VISION RESEARCH: A DECADE OF INSIGHT AND IMPACT

Over the past 10 years, the Vision Center of Excellence has led research to improve vision care for service members and veterans. This catalog highlights research studies focused on eye injuries and brain related vision problems, developed to impact readiness and recovery.

VCE Publications Advancing Military Eye Health, Readiness, and Recovery (2015-2025)

Introduction

This catalog includes more than 20 published coauthored/peer reviewed publications over the past decade. These publications cover a range of vision related topics that are important to military health, readiness and recovery. Our research helps providers, researchers, and policy makers better understand and respond to the eye care needs of service members and veterans. The list of publications is arranged chronologically, beginning with the most recent.

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Released: June 2025 by the Vision Center of Excellence. This product is reviewed annually and is current until superseded.

Behavioral Health Status after Globe Removal in U.S. Service Members

McMurray, H., Gu, W., Millian-Morell, L., Curry, J. C., Regasa, L. E., Chou, E., & Viswanathan, M. (2025). Behavioral Health Status after Globe Removal in U.S. Service Members. Ophthalmology. doi:10.1016/j.ophtha.2025.04.023

Objectives: To describe the incidence of new behavioral health (BH) diagnoses in patients who underwent globe removal (GR) in the Military Health System (MHS).

Design: Retrospective cohort study.

Subjects: Active-duty service members (SM) who underwent GR and/or were diagnosed with a BH diagnosis between 2017 to 2022 in the MHS system.

Methods: This retrospective study queried the MHS Mart (M2) database for patients who underwent GR secondary to trauma between 2017 and 2022. A multivariate Poisson regression model, adjusted for age and sex, was used to calculate the relative risk (RR) of new BH diagnoses in patients who underwent GR compared to those who did not. Patients with a BH diagnosis prior to GR were excluded from this analysis.

Main outcome measures: Probability of developing a new BH condition after GR compared to non-GR individuals.

Results: There were 901,595 SM patients with a BH diagnosis between 2017 to 2022, and 103 patients had a history of GR secondary to globe trauma. Among the GR group, 29 had a prior BH diagnosis and 27 had a new BH diagnosis post-GR. Compared to the population who have not undergone GR, the estimated RR (95% CI) for patients with a new BH diagnoses post-GR were as follows: suicide or suicidal ideation 47.2 (7.9-145.8), alcohol use disorder 17.3 (7.5-33.5), anxiety 12.8 (6.86-21.5), adjustment disorder 10.5 (5.9-17.0), substance use disorder 5.29 (1.64-12.3), and depression 8.0 (3.2-16.1). The number of lag days was shorter for patients who were diagnosed with a new BH condition after GR (median = 49 days) compared to those who were diagnosed with a BH condition before GR (median = 351 days). Due to the rare events of GR, there were substantial limitations in the calculation of estimated RR. However, this study suggests that patients undergoing GR are at an increased risk for developing a new BH diagnosis, with higher rates of suicide and/or suicidal ideation, substance disorders, and other mental health conditions compared to the non-GR population. Early BH screening is crucial for these patients.

Atraumatic Rhegmatogenous Retinal Detachment: Epidemiology and Association with Refractive Error in U.S. Armed Forces Service Members

Lee, I., Gu, W., Colyer, M., Debiec, M., Karesh, J., Justin, G., & Viswanathan, M. (2025). Atraumatic Rhegmatogenous Retinal Detachment: Epidemiology and Association with Refractive Error in U.S. Armed Forces Service Members. Ophthalmic Epidemiology, 1–8. doi:10.1080/09286586.2024.2434733

Purpose: To evaluate the incidence, refractive error (RE) association, and distribution of atraumatic rhegmatogenous retinal detachment (RRD) in U.S. military service members (SMs).

Methods: This study used data from the Military Health System (MHS) M2 database to identify active U.S. military and National Guard SMs diagnosed with RRD from 2017 to 2022. The RE in diopters (D) was manually extracted from available medical charts for 518 eyes. The annual incidence rate of RRD was calculated overall and evaluated in terms of age, gender, and RE. A multivariate Poisson regression model was used to estimate the relative risk (RR) for RRD with RE.

Results: From 2017 to 2022, 1,537 SMs were diagnosed with RRD and 1,243,189 were diagnosed with RE. One thousand two hundred seventy-five SMs had both diagnoses: RRD and RE. The overall incidence rate of RRD over the 6-year study was 16.3 per 100,000 people (16.4 and 15.9 for males and females, respectively). In all study groups, the incidence of RRD increased with age. SMs with RE had an overall 25-fold increased risk for RRD compared to SMs without RE. RE was present in 83.0% of cases of RRD. Myopia accounted for 93.3% of cases for eyes with detailed refractive data.

Conclusion: The incidence of RRD in U.S. SMs is comparable to other studies and is similar among male and female SMs. RE is present in most cases of RRD in SMs, with the most common type being low to moderate amounts of myopia.

Cost-Benefit Analysis of Comprehensive Military Eye Examination Policies

Armour, P., Vardavas, R. V., Prathyush Katragadda, S., Pujol-Mitchell, T., Nascimento De Lima, P., Fateh, B., Hernandez, H., Yi, S., Rojas Aguliera, J., & Gadwah-Meaden, C. (2024). Cost-Benefit Analysis of Comprehensive Military Eye Examination Policies. Rand Corporation.2024. doi:10.7249/RRA2188-1

Purpose: Vision readiness ensures that military service members have the visual fitness required to perform their missions successfully, maintain deployability, and serve without duty limitations. In this study, the authors gather data and develop models to ascertain the costs and benefits of moving from the current visual acuity screening process to comprehensive eye examinations intended to detect a wider range of visual dysfunctions.

