3ZZ;0NCP4ZZ;0NCQ0ZZ;0NCQ3ZZ;0NCQ4ZZ;0NDP0ZZ;0NDQ0ZZ;0NHP04Z;0NHP34Z; 0NHP44Z;0NHQ04Z;0NHQ34Z;0NHQ44Z;0NNP0ZZ;0NNP3ZZ;0NNP4ZZ;0NNQ0ZZ;0NNQ3ZZ;0NNQ4ZZ;0NQP0ZZ;0NQP3ZZ;0NQP4ZZ;0NQPXZZ;0NQQ0ZZ;0NQQ3ZZ;0NQQ4ZZ;0NQQXZZ;0NRP0*;0NRP3*;0NRP4*;0NRQ0*;0NRQ3*;0NRQ4*;0NSP0*;0NSP3*;0NSP4*;0NSP4ZZ;0NSPXZZ;0NSQ0*;0NSQ3*;0NSQ4*;0NSQ4ZZ;0NSQXZZ;0NTP0ZZ;0NTQ0ZZ;0NUP0*;0NUP3*;0NUP4*;0NUQ0*;0NUQ3*;0NUQ4*
High	2	Corneal surgery	CPT	65710;65730;65750;65755;65756;65770;65775;65780;66130;66250
			ICD-10 PCS	0858XZZ;0859XZZ;08D8X*;08D9X*;08N8XZZ;08N9XZZ;08R83*;08R8X*;08R93*;08R9X*;08T8XZZ;08T9XZZ;08U80*;08U83*;08U8X*;08U90*;08U93*;08U9X*
High	2	Glaucoma - complex	CPT	65815;66150;66160;66170;66172;66179;66180;66183;66184;66185;66500;66505;66600;66605;66625;66630;66635
			ICD-10 PCS	08123*;08133*;0820X*;0821X*;0890X0Z;0891X0Z;089230Z;089330Z;08P00*[a];08P03*[a];08P07*[a];08P08*[a];08P0X*;08P10*[a];08P13*[a];08P17*[a];08P18*[a];08P1X*[a];08PJ3*;08PK3*;08W00*;08W03*[a];08W07*a;08W08*[a];08W0X*[a];08W10*a;08W13*[a];08W17*[a];08W18*[a];08W1X*[a]
High	2	Complex cataract & anterior segment	CPT	65920;66682;66825;66852;669*;66982;66983;66985;66986;67005;67010;65235;65880
			ICD-10 PCS	08523ZZ;08533ZZ;0856XZZ;0857XZZ;085C3ZZ;085D3ZZ;085J3ZZ;085K3ZZ;0890X*;0891X*;08923ZZ;08933*;0896X*;0897X*;0898X*;0899X*;089C3*;089D3*;089J3*;089K3*;089K3*;08B6X*;08B7X*;08B8X*;08B9X*;08BC3*;08BD3*;08BJ*;08BK3*;08C0XZZ;08C1XZZ;08C23ZZ;08C2XZZ;08C33ZZ;08C3XZZ;08C6XZZ;08C7XZZ;08C8XZZ;08C9XZZ;08CC3ZZ;08CCXZZ;08CD3ZZ;08CDXZZ;08CJ3ZZ;08CJXZZ;08CK3ZZ;08CKXZZ;08DJ3ZZ;08DK3ZZ;08H00*;08H03*;08H07YZ;08H08YZ;08HX*;08H10*;08H13*;08H17YZ;08H18YZ;08H1X*;08NC3ZZ;08ND3ZZ;08NJ3ZZ;08NK3ZZ;08QJ3ZZ;08QK3ZZ;08RC3*;08RD3*;08RJ3*;08RK3*;08SC3ZZ;08SD3ZZ;08SJ3ZZ;08SK3ZZ;08TC3ZZ;08TD3ZZ;08TJ3ZZ;08TK3ZZ;08UC0*;08UC3*;08UD0*08UD3*;08W003Z;08WJ3*;08WJXJZ;08WK3*;08WKXJZ

