Visual Dysfunctions and Traumatic Brain Injury

Felix M. Barker II, OD; DoD/VA Vision Center of Excellence (VCE)
Natalya (Natasha) Merezhinskaya, PhD; DoD/VA Vision Center of Excellence (VCE)

Poll question
Choose one answer

- Which occupational area best describes your TBI-related practice?
  - Primary Care
  - Physical Medicine
  - PT/OT
  - Eye Care
  - Vision Rehabilitation

TBI Statistics

- In 2014,[1] about 2.87 million TBI-related emergency department (ED) visits, hospitalizations, and deaths occurred in the United States

- From 2006 to 2014, the number of TBI-related emergency department visits, hospitalizations, and deaths increased by 53%.

[1] Centers for Disease Control and Prevention (2019). Surveillance Report of Traumatic Brain Injury-related Emergency Department Visits, Hospitalizations, and Deaths—United States, 2014. Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

DoD TBI Totals Worldwide 2000-2018

Defense Health Agency

DoD Numbers for Traumatic Brain Injury
Worldwide – Totals

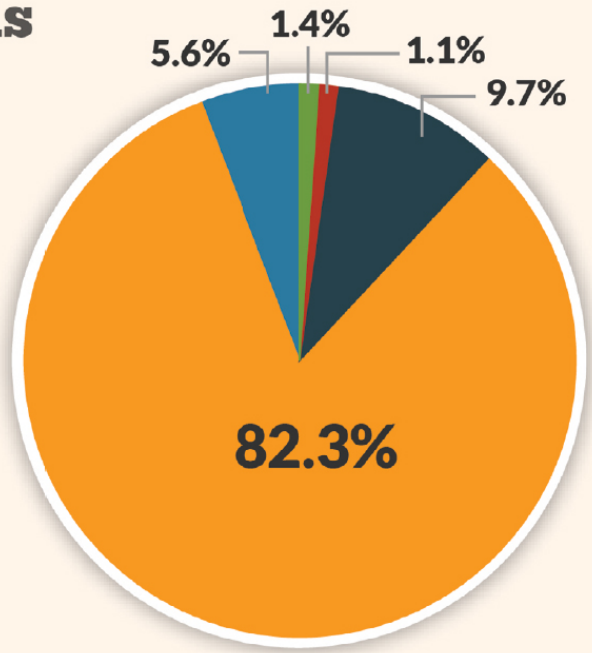
2000 - 2018 Q1

Penetrating	5,215
Severe	4,067
Moderate	37,424
Mild	315,897
Not Classifiable	21,344
Total - All Severities	**383,947**

Source: Defense Medical Surveillance System (DMSS), Theater Medical Data Store (TMDS) provided by the Armed Forces Health Surveillance Center (AFHSB)

Prepared by the Defense and Veterans Brain Injury Center (DVBIC)

*Percentages do not add up to 100% due to rounding



2000 - 2018 Q1, as of June 21, 2018

https://dvbic.dcoe.mil/dod-worldwide-numbers-tbi

Visual Deficits and Dysfunctions Associated with Traumatic Brain Injury: A Systematic Review and Meta-Analysis

Natalya Merezhinskaya, PhD, Rita K. Mallia, OD, MPA, DoHwan Park, PhD, Daniel W. Bryden, PhD, Karan Mathur, and Felix M. Barker II, OD, MS, FAAO

Optom Vis Sci. 2019 Aug;96(8):542-555

Objectives

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.