Key Findings: Under a wide range of assumptions, baseline and periodic comprehensive eye exams are cost-effective relative to current basic acuity screening. The average benefits for periodic comprehensive eye exams for all SMs exceed their costs given the inputs of the authors' model**.** More frequent exams are more cost-effective than less frequent exams, since these exams allow for earlier diagnoses of OVDs and more effective treatment. For occupations for which visual readiness is most pivotal, the cost-effectiveness of comprehensive eye exams is highest.

Recommendations: The military should introduce periodic comprehensive eye exams, especially for SMs for whom the negative impacts of undiagnosed OVDs on contributions to the force are high. Any systematic expansions of comprehensive eye exams would enable a greater understanding of the prevalence, incidence, and costs of OVDs among the unique SM population, helping future modeling efforts and vision-related policies.

Characterization of Mild Traumatic Brain Injury Cohort with Photophobia From the Defense and Veterans Eye Injury and Vision Registry

Merezhinskaya N, Bai AC, Park D, Barker Ii FM, Gu W. Characterization of Mild Traumatic Brain Injury Cohort With Photophobia From the Defense and Veterans Eye Injury and Vision Registry. Mil Med. 2024;189(Suppl 3):736-742. doi:10.1093/milmed/usae251

Introduction: Photophobia is a common visual symptom following mild traumatic brain injury (mTBI), which can adversely affect the military readiness and performance of service members (SMs). We employed the Defense and Veterans Eye Injury and Vision Registry (DVEIVR) to identify and describe a cohort of SMs diagnosed with photophobia post-mTBI. The objective of this study was to characterize comorbid conditions and symptoms in an mTBI cohort with photophobia, to assess their co-occurrence, to describe the persistence of photophobia, and to assess the effectiveness of utilization of currently available International Statistical Classification of Diseases and Related Health Problems (ICD) codes in reporting photophobia in this cohort.

Materials and Methods: The DVEIVR database was searched to identify a cohort of SMs experiencing photophobia after mTBI. Photophobia and other potentially related conditions and symptoms, both coded and descriptive, which were abstracted directly from the medical records of SMs, were found within DVEIVR. The presence of the conditions and symptoms comorbid with photophobia was characterized on both patient and encounter levels. Analysis of co-occurrence of photophobia with these conditions or symptoms was performed on the encounter level using co-occur package in the statistical program R. Persistence of photophobia up to 1 year since the injury was assessed. The utilization of currently available ICD codes for photophobia was analyzed.

Results: A total of 639 SMs exhibiting photophobia after mTBI were identified in DVEIVR. Headaches, including migraines, were the most frequently experienced comorbidity affecting 92% of the SMs in the cohort. The second most frequent complaint was dizziness and/or vertigo (53%) followed by nausea (42%), blurry vision (31%), and irritation and discomfort in the eye (17%). In all, 20% of encounters with photophobia had a complaint of headaches, followed by 8.3% of photophobia encounters co-occurring with dizziness and vertigo, 5.7%—with nausea, 4.5%—with blurred vision, and 2.1%—with subjective sensations in the eye. All comorbidities co-occurred with photophobia at probabilities higher than by chance alone. The percentage of mTBI SMs experiencing photophobia declined to 20% at 30 days after the injury, 17% at 3 months, 12% at 6 months, and 7% at 12 months post-injury, respectively. The use of currently available ICD codes for photophobia was very low—only 27.1% of the cohort had at least 1 ICD code recorded in their medical records.

Conclusions: The results of this study support the idea that there is a strong relationship between photophobia and headache after an mTBI. Additional research is warranted to better understand this relationship and its causes so that clinical management improves. The results of this study show a precipitous decline in the numbers of cases of photophobia after mTBI over the first 30 days and a longer-term persistence up to a year in a minority of cases, which is consistent with other research in this field. Various ICD codes, which are currently used to code for photophobia, along with other vision conditions, were not widely used to document photophobia symptoms. It is important to adopt

a dedicated ICD code for photophobia to improve the surveillance, data collection, and analysis of this condition.

Patterns of concomitant traumatic brain injury and ocular trauma in US service members

Gu W, Groves LL, McClellan SF. Patterns of concomitant traumatic brain injury and ocular trauma in US service members. Trauma Surg Acute Care Open. 2024 Mar 12;9(1): e001313. doi:10.1136/tsaco-2023-001313. PMID: 38481484; PMCID: PMC10936468.

Background: Concomitant traumatic brain injury (TBI) and ocular trauma (OT) are caused by the same physical mechanisms, which may complicate therapeutic intervention if screening and evaluation of each condition are not promptly initiated. The aim of this study is to identify concomitant TBI in OT patients and characterize the pattern of those injured service members (SMs) in non-combat environments to assist in the early detection and treatment of both TBI and OT.

Methods: Encounters matching the case definitions of TBI and OT for injured SMs were extracted from the Military Health System. Concomitant TBI and OT was identified as patients who were diagnosed with both medical conditions within 30 days. Incidence rates of concomitance were analyzed using a Poisson regression model. The odds of mechanisms and types of OT with concomitant TBI were analyzed using logistic regression models.

Results: From 2017 to 2021, there were 71 689 SMs diagnosed with TBI, and 69 358 patients diagnosed with OT. There were 3251 concomitant cases identified. The overall concomitance rate in OT patients was 4.7%. Clinical presentations of concomitant OT had a higher rate of complications. Blast, transport accidents, assaults, alcohol, falls, and sports-related injuries (in decreasing order) were significantly associated with concomitance rates. Compared with closed globe injuries, OT with orbital fractures, rupture, laceration, adnexal periocular injury, and penetrating injury had higher risks of concomitant TBI. For patients with orbital fractures, nearly half (44.1%) sustained a concomitant TBI.

Conclusions: A practical approach using temporal proximity of diagnostic data was developed to identify concomitant cases of TBI and OT which presented with more severe injury types than non-concomitant cases. These results indicate OT patients with orbital or open globe injuries sustained from high-impact mechanisms warrant further TBI screening to prompt early detection and treatment.