TABLE 3 (cont). CPT and PCS codes used to classify ocular injury severity

Strata	KSA tier	CPT/ICD-10 PCS grouping	Code type	Code set
Moderate	3	Strabismus	CPT	67311;67312;67314;67318;67320;67332;67399;65290
			ICD-10 PCS	085L0ZZ;085L3ZZ;085M0ZZ;085M3ZZ;089L0*;089L3*;089M0*;089M3*;08BL0*;08BL3*;08BM0*;08BM3*;08CL0ZZ;08CL3ZZ;08CLXZZ;08CM0ZZ;08CM3ZZ;08CMXZZ;08NL0ZZ;08NL3ZZ;08NM0ZZ;08NM3ZZ;08PL0*;08PL3*;08PM0*;08PM*08QL0ZZ;08QL3ZZ;08QM0ZZ;08QM3ZZ;08SL0ZZ;08SL3ZZ;08SM0ZZ;08SM3ZZ;08TL0ZZ;08TL3ZZ;08TM0ZZ;08TM3ZZ;08UL0*;08UL3*;08UM0*;08UM3*;08WL0*;08WL3*;08WM0*;08WM3*;08XL0ZZ;08XL3ZZ;08XM0ZZ;08XM3ZZ
Moderate	3	Oculoplastic & orbit - eyelid	CPT	67966;12011;12013;12014;12015;12017;12020;12051;12052;12053;12054;13151;13152;13160;14060;15115;15120;15260;15820;15821;15822;15823;21282;67700;67715;67835;67882;67900;67901;67902;67903;67904;67908;67909;67912;67916;67917;67971;67923;67924;6793*;67950;67961;67999;37609;1164*;68810;67875;68400;68510;68525;68530;68700;68770;68815;68816;68899
			ICD-10 PCS	080N0*;080N3*;080NX*;080P0*;080P3*;080PX*;080Q0*;080Q3*;080QX*;080R0*;080R3*;080RX*;085N0ZZ;085N3ZZ;085NXZZ;085P0ZZ;085P3ZZ;085PXZZ;085Q0ZZ;085Q3ZZ;085QXZZ;085R0ZZ;085R3ZZ;085RXZZ;085X0ZZ;085X3ZZ;085X7ZZ;085X8ZZ;085Y0ZZ;085Y3ZZ;085Y7ZZ;085Y8ZZ;087X0*;087X3*;087X7*;087X8*;087Y0*;087Y3*;087Y7*;087Y8*;089N0*;089N3*;089NX*;089P0*;089P3*;089PX*;089Q0*;089Q3*;089QX*;089R0*;089R3*;089RX*;089X0*;089X3*;089X7*;089X8*;089Y0*;089Y3*;089Y7*;089Y8*;08BN0*;08BN3*;08BNX*;08BP0*;08BP3*;08BPX*;08BQ0*;08BQ3*;08BQX*;08BR0*;08BR3*;08BRX*;08CN0ZZ;08CN3ZZ;08CNXZZ;08CP0ZZ;08CP3ZZ;08CPXZZ;08CQ0ZZ;08CQ3ZZ;08CQXZZ;08CR0ZZ;08CR3ZZ;08CRXZZ;08CV0ZZ;08CV3ZZ;08CVXZZ;08CW0ZZ;08CW3ZZ;08CWXZZ;08CX0ZZ;08CX3ZZ;08CX7ZZ;08CX8ZZ;08CY0ZZ;08CY3ZZ;08CY7ZZ;08CY8ZZ;08LX0*;08LX3*;08LX7*;08LX8*;08LY0*;08LY3*;08LY7*;08LY8*;08MNXZZ;08MPXZZ;08MQXZZ;08MRXZZ;08N0XZZ;08N1XZZ;08NN0ZZ;08NN3Z;08NNXZZ;08NP0ZZ;08NP3ZZ;08NPXZZ;08NQ0ZZ;08NQ3ZZ;08NQXZZ;08NR0ZZ;08NR3ZZ;08NRXZZ;08NV0ZZ;08NV3ZZ;08NW0ZZ;08NW3ZZ;08NX0ZZ;08NX3ZZ;08NX7ZZ;08NX8ZZ;08NY0ZZ;08NY3ZZ;08NY7ZZ;08NY8ZZ;08QN0ZZ;08QN3ZZ;08QNXZZ;08QP0ZZ;08QP3ZZ;08QPXZZ;08QQ0ZZ;08QQ3ZZ;08QQXZZ;08QR0ZZ;08QR3ZZ;08QRXZZ;0QX7ZZ;08QX8ZZ;08QY0ZZ;08QY3ZZ;08QY7ZZ;08QY8ZZ;08RN0*;08RN3*;08RNX*;08RP0*;08RP3*;08RPX*;08RQ0*;08RQ3*;08RQX*;08RR0*;08RR3*;08RRX*;08RSX*;08TX*;08SN0ZZ;08SN3ZZ;08SNXZZ;08SP0ZZ;08SP3ZZ;08SPXZZ;08SQ0ZZ;08SQ3ZZ;08SQXZZ;08SR0ZZ;08SR3ZZ;08SRXZZ;08SX0ZZ;08SX3ZZ;08SX7ZZ;08SX8ZZ;08SY0ZZ;08SY3ZZ08SY7ZZ;08SY8ZZ;08TN0ZZ;08TNXZZ;08TP0ZZ;08TPXZZ;08TQ0ZZ;08TQXZZ;08TR0ZZ;08TRXZZ;08UN0*;08UN3*;08UNX*;08UP0*;08UP3*;08UPX*;08UQ0*;08UQ3*;08UX*;08UR0*;08UR3*;08URX*;08UX07Z
Moderate	3	Cataract	CPT	66984;66820;66840
Moderate	3	Glaucoma	CPT	65865;6587*;66700;66720;66740;66770;66990;0191T;0449T;0474T
Moderate	3	Conjunctival/ superficial cornea	CPT	65270;65272;65273;65400;65410;6542*;65435;65436;65450;65778;65779;68020;68040;68100;6811*;6813*;68320;68325;68326;6833*;68340;6836*;68399
			ICD-10 PCS	085SXZZ;085TXZZ;089SX*;089TX*;08BSX*;08BTX*;08CSXZZ;08CTXZZ;08NSXZZ;08NTXZZ;08QSXZZ;08QTXZZ