Literature Review vs Systematic Review

Literature Review	Systematic Review
Study question can be general and not well defined	Study question is well defined and focused
Publications are searched randomly, "pick and choose" approach; using only few databases	Publications are searched using established methodology; using several large databases
Papers are reviewed without any procedural restrictions	Publications are reviewed using an established procedure; strict inclusion and exclusion criteria are applied; two or more researchers to establish inter-rater reliability
A writer gives a subjective interpretation of the data	Data is analyzed using referenced methodology; the bias, strength of evidence, etc. are considered in the analysis

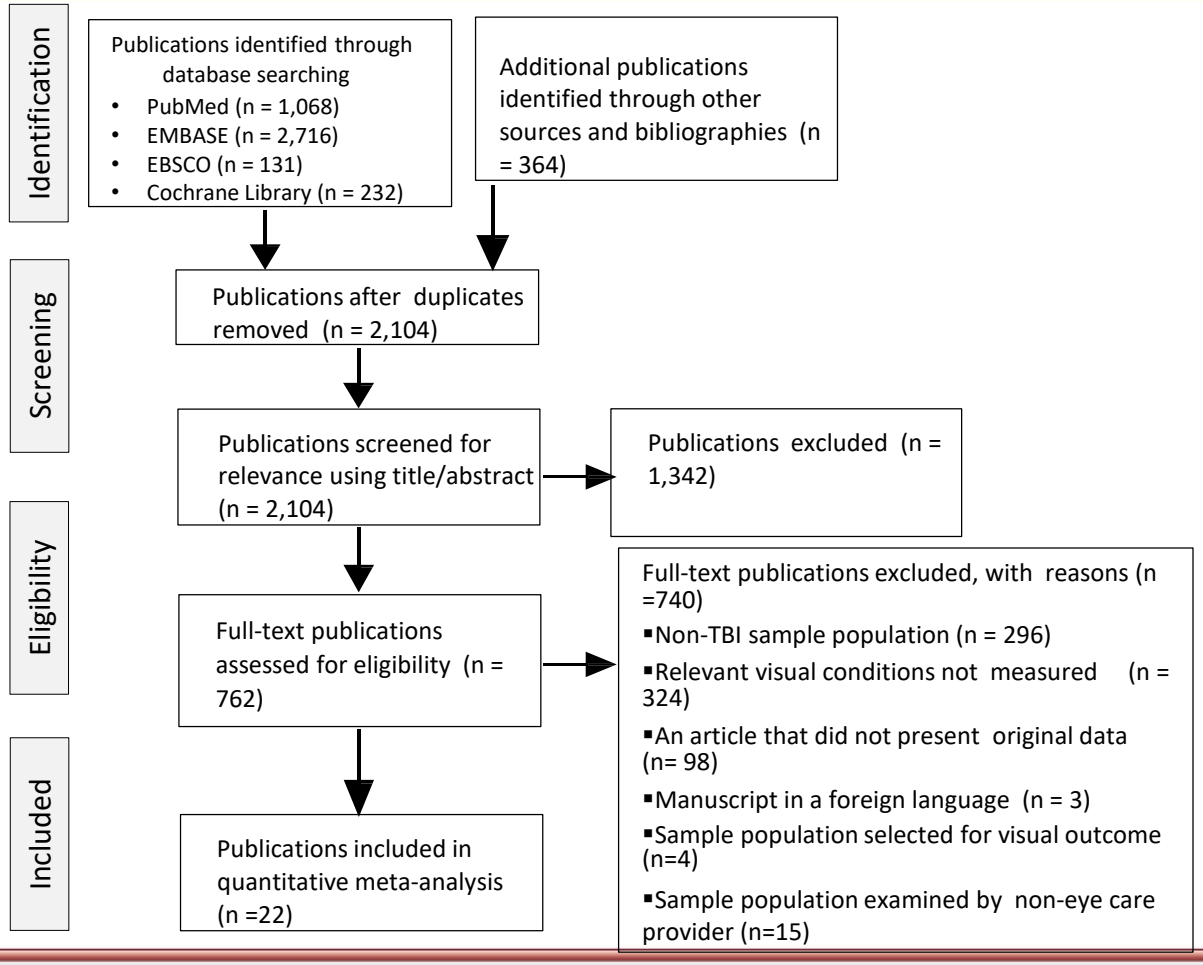
Meta-Analysis

- Meta-analysis is a set of techniques used “to combine the results of a number of different reports into one report to create a single, more precise estimate of an effect” (Ferrer, 1998). The aims of meta-analysis are “to increase statistical power; to deal with controversy when individual studies disagree; to improve estimates of size of effect, and to answer new questions not previously posed in component studies” (Hunter and Schmidt, 1990)