Cataracts after Ophthalmic and Nonophthalmic Trauma Exposure in Service Members, U.S. Armed Forces

Viswanathan, M., Gu, W., Blanch, R. J., & Groves, L. L. (2023). Cataracts after ophthalmic and nonophthalmic trauma exposure in service members, U.S. Armed Forces. Military Medicine, 189(5–6). doi:10.1093/milmed/usad414

Introduction: We aimed to identify injury-related risk factors for secondary cataract incidence after eye and brain injury and polytrauma. We also examined the effect of direct and indirect eye injury management on cataract diagnosis and treatment. Prevention or mitigation strategies require knowledge of the causes and types of combat injuries, which will enable more appropriate targeting of resources toward prevention and more efficient management of such injuries.

Materials and Methods: Data were gathered from the Military Health System using the Military Health System Management and Analysis Reporting Tool (M2) between 2017 and 2021 from inpatient and outpatient Service Members (SMs) (active duty and National Guard). The date of the first cataract diagnosis was tracked to estimate the annual incidence rate, and it was longitudinally linked to any prior diagnosis of ocular trauma (OT), traumatic brain injury (TBI), or polytrauma to calculate the relative risk. International Classification of Disease codes, 10th Revision, were used to identify those diagnosed with cataracts, TBI, and polytrauma. Defense and Veterans Eye Injury and Vision Registry data were used to examine SMs who sustained ocular injuries from 2003-2020 and who may have had cataract surgery following a cataract diagnosis.

Results: The relative risk of traumatic cataract formation from OT, TBI, and polytrauma are 5.71 (95% CI, 5.05-6.42), 2.32 (95% CI, 2.03-2.63), and 8.95 (95% CI, 6.23-12.38), respectively. Traumatic cataracts in SMs more commonly result from open-globe injuries (70%) than closed-globe injuries (30%). By specific sub-injury type, traumatic cataracts occur most frequently from intraocular foreign bodies (22%). More than 400 patients in the cohort suffered from TBI and traumatic cataracts, more than 300 from OT and cataracts, and more than 20 from polytrauma and cataracts. The battlefield is the riskiest environment for trauma exposure, with 62% of OT occurring in combat. There was a statistically significant difference between the mean visual acuity value before cataract surgery ($M = 1.17$, $SD = 0.72$) and the mean visual acuity value after cataract surgery ($M = 0.44$, $SD = 0.66$, $P < .001$).

Conclusion: Traumatic cataracts often occur in SMs who sustain ocular injuries. New to the literature is that relationships exist between traumatic cataract formation and nonglobe trauma, specifically TBI and polytrauma. Ocular injury calls for an ophthalmic examination. A low threshold should exist for routine ocular exam consultation in the setting of TBI and polytrauma. Separately, polytrauma patients should undergo a review of systems questions, particularly questions about the ocular and visual pathways. A positive response to screening warrants further investigation of possible ocular pathology, including traumatic cataract formation. Cataract surgery is an effective treatment in improving the vision of SMs who suffer from traumatic cataracts. Constant effort must be made to limit occurrences of occupation-related traumatic cataracts.

The Use of Preoperative Prophylactic Systemic Antibiotics for the Prevention of Endophthalmitis in Open Globe Injuries: A Meta-Analysis

Patterson TJ, McKinney D, Ritson J, McLean C, Gu W, Colyer M, McClellan SF, Miller SC, Justin GA, Hoskin AK, Cavuoto K, Leong J, Ascarza AR, Woreta FA, Miller KE, Caldwell MC, Gensheimer WG, Williamson T, Dhawahir-Scala F, Shah P, Coombes A, Sundar G, Mazzoli RA, Woodcock M, Kuhn F, Watson SL, Gomes RSM, Agrawal R, Blanch RJ. The Use of Preoperative Prophylactic Systemic Antibiotics for the Prevention of Endophthalmitis in Open Globe Injuries: A Meta-Analysis. Ophthalmol Retina. 2023 Nov;7(11):972-981. doi:10.1016/j.oret.2023.06.022. Epub 2023 Jul 4. PMID: 37406735.

Topic: This study reports the effect of systemic prophylactic antibiotics (and their route) on the risk of endophthalmitis after open globe injury (OGI).

Clinical relevance: Endophthalmitis is a major complication of OGI; it can lead to rapid sight loss in the affected eye. The administration of systemic antibiotic prophylaxis is common practice in some health care systems, although there is no consensus on their use.

Methods: PubMed, CENTRAL, Web of Science, CINAHL, and Embase were searched. This was completed July 6, 2021, and updated December 10, 2022. We included randomized and nonrandomized prospective studies which reported the rate of post-OGI endophthalmitis when systemic preoperative antibiotic prophylaxis (via the oral or IV route) was given. The Cochrane Risk of Bias tool and ROBINS-I tool were used for assessing the risk of bias. Where meta-analysis was performed, results were reported as an odds ratio. PROSPERO registration: CRD42021271271.

Results: Three studies were included. One prospective observational study compared outcomes of patients who had received systemic or no systemic preoperative antibiotics. The endophthalmitis rates reported were 3.75% and 4.91% in the systemic and no systemic preoperative antibiotics groups, a nonsignificant difference (P = 0.68). Two randomized controlled trials were included (1555 patients). The rates of endophthalmitis were 17 events in 751 patients (2.26%) and 17 events in 804 patients (2.11%) in the oral antibiotics and IV (± oral) antibiotics groups, respectively. Meta-analysis demonstrated no significant differences between groups (odds ratio, 1.07; 95% confidence interval, 0.54-2.12).

Conclusions: The incidences of endophthalmitis after OGI were low with and without systemic antibiotic prophylaxis, although high-risk cases were excluded in the included studies. When antibiotic prophylaxis is considered, there is moderate evidence that oral antibiotic administration is noninferior to IV.