[a]Denotes all nested codes with exception of 1Z for all marked codes.
KSA, knowledge, skills and abilities; CPT, Current Procedural Terminology; PCS, Procedural Classification System; ICD-10, International Classification of Diseases, 10th Revision.

per individual during the study period. Data analysis and case classification were conducted using R, version 4.0.3 (2020, R Core Team).

The results of the classification by the algorithm were verified by the VCE team of medical auditors using clinical data. Study auditors had clinical backgrounds in eye care and were trained on ocular care medical record abstraction and classification of ocular injuries using DVEIVR business rules for data abstraction. Cohen's kappa was used to measure agreement between the outcomes of the VCE algorithmic classification and record review. A total of 1,000 individuals (500 complicated and 500 uncomplicated) with relevant encounter data from 2018 were randomly selected for medical record validation. These data were used to develop and troubleshoot the algorithm. For example, ICD-10 codes S05.70X*, S05.71X, and S05.72X were added to the complication list after this condition (avulsion of eye) was found documented in the medical record

TABLE 4. Counts of the 10 most commonly documented complications of ocular injuries (n=12,365)

Complication	No.	% total
Orbital floor fracture	2,441	19.7
Iridocyclitis	2,381	19.3
Recurrent corneal erosion	1,579	12.8
Corneal ulcer	1,070	8.7
Keratitis	870	7.0
Hyphema	652	5.3
Corneal opacity	576	4.7
Retinal break	359	2.9
Orbital fracture unspecified	352	2.8
Orbital medial fracture	221	1.8
Other	1,864	15.1

No., number.

following initial injury documentation. The VCE is currently evaluating outcome data of available cases for complicated injury using information in the DVEIVR to further explore the utility of injury severity stratification.

RESULTS

From 2016 through 2019, 12,664 complicated and 49,016 uncomplicated injuries were identified among 59,653 active duty service members using the classification algorithm **(Figure)**. Of the individuals with complicated injuries, 6,119 had complications only, 5,554 had medical procedures only, and 991 had documentation of both complications and medical procedures. Individuals with complicated injuries were further classified as having injuries of low severity (n=1,864), moderate severity (n=8,785), and high severity (n=2,015). A total of 2,834 individuals with uncomplicated injuries had multiple occurrences of such injuries **(data not shown)**.