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion criteria
TBI diagnosis by a trained medical professional	Single case designs
Screening/diagnostic testing for visual dysfunctions by an eye care provider	The sample population artificially selected for one of the visual outcomes
Published in English in a peer-reviewed journal with full text available	The sample population previously diagnosed with a chronic (or other) eye condition
Accommodation was measured in non-presbyopic TBI populations	Brain injury unrelated to trauma
	TBI and/or visual outcomes were self-reported or otherwise not clinically diagnosed

Flow diagram of the systematic literature search process according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)



Statistical Analysis

- All statistical analyses were conducted using R statistical software (3.4.2) and its ‘meta’ and ‘metafor’ package.
- Prevalence rates were calculated by dividing the number of individuals with TBI diagnosed with the visual outcome by the total number of individuals diagnosed with TBI.
- Subgroup analysis was performed for four moderators: (1) study design (prospective versus retrospective) (2) TBI severity (3) diagnostic criteria and (4) Risk of Bias (RoB)

Prevalence of Visual Dysfunctions in TBI Patients

Visual dysfunction	Accommodative Dysfunction	Convergence Insufficiency	Visual Field Loss	Visual Acuity
Total patient count	1,271	2,140	2, 106	1,333
Prevalence 95% CI	**42.85%** 31.1-54.7	**36.3%** 28.2 – 44.9	**18.2%** 10.6 – 27.1	**0%** 0.0 – 1.1
Heterogeneity,I^2	91.35%	89.94%	92.67%	62.2%
Prevalence, no TBI control (lit.)	5.8% – 32.4%	4.2% – 31.4%	0% - 3%	<1%

Prevalence of Visual Field Loss in Moderate-to-Severe TBI Compared to Mild TBI

TBI Severity	Moderate to Severe TBI	Mild TBI
Prevalence 95% CI	**39.8%** 29.8 – 50.3	**6.6%** 6.9 – 34.2

- The prevalence of accommodative dysfunction and convergence insufficiency did not differ in patients with moderate-to-severe compared to mild TBI
- Only one study of moderate-to-severe TBI data was available for accommodative dysfunction

Other Moderating Variables and Their Relationship with Visual Outcome Prevalence

- In addition to TBI severity, the studies were evaluated on the association of the prevalence rates with RoB, diagnostic criteria, and study design (prospective versus retrospective)
- No singular factor accounted for a statistically significant portion of the heterogeneity
- The screening/diagnostic criteria for the visual dysfunctions varied significantly between different studies (e.q. diagnostic cut offs for the NPC varied from 6-12.7 cm)
- Many studies had incomplete data on the demographics, TBI severity, mechanism of injury, etc.

Conclusions

- Accommodative dysfunction and convergence insufficiency are the most prevalent of the four visual outcomes examined in this study, followed by the visual field loss.
- The relatively low prevalence of visual acuity loss due to neurologic consequences of TBI and in the absence of eye injury suggests that the test for visual acuity, the most commonly performed measure of the visual system, is an insufficient stand-alone surrogate for overall visual health.
- Heterogeneity was one of the major limitations of this study with no one single factor but rather a combination of several factors responsible for it.
- A carefully constructed prospective trial with a large sample and consistent evaluation techniques will have a tremendous impact on the field and will address the various limitations outlined above.