Optometric Brain Injury Curriculum in Federal Residency Training Programs: A Consensus Report

Jackson KM, Merezhinskaya N, Mallia RK, Barker Ii FM. Optometric Brain Injury Curriculum in Federal Residency Training Programs: A Consensus Report. Mil Med. 2023;188(Suppl 1):49-55. doi:10.1093/milmed/usac356

Introduction: Brain injury often impacts the visual system. Diagnosis and treatment of visual system problems related to brain injury is a field with less settled science and more variation in practice than most specialty fields. Most optometric brain injury residency programs are in federal clinics (VA and DOD). A consensus core curriculum has been created that will allow some consistency while facilitating program strengths.

Materials and methods: Kern's curriculum development model and a focus group of subject matter experts were used to reach consensus in producing a core curriculum to provide a common framework for brain injury optometric residency programs.

Results: A common high-level curriculum was developed with educational goals through consensus.

Conclusions: In a relatively new subspeciality without a firm foundation of settled science, a common curriculum will help provide a common framework to facilitate clinical and research progress in this field. The process sought out expertise and community building to help improve the adoption of this curriculum. This core curriculum will provide a framework for educating optometric residents in the diagnosis, management, and rehabilitation of patients with visual sequelae because of brain injury. It is intended to ensure that appropriate topics are covered while allowing for flexibility according to each program's strengths and resources.

Trend of Incidence of Ocular Injury in Service Members of the U.S. Armed Forces in 2016–2019

Reynolds, Mark E., and Weidong Gu. 2022. "Trend of Incidence of Ocular Injury in Service Members of the U.S. Armed Forces in 2016–2019." Ophthalmic Epidemiology 30 (4): 434–40. doi:10.1080/09286586.2022.2129697

Purpose: Ocular injuries pose a significant threat to performance of military functions by the U.S. service members. To estimate the burden of ocular injuries in service members, administrative health records from the Military Health System were collected and analyzed, inclusive of ocular injuries incurred during deployment, military training, or outside of duty hours.

Methods: Patient encounters which matched the predesignated ICD10 codes for ocular injury and complications were extracted and were longitudinally analyzed to categorize patients into complicated (documentation of surgical procedure performed or ocular condition requiring further treatment) or uncomplicated (documentation of injury only). Comparison of incidence rates between groups was made, and geospatial analysis of the number of patients with ocular injury was conducted.

Results: A total of 61,680 incidences of ocular injuries were identified from 2016 to 2019. The incidence rates for complicated and uncomplicated injuries were 21.3 and 82.3 per 10,000, respectively. The incidence rate of uncomplicated injury declined from 2016 to 2019, while that of complicated injury was relatively stable. For complicated ocular injury, the relative risk of males was 62% higher than that of females. The incidence rates of the Army and the Marines were

significantly higher than those of the Air Force. California, Texas, and Virginia ranked top three in the numbers of complicated ocular injury patients. Unintentional injuries and struck were the most frequently coded intention and mechanism.

Conclusion: Our results provide the critical information on trends of ocular injuries in relation to demographics, service branches, and occupations. Categorization of the severity of ocular injuries is important to inform health services operations analysis across the Military Health System to enhance medical readiness and improve outcomes.

Incidence of Optic Neuritis and the Associated Risk of Multiple Sclerosis for Service Members of U.S. Armed Forces

Gu W, Tagg NT, Panchal NL, Brown-Bickerstaff CA, Nyman JM, Reynolds ME. Incidence of Optic Neuritis and the Associated Risk of Multiple Sclerosis for Service Members of U.S. Armed Forces. Mil Med. 2023;188(3-4):e697-e702. doi:10.1093/milmed/usab352

Introduction: Optic neuritis (ON), an acute inflammation of the optic nerve resulting in eye pain and temporary vision loss, is one of the leading causes of vision-related hospital bed days in the U.S. Military and may be a harbinger of multiple sclerosis (MS). We developed a case identification algorithm to estimate incidence rates of ON and the conversion rate to MS based on a retrospective assessment of medical records of service members (SMs) of the U.S. Armed Force.

Materials and methods: Electronic medical records (EMRs) from 2006 to 2018 in the Defense Medical Surveillance System were screened using the case identification algorithms for ON and MS diagnosis. The incidences rates of ON were calculated. The rates of conversion to MS was modeled using the Kaplan-Meier survival analysis.

Results: The overall incidence rate of ON was 8.1 per 100,000 from 2006 to 2018. Females had a rate (16.9 per 100,000) three times higher than males. Most (68%) of subsequent diagnoses of MS were made within 1 year after diagnosis of ON. The overall 5-year risk of progression to MS was 15% (11%-16% for 95% CI). The risk of conversion to MS in females was significantly higher than in males.

Conclusions: We developed an efficient tool to explore the EMR database to estimate the burden of ON in the U.S. Military and the MS conversion based on a dynamic cohort. The estimated conversion rates to MS feeds into inform retention and fitness-for-duty policy in these SMs.

Photophobia Associated with Traumatic Brain Injury: A Systematic Review and Meta-analysis

Merezhinskaya N, Mallia RK, Park D, Millian-Morell L, Barker FM 2nd. Photophobia Associated with Traumatic Brain Injury: A Systematic Review and Meta-analysis. Optom Vis Sci. 2021;98(8):891-900. doi:10.1097/OPX.0000000000001757

Significance: This study reports the prevalence and relative risk of photophobia in patients with traumatic brain injury (TBI).

Objectives: This study aimed to conduct a systematic review and meta-analysis to determine the prevalence and relative risk of photophobia in patients with TBI.

Data sources: Three databases were used for literature search: PubMed, EMBASE, and Cochrane Library.

Study appraisal and synthesis methods: Publications reporting the prevalence of photophobia after TBI in patients of any age were included. A series of meta-regression analyses based on a generalized linear mixed model was performed to identify potential sources of heterogeneity in the prevalence estimates.