Approximately half (52%) of complications were concurrent (diagnosed on the same day as the ocular injury) or immediately following the initial injuries. Eighty five percent and 91% of complications occurred within 30 and 90 days of the documentation of the initial injury, respectively. Of the individuals (n=7,089) with complicated injuries, 1,184 had more than one complication.

Among the types of complications (n=12,365), the top 3 complications included orbital floor fracture (20%), iridocyclitis (19%), and recurrent corneal erosion (13%). The top 10 complications accounted for 85% of total complications **(Table 4).**

Of the 1,000 individuals selected for verification of the algorithm, 844 records were available for chart review using the Armed Forces Health Longitudinal Technology Application (AHLTA) or the Joint Legacy Viewer. Of the 445 cases classified as complicated by the algorithm, 443 (99.6%) were found to be correctly categorized based on medical record review **(data not shown).** Of the 399 cases classified as uncomplicated by the algorithm, 392 (98.2%) were found to be correctly categorized based on record review **(data not shown)**. Agreement of classifications between the algorithm and chart review was high (kappa=0.96).

EDITORIAL COMMENT

Through the application of the described algorithm which assesses multiple diagnoses and/or prescribed surgical procedures, ocular injuries were categorized and stratified into groups that more accurately reflect the complexity and severity of these injuries to improve classification of ocular injury. The resulting categorizations were verified using an audit of clinical data with a high degree of agreement. The clinical reality of the complex nature of ocular injuries is especially difficult to capture by conventional surveillance which relies on a single diagnostic code in administrative records. Categorizing using a single code may produce inaccurate data that are difficult to interpret from a public health, clinical, or operational perspective. The implications for accurate case definitions by systematical evaluation of associated complications and procedures for surveillance and research are significant.

Furthermore, the results of this analysis show that 85% of complicated injuries had the first documented complication within the first 30 days of the initial injury. This approach can be adapted to surveillance systems which require update at an interval less than 12 months; for example, a quarterly update can capture and categorize the vast majority (90%) of cases. The potential miscategorization due to limited length-of-care episodes is likely minimal due to the frequency of concurrent complications and procedures. Annual analysis would enable further evaluation of all associated complications and procedures, allowing for refinement of public health interventions targeting primary prevention, detailed outcome analysis to inform tertiary prevention efforts, and quantitation of health care burden. In addition, identification of cases for review in conjunction with detailed clinical information available in the DVEIVR could identify best practices in clinical treatment of military ocular injuries.

An ocular injury frequently involves multiple anatomic structures with multiple complications. For example, contusion might be associated with hyphema (an accumulation of blood in the anterior chamber of the eye), vitreous hemorrhage, orbital floor fracture, traumatic cataract, and optic nerve injury which cannot be captured by conventional surveillance methods relying on first-recorded ICD code. Data from the application of the algorithm showed that 15.6% of complicated injuries had multiple complications (ranging from 2 to 6 unique complications).

There are limitations to this approach. It is known that EHR data are mainly for administrative uses and have no guarantee for accuracy of coded diagnoses for surveillance and research.[7,8] The limitations of administrative/claims data for secondary use have been described previously, specifically in regards to ophthalmic care. For example, it has been noted that patients may be misclassified due to misdiagnosis, miscoding, as well as coding practices of multiple providers with varying coding experience.[9] Furthermore ocular injuries can be complex and involve multiple anatomic regions which cannot be appropriately captured by the conventional surveillance approaches. It is necessary to

utilize multiple medical data points, e.g., diagnoses, prescribed procedures and medications, to increase accuracy of case identification based on electronic health record.[10]

In addition, ocular burns and corrosion were not included in this analysis; these injuries will need to be explored separately with modifications to the case definition with special consideration given to expected complications more likely in these injuries (for example, ocular surface complications such as dry eye syndrome or exposure keratopathy, and lid complications such as entropion or ectropion).

It was assumed that the new case definition captured all ocular injuries without considering the possibility of missing true cases of ocular injury in M2. It is, however, extremely unlikely that there were ocular injuries which leave no trace of clinical information to be captured by this case definition. This study did not select samples of uncaptured cases as negative controls for validation because it would have needed a large sample to identify false negatives given the extremely rare likelihood. Therefore, no estimation was made of sensitivity, specificity, positive predictive value, and negative predictive value for the case definition.