Poll question
Choose one answer

- What is your knowledge and skill level regarding post-TBI eye/vision-related effects?
  - Exclusively
  - Heavily
  - Occasionally
  - Rarely
  - Never

Clinical Impact-
Near Distance Visual Dysfunctions

- Accommodation and Convergence are frequently affected after TBI of any severity and have the potential to affect reading and other near visual tasks
  - Accommodative Dysfunction (AD) affects focusing to reading and other near target distances.
  - Convergence Insufficiency (CI) reduces the ability to turn the eyes inwardly to near (reading) distances, thus affecting ability to maintain single vision at near.

https://www.dvidshub.net/image/5576874/usns-comfort-crew-treats-patients-peru-medical-sites

Symptoms of Near Visual Dysfunctions

- Visual blurring at near visual distances
- Doubling of vision at near visual distances
- Losing your place while reading
- Inability to sustain reading and other near visual tasks
- Sensitivity to light

https://www.dvidshub.net/search/?q=5737568&view=grid

TBI-related Visual Dysfunctions Can Affect Rehabilitation and Reintegration

- Because visual acuity is usually normal after TBI, patients may often be unaware of visual dysfunctions and attribute difficulties with reading and other symptoms to co-morbid conditions, such as PTSD, or psychosocial factors.
- Referral to an Eye Care Provider can help manage these problems using:
  - ❑ Lenses
  - ❑ Prisms
  - ❑ Visual Rehabilitation

Visual Field Defects After TBI

- Less frequent than Accommodation and Convergence Problems
- More common with increasing TBI Severity
- Reading and mobility symptoms
- Requires Neurological Assessment/management
- Requires specific rehabilitation

https://www.dvidshub.net/image/884840/warfighter-eye-center

Other TBI-Associated Oculomotor Dysfunctions

- Smooth Pursuit Dysfunction
- Saccadic Dysfunction
- Muscle Paresis
- Heterophoria
  - Lateral
  - Vertical

https://www.dvidshub.net/image/1744212/scott-air-force-base-optometry

Ask About and Look for Ocular Trauma

- TBI can be associated with eye trauma that is not realized by the patient.
- Vision Acuity may be normal
- The injury may be occult and may pre-dispose the patient to future vision loss
- Referral to eye care may be important

- Iridodialysis (iris disinsertion) due to eye trauma predisposes the individual to future glaucoma