Results: Seventy-five eligible publications were identified. The prevalence of photophobia was 30.46% (95% confidence interval [CI], 20.05 to 40.88%) at 1 week after the injury. Prevalence decreased to 19.34% (95% CI, 10.40 to 28.27%) between 1 week and 1 month after TBI and to 13.51% (95% CI, 5.77 to 21.24%) between 1 and 3 months after the injury. The rapid decrease in the prevalence of photophobia in the first 3 months after a TBI injury was significant ($P < .001$). Three months post-TBI, the prevalence of photophobia leveled off to a near plateau with nonsignificant variability, increasing between 3 and 6 months (17.68%; 95% CI, 9.05 to 26.32%) and decreasing between 6 and 12 months since TBI (14.85%; 95% CI, 6.80 to 22.90%). Subgroup analysis of 14 publications that contained control data showed that the estimated risk ratio for photophobia was significantly higher in the TBI than in the control group during the entire 12 months after TBI.

Conclusions and implications of key findings: This study demonstrates that photophobia is a frequent complaint after TBI, which largely resolves for many individuals within 3 months after the injury. For some patients, however, photophobia can last up to 12 months and possibly longer. Developing an objective quantitative methodology for measuring photophobia, validating a dedicated photophobia questionnaire, and having a specific photophobia International Classification of Diseases, Tenth Revision code would greatly improve data gathering and analysis.

Contact Lens Wear, Corneal Complications, and U.S. Service Member Readiness

Flanagan G, Velez T, Gu W, Singman E. Contact Lens Wear, Corneal Complications, and U.S. Service Member Readiness. Mil Med. 2020;185(11-12):e2071-e2075. doi:10.1093/milmed/usaa187

Introduction: Ulcerative keratitis (UK), or corneal ulcer, is a sight-threatening and readiness-lowering medical condition that begins with a corneal infiltrative event (CIE). Contact lens (CL) wear poses a particular risk for a CIE and therefore is restricted for most active-duty service members (SMs). In this study, we explored a large Department of Defense/Veterans Affairs (DOD/VA) database to estimate the prevalence of UK and CIE and their association with CL wear.

Materials and methods: The DOD/VA Defense and Veterans Eye Injury Vision Registry, an initiative of the DOD/VA Vision Center of Excellence, was explored using natural language processing software to search for words and diagnostic codes that might identify cornea injuries and CL wear. The effect of UK and CIE on readiness was explored by evaluating the duration between the first and final visits noted in the database.

Results: A total of 213 UK cases were identified among the 27,402 SMs for whom data were recorded in Defense and Veterans Eye Injury Vision Registry. The odds ratios of UK and CIE being associated with CL wear were 13.34 and 2.20, respectively. A less specific code (superficial corneal injury) was found to be the most commonly used diagnosis in the database, and the odds ratio of CL wearers having that diagnosis was 2.25. CL-wearing patients with corneal disease also required more clinic encounters than those who did not wear CLs.

Conclusions: This study supports the current restriction on CL wear among nonpilot active duty SMs and quantifies the significantly enhanced risk of developing corneal ulcers posed by that habit.

The Relationship Between Severe Visual Acuity Loss, Traumatic Brain Injuries, and Ocular Injuries in American Service Members From 2001 to 2015

Flanagan, G., Velez, T., Gu, W., & Singman, E. (2020). The Relationship Between Severe Visual Acuity Loss, Traumatic Brain Injuries, and Ocular Injuries in American Service Members From 2001 to 2015. Military medicine, 185(9-10), e1576–e1583. doi:10.1093/milmed/usaa154

Introduction: Although traumatic brain injury (TBI) is known to cause many visual problems, the correlation between the extent of severe visual acuity loss (SVAL) and severity of TBI has not been widely explored. In this retrospective analysis, combined information from Department of Defense (DOD)/Veterans Affairs ocular injury and TBI repositories were used to evaluate the relationship between chronic SVAL, TBI, ocular injuries, and associated ocular sequelae for U.S. service members serving between 2001 and 2015.

Materials and methods: The Defense and Veterans Eye Injury and Vision Registry (DVEIVR) is an initiative led by the DOD and Veterans Affairs that consists of clinical and related data for service members serving in theater since 2001. The Defense and Veterans Brain Injury Center (DVBIC) is the DoD's office for tracking TBI data in the military and maintains data on active-duty service members with a TBI diagnosis since 2000. Longitudinal data from these 2 resources for encounters between February 2001 and October 2015 were analyzed to understand the relation between SVAL, and TBI while adjusting for ocular covariates such as open globe injury (OGI), disorders of the anterior segment and disorders of the posterior segment in a logistic regression model. TBI cases in DVEIVR were identified using DVBIC data and classified according to International Statistical Classification of Diseases criteria established by DVBIC. Head trauma and other open head wounds (OOHW) were also included. SVAL cases in DVEIVR were identified using both International Statistical Classification of Diseases criteria for blindness and low vision as well as visual acuity test data recorded in DVEIVR.

Results: Data for a total of 25,193 unique patients with 88,996 encounters were recorded in DVEIVR from February 2001 to November 2015. Of these, 7,217 TBI and 1,367 low vision cases were identified, with 638 patients experiencing both. In a full logistic model, neither UTBI nor differentiated TBI (DTBI, i.e., mild, moderate, severe, penetrating, or unclassified) were significant risk factors for SVAL although ocular injuries (disorders of the anterior segment, disorders of the posterior segment, and OGI) and OOHW were significant.

Conclusion: Any direct injury to the eye or head risks SVAL but the location and severity will modify that risk. After adjusting for OGIs, OOHW and their sequelae, TBI was found to not be a significant risk factor for SVAL in patients recorded in DVEIVR. Further research is needed to explore whether TBI is associated with more moderate levels of vision acuity loss.