The main purpose of injury surveillance efforts is to inform the development, prioritization, and execution of injury prevention initiatives. The results of this study demonstrated that categorization of ocular injuries could be obtained by evaluation of episodes of care recorded in administrative records for the secondary uses of surveillance and research. The longitudinal approach ensures more reliable characterization of injuries which offers several advantages: 1) it removes reliance on single ICD-10 codes for categorization of ocular injuries, 2) it increases the sensitivity and specificity of the case definition of ocular injury, 3) it provides a measure of severity of ocular injuries, and 4) it provides increased granularity of data for ocular injuries categorized as complicated, with capture of multiple associated complications and procedures. The resultant outcome provides a rich, clinically-relevant dataset for outcome and health system analysis.

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Disclaimer: The contents, views, or opinions expressed in this publication are those of the author(s) and do not necessarily reflect the official policy or position of the Defense Health Agency, Department of Defense, or the U.S. Government.

Disclosure: Utilization of data and development of the case definition methodology was completed under the DHA Office of Research Protection #935913.

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Surveillance Snapshot: Health Care Burden Attributable to Osteoarthritis and Spondylosis, Active Component, U.S. Armed Forces, 2016–2020

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TABLE. Counts of medical encounters[a] with first-listed osteoarthritis or spondylosis diagnoses and unique individuals affected,[b] by encounter type, active component, U.S. Armed Forces, 2016–2020

	Inpatient			Outpatient		Total	
	No. individuals affected	No. inpatient encounters	No. inpatient bed days	No. individuals affected	No. ambulatory encounters	No. individuals affected	No. medical encounters
Osteoarthritis	276	288	1,409	71,294	211,319	71,338	211,607
Spondylosis	790	801	2,482	86,394	334,892	86,485	335,693

[a]Only 1 encounter was counted per individual per day.
[b]The number of unique service members with at least 1 inpatient or outpatient encounter with a qualifying osteoarthritis or spondylosis diagnosis in the first diagnostic position.
No. number.

Osteoarthritis (OA) and spondylosis (OA of the spine) can result in pain and functional impairment and account for significant morbidity burdens among U.S. civilian and military populations.[1–3] Management of cases of OA requires substantial health care resources and incurs considerable costs.[4] A recent *MSMR* analysis described the incidence of OA and spondylosis diagnoses among active component service members of the U.S. Armed Forces during 2016–2020.[5] Crude annual incidence rates of both conditions decreased markedly from 2016 through 2020 with declines evident in all of the demographic and military subgroups examined.[5]

This snapshot summarizes the total numbers of inpatient and outpatient encounters with an OA or spondylosis diagnosis in the first diagnostic position and the total numbers of unique individuals affected by these conditions during the same 5-year surveillance period. Totals included both incident and prevalent cases. Among active component service members during 2016–2020, a total of 71,338 unique individuals were affected by OA **(Table)**. These individuals contributed a total of 211,607 OA-related medical encounters, representing an average of 3 medical encounters per affected individual. The vast majority (99.9%) of the total OA-related medical encounters were in outpatient settings. Service members affected by OA who had 1 or more OA-related hospitalizations (n=276) were associated with a total of 1,409 hospital bed days.

Between 2016 and 2020, a total of 86,485 unique individuals were affected by spondylosis **(Table)**. These individuals had a total of 335,693 spondylosis-related medical encounters, representing 4 medical encounters per affected individual. Similar to OA, the vast majority (99.8%) of the total spondylosis-related medical encounters were in outpatient settings. Spondylosis-related hospitalizations (n=790) accounted for a total of 2,482 hospital bed days.

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Medical Surveillance Monthly Report (MSMR)
Armed Forces Health Surveillance Division
11800 Tech Road, Suite 220
Silver Spring, MD 20904

MEDICAL SURVEILLANCE MONTHLY REPORT (MSMR), in continuous publication since 1995, is produced by the Armed Forces Health Surveillance Division (AFHSD). AFHSD is a designated public health authority within the Defense Health Agency. The *MSMR* provides evidence-based estimates of the incidence, distribution, impact, and trends of illness and injuries among U.S. military members and associated populations. Most reports in the *MSMR* are based on summaries of medical administrative data that are routinely provided to the AFHSD and integrated into the Defense Medical Surveillance System for health surveillance purposes.

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ISSN 2158-0111 (print)
ISSN 2152-8217 (online)