Source: Won I. Kim, MD COL MC USA

Summary

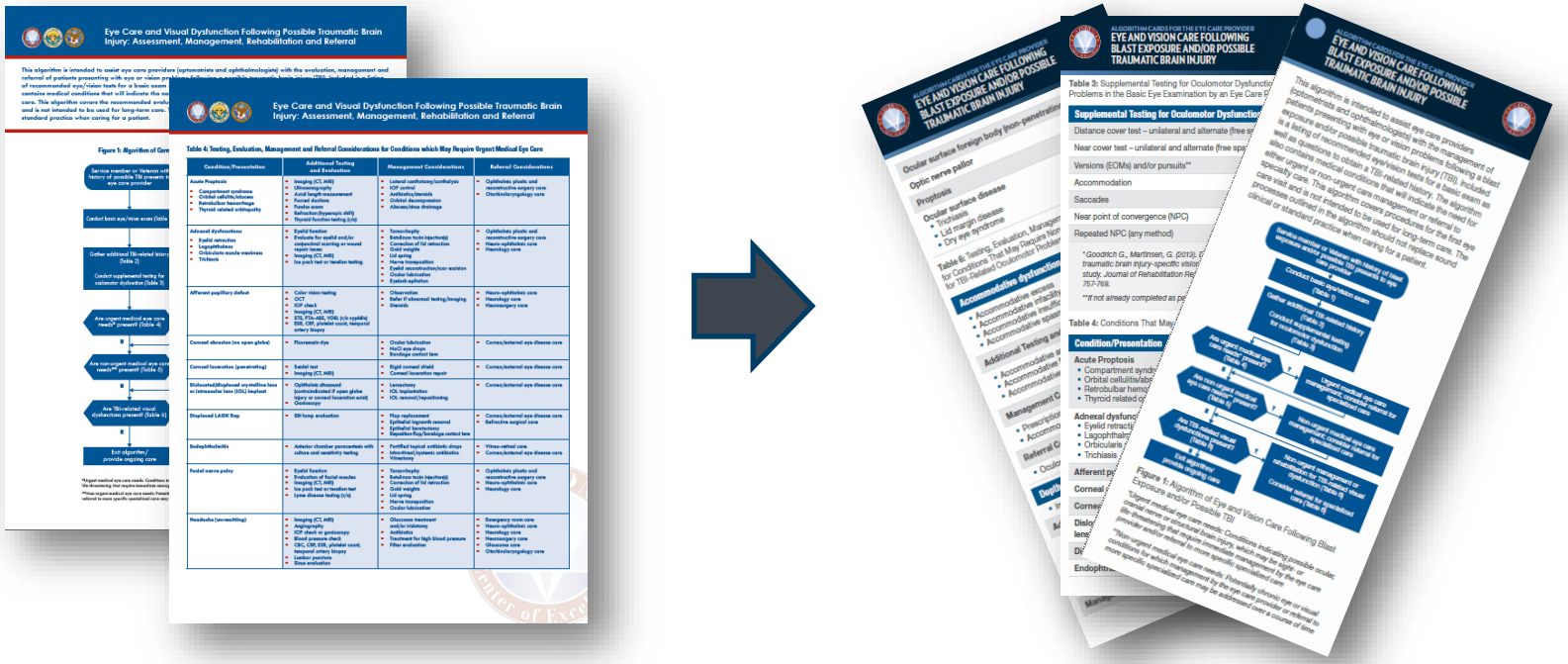
- TBI is commonly associated with Accommodative and/or Convergence problems that may affect rehabilitation and reintegration
- History of reading problems, especially sustained reading, is common
- Visual Acuity is not a good screen since it is often normal.
- Visual field defects are also common
- Saccadic/pursuit eye movements can be affected
- Eye muscle paralysis can occur
- Both frank and occult eye injuries may occur
- Referral to Eye Care is important
- Referral by eye care providers to TBI care providers is important for patients with these vision conditions who may have experienced TBI but may not have been fully worked up

VCE Clinical Recommendations

- CR for the **Eye Care Provider** Eye and Vision Care Following **Blast Exposure and/or Possible TBI**
- CR for the **Eye Care Provider** Assessment and Management of **Oculomotor Dysfunctions Associated with TBI**
- CR for the **Eye Care Provider and Rehabilitation Specialists** Rehabilitation of Patients with **Visual Field Loss Associated with Traumatic or Acquired Brain Injury**

CR Pocket Cards

Developed as a portable tool for responders in theater, the **Clinical Recommendation Reference Card** offers a concise representation of the main points of the CR, including the algorithm of care along with tables of evaluation questions, urgent and non-urgent medical conditions, and evaluation and management recommendations for oculomotor dysfunctions.



Patient Brochure

Vision Problems Associated With Traumatic Brain Injury

Developed as an educational tool for patients to learn the signs and symptoms of TBI-related vision problems.

INTRODUCTION

Changes in vision can occur following blast exposure, eye injury, concussion or a traumatic brain injury (TBI). People affected by these problems may not be immediately aware of the impact on their vision, because some injuries are subtle or may be overlooked in the presence of other more obvious combat trauma to other parts of the body. Being aware of the symptoms and changes in the eye and vision is crucial to maximizing recovery from vision problems of all causes.

Did you know?

- According to the National Institute of Neurological Disorders and Stroke, approximately 1.4 million people experience a TBI annually.
- An estimated 23.3% of people with TBI are thought to experience vision impairments and/or visual dysfunctions that can hinder the person's success in school or at work.*
- Research shows more than half of the human brain is devoted directly or indirectly to vision, making brain injury an important cause of vision impairment.†

*Alvarez T, et al. (2012). Concurrent Vision Dysfunctions in Convergence Insufficiency With Traumatic Brain Injury. Optometry and Vision Science, 89(12), 1740-51.