The ABCs of Ocular Trauma: Adapting a Familiar Mnemonic for Rapid Eye Exam in the Pre-Ophthalmic Zone of Care

Kroesen, C. F., Snider, M., Bailey, J., Buchanan, A., Karesh, J. W., La Piana, F., Seefeldt, E., Egan, J. A., & Mazzoli, R. A. (2020). The ABCs of Ocular Trauma: Adapting a Familiar Mnemonic for Rapid Eye Exam in the Pre-Ophthalmic Zone of Care. Military medicine, 185(Suppl 1), 448–453. doi:10.1093/milmed/usz262

Introduction: Evaluation and management of eye trauma is daunting to many practitioners. For general medical emergencies, the familiar ABCs mnemonic serves to both recompose the provider as well as provide a logical order for evaluation and action. We recently adapted an ABCs mnemonic to provide non-ophthalmologists with a familiar method for systematically evaluating and managing eye trauma. A = ACUITY. Visual acuity is the most importance piece of information in eye trauma. B = BEST exam of BOTH eyes. Starting with acuity, examination proceeds from the front to the rear of the eye. Examine the uninjured eye first. C = CONTIGUOUS STRUCTURES and CONTACT LENSES. Examine structures contiguous to the apparent injury. Inspect for contact lens wear. D = DRUGS, DIAGNOSTIC IMAGING, and the DON'TS. Start antibiotics, antiemetics, and analgesics. Administer tetanus. Obtain computerized tomography if available. Do not attempt ocular ultrasound or magnetic resonance imaging. Do not apply pressure to the eye. Do not patch the eye or apply any medication. E = EYE SHIELD and EVACUATE. Shield and ship to ophthalmology. The mnemonic was adapted to reflect current Joint Trauma Services and Tactical Combat Casualty Care practice guidelines. We believe this familiar mnemonic will serve as a useful tool in allowing non-ophthalmologists to comfortably and safely evaluate an eye for trauma**.**

Incidence and Prevalence of Idiopathic Corneal Ectasias, Active Component, 2001– 2018

Reynolds, M. E., Morgenstern, A. S., Mallia, R. K., Ying, S., & Stahlman, S. (2020). Brief report: Incidence and prevalence of idiopathic corneal ectasias, active component, 2001-2018. MSMR, 27(1), 24–27.

Introduction: Corneal ectasias are a category of eye diseases characterized by progressive steepening and thinning of the collagen-based corneal stroma. Individually, these conditions are part of their own unique primary disease process or can occur as result of refractive surgery.

Conditions characterized as corneal ectasias include keratoconus, pellucid marginal degeneration (PMD), keratoglobus, and post-refractive surgical ectasia. These disorders can be differentiated based on the pattern and location of corneal thinning, age of onset, and surgical history. The current report summarizes the frequencies, rates, and temporal trends of idiopathic corneal ectasias among active component service members during 2001–2018.

Method: The surveillance period was 1 January 2001 to 31 December 2018. The surveillance population included all individuals who served in the active component of the U.S. Army, Navy, Air Force, or Marine Corps at any time during the surveillance period. Diagnoses of corneal ectasias were ascertained from records maintained in the Defense Medical Surveillance System (DMSS) that document outpatient encounters of active component service members. Such records reflect care in fixed military treatment facilities of the Military Health System (MHS) and in civilian sources of health care underwritten by the Department of Defense.

Result: During 2001–2018, a total of 10,562 active component service members received incident diagnoses of idiopathic corneal ectasias, for a crude overall incidence rate of 45.3 per 100,000 p-yrs. Rates among male and female service members were relatively similar. Overall rates were highest among service members 30–34 years of age (54.2 per 100,000 p-yrs) and lowest among those less than 20 years old (30.3 per 100,000 p-yrs). Incidence rates were higher among officers compared to enlisted service members. Rates of idiopathic corneal ectasias were highest among Army personnel (52.6 per 100,000 p-yrs) and lowest among Marines Corps members (27.6 per 100,000 p-yrs). Across military occupations, overall incidence rates of idiopathic corneal ectasia diagnoses were highest among healthcare workers (58.5 per 100,000 p-yrs) and lowest among pilots/air crew (27.9 per 100,000 p-yrs).

Conclusion: This report demonstrated a crude overall incidence rate of idiopathic corneal ectasia diagnoses of 45.3 per 100,000 p-yrs among active component service members during 2001–2018. Early studies in Olmstead County, MN, estimated the incidence of keratoconus at 1 in 2,000 in that population, with a corresponding prevalence rate of 54.5 per 100,000 persons (per year).6 However, these data were collected before widespread use of computerized corneal topography and tomography devices, which provide more accurate and repeatable measurements of the cornea and its structure, including progression analysis of the disease. As recently as 2017, in conjunction with the advent of these newer and more sensitive computerized diagnostic methods, the annual incidence and prevalence of keratoconus in a civilian population were shown to be 5- to 10-fold higher than previously reported.7 While these estimated rates of keratoconus among civilian populations provide some reference, there are no currently available reports allowing for direct

comparisons for the wider group of corneal ectasias. The results of the current analysis provide a baseline for future surveillance of corneal ectasias and evaluation of interventions among military populations

Absolute and Relative Morbidity Burdens Attributable to Ocular and Vision-Related Conditions, Active Component, U.S. Armed Forces, 2018

Reynolds, M. E., Williams, V. F., Taubman, S. B., & Stahlman, S. (2019). Absolute and relative morbidity burdens attributable to ocular and vision-related conditions, active component, U.S. Armed Forces, 2018. MSMR, 26(9), 4–11.

Purpose: The current report used an ocular and vision disease classification system and several healthcare burden measures to quantify the impacts of various ocular and vision-related illnesses and injuries among active component service members of the U.S. Armed Forces during 2018. More service members received care for refractive error and related disorders than any other ocular and vision-related major category; this category accounted for slightly more than one-half (51.1%) of all ocular and vision-related medical encounters. Conjunctival disorders accounted for the next highest percentage of total medical encounters (13.3%) followed by corneal disorders (7.5%). The 3 specific ocular and vision-related conditions that accounted for the most medical encounters (i.e., myopia, astigmatism, and acute conjunctivitis) accounted for almost one-half (47.7%) of all ocular and vision-related medical encounters overall. In general, the conditions that accounted for the most medical encounters were predominantly refractive error and related disorders and conjunctival disorders. More active component service members received medical care for myopia than for any other specific condition. Optic nerve conditions and visual discomfort/disturbances accounted for more than one quarter (30.1%) of all ocular and vision-related hospital bed days.