†NIT Research - Brain Processing of Visual Information. (1996, December). http://newsoffice.mit.edu/1996/visualprocessing

COMMON CAUSES OF EYE INJURY & TBI-RELATED VISION PROBLEMS

Common causes include:

- Blast exposure
- Blunt force
- Car accidents
- Falls
- Assaults

Goodrich and Martinsen* developed a list of recommended questions to obtain a detailed ocular history for a Service member or Veteran who has been exposed to a blast or sustained an eye or head injury, including:

- Have you noticed a change in your vision since your injury?
- Do you bump into objects and walls more now than before your injury?
- Have you had any double vision since your injury?
- Have you noticed a change in your ability to read since your injury?

*Goodrich G., Martinsen, G. (2013). Development of a mild traumatic brain injury-specific vision screening protocol: a Delphi study. Journal of Rehabilitation Research & Development, 50(6), 757-768.

vce.health.mil

Many visual dysfunctions can be improved through these commonly recommended treatments:

- Prescription glasses or contact lenses
- Prisms
- Oculomotor therapy
- Vision therapy
- Pharmacotherapy *(medication management)*
- Surgery

CONCLUSION

Eye/head trauma or exposure to a blast can result in both obvious and subtle injuries to the eye or in the brain resulting in both immediate and/or longer term vision loss and visual dysfunction. If you have been exposed to a blast and/or suspect you may have sustained a TBI, it is important to closely monitor your vision and eye health. If you have experienced any change in vision, visit an eye care provider (optometrist or ophthalmologist).

OTHER RESOURCES

- **Defense and Veterans Brain Injury Center** http://dvbic.dcoe.mil
- **BrainLine Military** www.BrainLineMilitary.org

- Cataract
- Nystagmus *(involuntary eye movements)*
- Dry eye syndrome
- Low vision
- Trouble focusing
- Blurred vision
- Eye strain
- Frequent headaches
- Difficulty reading
- Sensitivity to light
- Night blindness

VISION CENTER OF EXCELLENCE

Walter Reed National Military Medical Center
8901 Rockville Pike, Suite 1403-A
Bethesda, Maryland 20889
301-400-1130

Administrative Office
5113 Leesburg Pike
Skyline Four, Suite 602
Falls Church, VA 22041

vce.health.mil
facebook.com/VisionCoE
twitter.com/VisionCoE

VISION CENTER OF EXCELLENCE

VISION PROBLEMS ASSOCIATED WITH TRAUMATIC BRAIN INJURY

vce.health.mil

Incidence and Temporal Presentation of Visual Dysfunction following Diagnosis of Traumatic Brain Injury, Active Component, U.S. Armed Forces, 2006-2017

Mark E. Reynolds, MD, MPH; Felix M. Barker II, OD, MS; Natalya Merezhinskaya, PhD; Gi-Taik Oh, MS; Shauna Stahlman, PhD, MPH

MSMR 2019 Sep; 26 (9):13-24

Inclusion and Exclusion Criteria

- Data for 2006-2017 were obtained from the Defense Medical Surveillance System (DMSS), a longitudinal administrative data warehouse (171 868 cases of mTBI and 18 237 cases of moderate/severe TBI)
- Data were limited to recorded diagnostic codes and demographic values
- Each TBI case was matched to another active component military member (control) who had never been diagnosed with TBI or ocular trauma during their service

Inclusion Criteria	Exclusion criteria
TBI diagnosis	Any type of ocular trauma at any time during military service
At least two medical encounters for the same visual dysfunction within one year	Diagnosis for any visual dysfunction before TBI incident date

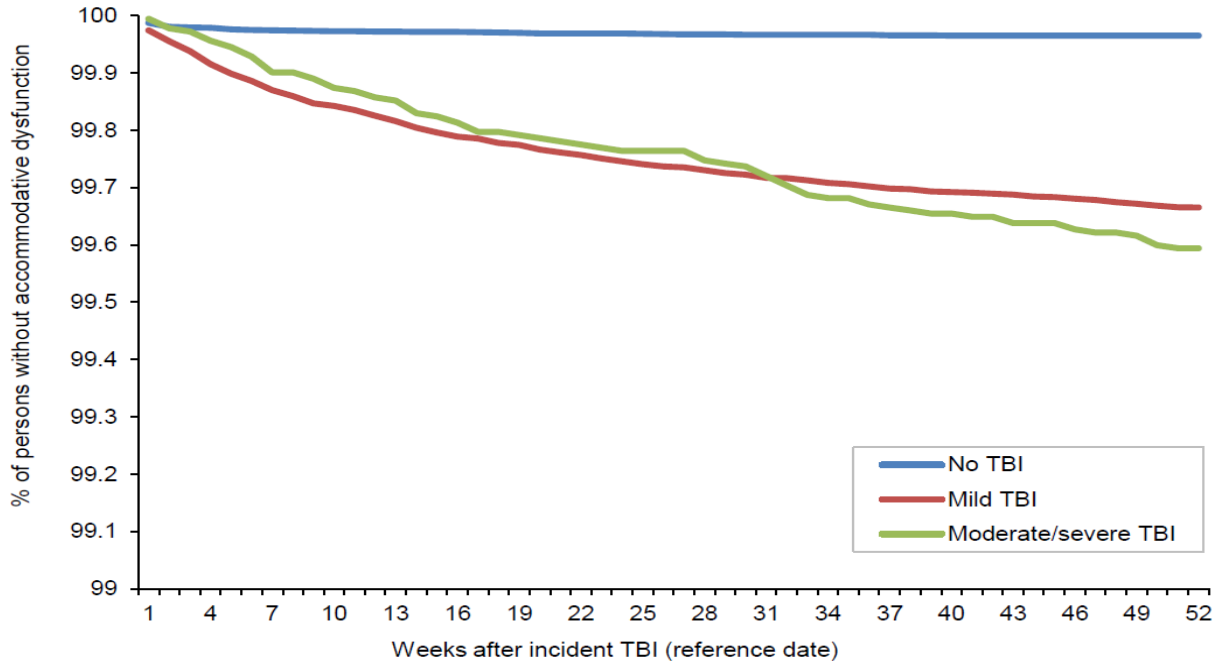
Multivariable Poisson Regression Models for Visual Dysfunction Outcome*

Visual dysfunction	Adjusted Incidence Rate (AIR)	95% CI	P-value
Accommodative Dysfunction			
Mild TBI vs no TBI	3.58	2.70-4.76	<0.0001
Moderate/severe TBI vs no TBI	4.68	3.29-6.66	<0.0001
Convergence Insufficiency			
Mild TBI vs no TBI	3.98	3.09-5.13	<0.0001
Moderate/severe TBI vs no TBI	5.64	4.16-7.65	<0.0001

* All models adjusted for service, sex, race/ethnicity, age, rank, military occupation, and deployment history