Incidence and temporal presentation of visual dysfunction following diagnosis of traumatic brain injury, active component, U.S. Armed Forces, 2006-2017

Reynolds ME, Barker FM; Natalya Merezhinskaya N, Oh GT, Stahlman S. Incidence and temporal presentation of visual dysfunction following diagnosis of traumatic brain injury, active component, U.S. Armed Forces, 2006–2017. MSMR. 2019;26(9):13-25.

Introduction: This analysis describes the incidence of visual dysfunctions following a diagnosis of traumatic brain injury (TBI) among active component service members. The visual dysfunctions were divided into 9 major categories. A comparison group of service members with no history of TBI was used to determine relative incidence rates. The most commonly diagnosed visual dysfunctions were subjective visual disturbances, convergence insufficiency (CI), visual field loss, and accommodative dysfunction (AD). Service members with mild or moderate/severe TBI had significantly higher incidences of AD and CI compared to service members with no TBI. Results of survival analysis showed that service members with mild or moderate/severe TBI had lower

probabilities of remaining without the visual dysfunction outcome at almost every week of follow-up in the first year after TBI diagnosis compared to those with no TBI. The findings of this report suggest opportunities to improve both documentation and access to care for service members with these conditions.

Incidence and prevalence of selected refractive errors, active component, U.S. Armed Forces, 2001-2018

Reynolds ME, Williams VF, Taubman SB, Stahlman S. Incidence and prevalence of selected refractive errors, active component, U.S. Armed Forces, 2001–2018 MSMR. 2019;26(9):26-30.

Introduction: During 2001-2018, there were approximately 1.38 million incident diagnoses of myopia, 1.21 million incident diagnoses of astigmatism, and 492,000 incident diagnoses of hyperopia among active component service members (crude overall incidence rates of 7.8, 6.6, and 2.2 diagnoses per 100 person years, respectively). Incidence rates of all 3 conditions were higher among women compared to men. Service members in the Marine Corps, enlisted personnel, and those working in other/unknown military occupations had higher overall rates of incident myopia diagnoses compared to their respective counterparts. Incidence rates of astigmatism diagnoses were similar across all services and among both enlisted personnel and officers. Overall rates of hyperopia diagnoses were similar across all race/ethnicity groups and service branches and among both enlisted personnel and officers. However, across occupational groups, overall rates of hyperopia and astigmatism diagnoses were highest among service members working in healthcare occupations. Future analyses should focus on the specific effects of military refractive surgery programs on the readiness of service members.

Incident and recurrent cases of central serous chorioretinopathy, active component, U.S. Armed Forces, 2001-2018

Reynolds ME, Karesh JW, Gi-Taik Oh GT, Stahlman S. Incident and recurrent cases of central serous chorioretinopathy, active component, U.S. Armed Forces, 2001–2018 MSMR. 2019;26(9):31-34.

Introduction: Central serous chorioretinopathy (CSCR) is a condition that affects central visual function. It can produce blurred and/or distorted vision that can impact the performance of military duties. CSCR can recur in susceptible individuals. Incident cases of CSCR among active component service members were found to average 18.3 per 100,000 person-years (p-yrs) during 2001-2018. Incidence rates increased during the surveillance period by 60.7% and were more common with increasing age. Overall rates of incident CSCR diagnoses were highest among Air Force (20.7 per 100,000 p-yrs) and Navy members (19.9 per 100,000 p-yrs) and lowest among Marine Corps members (12.5 per 100,000 p-yrs). Pilot/air crew occupational groups had rates almost twice that of other groups. Annual recurrence rates increased 71.4% over the course of the 18-year period.

Visual deficits and dysfunctions associated with traumatic brain injury: A systematic review and meta-analysis

Merezhinskaya, N., Mallia, R. K., Park, D., Bryden, D. W., Mathur, K., & Barker, F. M., 2nd (2019). Visual Deficits and Dysfunctions Associated with Traumatic Brain Injury: A Systematic Review and Meta-analysis. Optometry and vision science: official publication of the American Academy of Optometry, 96(8), 542–555. doi:10.1097/OPX.0000000000001407

Significance: This study reports prevalence data combined independently for accommodative dysfunction, convergence insufficiency, visual field loss, and visual acuity loss in patients with traumatic brain injury in the absence of eye injury.

Objective: The objective of this study was to conduct a systematic review and meta-analysis to determine the prevalence rates of accommodative dysfunction, convergence insufficiency, visual field loss, and visual acuity loss in TBI patients without concomitant eye injury.

Data sources: The data sources used in this study were PubMed, EMBASE, EBSCO, and Cochrane Library.

Study appraisal and synthesis methods: Publications reporting the prevalence of diagnosed accommodative dysfunction, convergence insufficiency, visual field loss, or visual acuity loss to the level of legal blindness in TBI patients of any age were included. Univariate meta regression analyses and subgroup analyses were performed to account for statistical heterogeneity.

Results: Twenty-two eligible publications were identified across the four visual conditions. Random-effects models yielded combined prevalence estimates: accommodative dysfunction (42.8; 95% confidence interval [CI], 31.3 to 54.7), convergence insufficiency (36.3%; 95% CI, 28.2 to 44.9%), visual field loss (18.2%; 95% CI, 10.6 to 27.1%), and visual acuity loss (0.0%; 95% CI, 0.0 to 1.1%). Meta regression and subgroup analyses revealed that visual field loss was significantly more prevalent in moderate to severe (39.8%; 95% CI, 29.8 to 50.3%) compared with mild TBI (6.6%; 95% CI, 0 to 19.5%).