Survival Curves for Accommodative Dysfunction

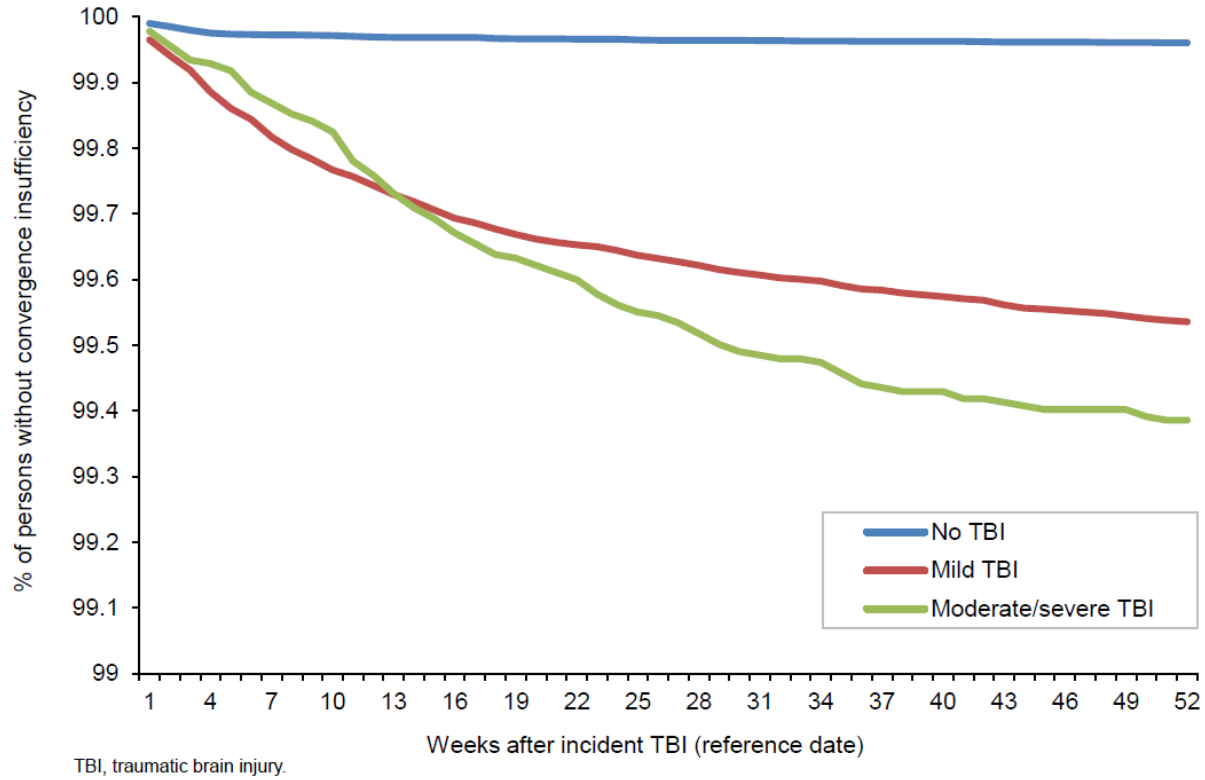
FIGURE 1. Percentage of individuals without incident accommodative dysfunction diagnosis during the 1-year follow-up period, by TBI cohort, 2006–2018



TBI, traumatic brain injury.

Survival Curves for Convergence Insufficiency

FIGURE 2. Percentage of individuals without incident convergence insufficiency diagnosis during the 1-year follow-up period, by TBI cohort, 2006–2018



TBI, traumatic brain injury.

Conclusions

- Service members with mild or moderate/severe TBI have significantly higher AIRs of AD and CI compared to service members with no TBI
- AD or CI could be diagnosed soon after the initial TBI diagnosis and this diagnosis was rendered at any time up to the limit of this study (52 weeks)
- Providing primary care providers with standardized screening instruments and referral guidelines for visual dysfunctions after TBI would increase evaluations by eye care providers
- Eye care providers diagnosing AD and CI in service members should seek a history of TBI which may not have been documented
- The development and dissemination of standard documentation and coding guidelines for visual dysfunctions following TBI is expected to improve surveillance and monitoring efforts for these important conditions and facilitate continuity of care for affected service members

VCE/Uniformed Services University TBI Delphi Consensus Project

- Goal: To seek consensus from a broad panel of subject matter experts (SMEs) on the following questions:

  - What visual functions can be affected as a result of TBI;

  - What tests are recommended for both screening and specialized eye care examination post-TBI;

  - How these tests should be performed (including normative values)

- SMEs panel:
  - Ophthalmology, Optometry, Neurology, Audiology, Low Vision and Blind Care Rehabilitation, Physical Therapy, Physiatry, Occupational Therapy; Sports Medicine
  - VA, DoD, civilian

Vision Center of Excellence/ Uniformed Services University TBI Delphi Consensus Project

Photo courtesy VCE

QUESTIONS?

Poll question
Choose one answer

- How useful was presented information for your TBI-related activities?
  - Very useful
  - Somewhat useful
  - Not very useful