Conclusions and implications of key findings: This study demonstrates that accommodative dysfunction, convergence insufficiency, and visual field loss are common sequelae of TBI. Prospective longitudinal research with rigorous and uniform methodology is needed to better understand short- and long-term effects of TBI on the vision system.

The Joint Pathology Center/Vision Center of Excellence Approach to Analyzing Intra-Ocular "Foreign Bodies"

Lewin-Smith MR, Strausborger SL, Jenkins HM, Merezhinskaya N, Latkany PA, Mazzoli RA, Colyer MH, Mines MJ. et al. The Joint Pathology Center/Vision Center of Excellence Approach to Analyzing Intra-Ocular "Foreign Bodies". Mil Med. 2019;184(Suppl 1):565-570. doi:10.1093/milmed/usy307

Background: The Military Health System recognizes the importance of analyzing "foreign bodies" removed from US service members through several policy documents. This activity focuses on detecting potentially toxic metals. Intra-ocular "foreign bodies" (IOFBs) represent a small, clinically important subset. The development of ocular metallosis with iron and copper fragments is a specific local reaction to IOFBs. The results of the compositional analysis of removed IOFBs can influence clinical management decisions aimed at optimizing the preservation of sight.

Method: The Joint Pathology Center (JPC) and Vision Center of Excellence (VCE) have established a pathway for the analysis of IOFBs removed from Department of Defense and Veterans Health Administration patients. The analysis of IOFBs uses analytical methods to provide information about the fragments' surface elemental and molecular composition.

Results: Metallic specimens analyzed included iron and copper-containing fragments. Non-metallic IOFBs analyzed include glass, plastic (polyurethane), and nitro-cellulose fragments.

Conclusion: The JPC/VCE approach to analyzing IOFBs promotes uniform handling and shipping of specimens to minimize contamination. The analytical approach allows for the characterization of IOFBs with a wide variety of compositions. The results support clinical management decisions aimed at optimal treatment for the preservation of patients' visual acuity.

Open Globe Injury Patient Identification in Warfare Clinical Notes

Apostolova E, White HA, Morris PA, Eliason DA, Velez T. Open Globe Injury Patient Identification in Warfare Clinical Notes. AMIA Annu Symp Proc. 2018;2017:403-410.

Introduction: The aim of this study is to utilize the Defense and Veterans Eye Injury and Vision Registry clinical data derived from DOD and VA medical systems which include documentation of care while in combat and develop methods for comprehensive and reliable Open Globe Injury (OGI) patient identification. In particular, we focus on the use of free-form clinical notes, since structured data, such as diagnoses or procedure codes, as found in early post-trauma clinical records, may not be a comprehensive and reliable indicator of OGIs. The challenges of the task include low incidence rate (few positive examples), idiosyncratic military ophthalmology vocabulary, extreme brevity of notes, specialized abbreviations, typos and misspellings. We modeled the problem as a text classification task and utilized a combination of supervised learning (SVMs) and word embeddings learnt in an unsupervised manner, achieving a precision of 92.50% and a recall of89.83%o. The described techniques are applicable to patient cohort identification with limited training data and low incidence rate.

Ocular Manifestations of Mosquito-Transmitted Diseases

Karesh JW, Mazzoli RA, Heintz SK. Ocular Manifestations of Mosquito-Transmitted Diseases. Mil Med. 2018 Mar 1;183(suppl_1):450-458. doi:10.1093/milmed/usx183.

Introduction: Of the 3,548 known mosquito species, about 100 transmit human diseases. Mosquitoes are distributed globally throughout tropical and temperate regions where standing water sources are available for egg laying and the maturation of larva. Female mosquitoes require blood meals for egg production. This is the main pathway for disease transmission. Mosquitoes carry several pathogenic organisms responsible for significant ocular pathology and vision loss including West Nile, Rift Valley, chikungunya, dengue viruses, various encephalitis viruses, malarial parasites, Francisella tularensis, microfilarial parasites, including Dirofilaria, Wuchereria, and Brugia spp., and human botfly larvae. Health care providers may not be familiar with many of these mosquito-transmitted diseases or their associated ocular findings delaying diagnosis, treatment, and recovery of visual function. This article aims to provide an overview of the ocular manifestations associated with mosquito-transmitted diseases.

Simplified Method for Rapid Field Assessment of Visual Acuity by First Responders After Ocular Injury

Godbole NJ, Seefeldt ES, Raymond WR, Karesh JW, Morgenstern A, Egan JA, Colyer MH, Mazzoli RA. Simplified Method for Rapid Field Assessment of Visual Acuity by First Responders After Ocular Injury. Mil Med. 2018 Mar 1;183(suppl_1):219-223. doi:10.1093/milmed/usx175.

Objective: Initial visual acuity after ocular injury is an important measure, as it is an accurate predictor of final visual outcome and gives a rapid estimation of the overall severity of the injury, thereby aiding evacuation prioritization. We devised a simple method for rapidly assessing visual acuity in the field without having to rely on formal screening cards.

Methods: Using common objects, icons, and text found in the injury zone - for example, common military name tapes, rank insignias, patches, emblems, and helmet camouflage bands, which will be known collectively as the Army Combat Optotypes (ACOs) - a Snellen-equivalent method of assessing visual acuity was devised and correlated to the ocular trauma score (OTS).

Results: Ability to read the ACOs at 2, 3, and 5 ft correlates with acuities in the range from 20/20 to 20/400. Identification of ACOs with visual acuity of 20/50 and 20/200 approximates important inflection points of severity for the OTS.

Conclusion: Accurately assessing visual acuity in the field after ocular injury provides essential information but does not require sophisticated screening equipment. Pertinent and accurate acuities can be rapidly estimated using commonly available text or graphical icons such as standard name tapes, patches, and rank insignias.