

Traumatic Brain Injury as a Chronic Disease: Addressing Common Physical, Psychological, and Social Sequelae in the Years and Decades Following the Injury

Dr. Diane Mortimer; Dr. Paola Toussaint Gonzalez; Kelsey Macomber, LICSW



Session Description

TBI survivors and their caregivers often face significant stressors after the acute phase is over.

Addressing these issues through use of a chronic illness model could help survivors successfully implement post-injury adaptations and optimize quality of life.

Complications, including medication non-adherence, falls, and housing issues, could be anticipated and prevented.

Objectives

After participating in this session, learners will be able to:

- describe at least three common physical, psychological, and social sequelae of TBI that tend to occur years or decades after the injury.
- discuss at least three common age-related changes that can significantly affect TBI survivors as they live in the years and decades after injury.
- discuss at least three ways that a chronic illness model, including case management and regularly scheduled medical follow up, can help prevent complications and can help optimize quality of life in brain injury survivors.

Speakers

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Disclosures

We do not have any disclosures.

Kelsey Macomber and Diane Mortimer work at the VA. The viewpoints presented here are ours. We are not speaking on behalf of VA or US government.

988 for Suicide prevention

988 Suicide & Crisis Lifeline

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24/7, confidential crisis support

for Veterans and their loved ones

You don't have to be enrolled in VA benefits or health care to connect.

Dial 988 then Press 1

Chat online

Text 838255



Part 1: TBI as a Chronic Disease

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TBI in the world:

TBI is a major socioeconomic and health problem worldwide:

It is a “silent epidemic”

Many TBI-related issues and longer term impact may not be visible

It remains the main cause of morbidity and mortality in those aged <45 years.

The incidence of TBI is commonly underestimated, as mild TBI is often underreported and many individuals may not present to hospital.

Part 1: TBI as a Chronic Disease

There are an estimated 1.7 million people with a TBI annually and over 5.3 million people live with a disability due to TBI in the USA alone.

Globally, incidence:

Mild TBI: 100–300 per 100,000

Moderate TBI: 15–20 per 100,000

Severe TBI: 12–14 per 100,000

Incidence of TBI is greater in regions characterized by socioeconomic deprivation with higher mortality in those with severe injuries and the elderly.

Traumatic Brain Injury: A Disease Process, Not an Event

Brent E. Masel¹ and Douglas S. DeWitt²

Event: “the final result; the outcome.”

Chronic disease - having one or more of the following characteristics: it is permanent, caused by non-reversible pathological alterations, requires special training of the patient for rehabilitation, and/or may require a long period of observation, supervision, or care

(World Health Organization, 2002).

Brain Injury as a Chronic Condition

Are residual effects of TBI static once initial recovery has plateaued?

Change is more common!

After 10 years, as many as 1 in 3 persons decline from a previously achieved outcome, with most deteriorating 2 categories on the Glasgow Outcome Scale-Extended.

Accumulating evidence that a subset of TBIs triggers progressive degenerative processes affecting cognitive or motor function, or both.

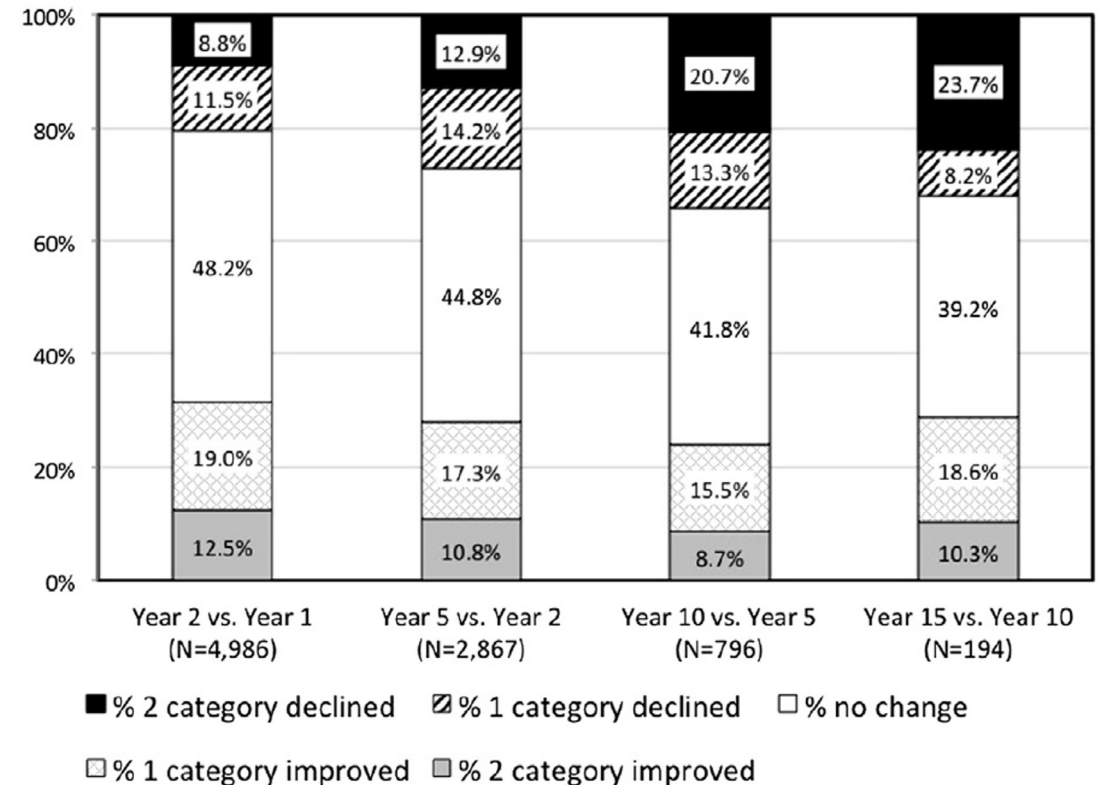


Fig 1 One- and 2-category change in Glasgow Outcome Scale-Extended² score 2 to 15 years after TBI.

Brain Injury as a Chronic Condition

“Injury to the brain can evolve into a lifelong health condition termed chronic brain injury (CBI). CBI impairs the brain and other organ systems and may persist or progress over an individual’s life span. CBI must be identified and proactively managed as a lifelong condition to improve health, independent function and participation in society.”

Hammond FM, Malec JF. Rethinking brain injury. *Brain Inj Prof* 2013; 10. In press.

From the TBI Model Systems (TBIMS) collaboration

By 5 years after injury:

- one in five had died

- 12% of survivors were living in institutional settings

- 50% had been readmitted to hospital at least once

Of those who survived, the majority were moderately or severely disabled and **more than a third had deteriorated from a previously achieved level after injury.**

Deterioration in functional outcome was evident across all age groups, implying that decline is **not simply age-related.**

The **typical trajectory** was to improve gradually over time for about 10 years, plateau, and then decline.

Late mortality after TBI

Many studies have examined mortality within the first 6 months after brain injury, but far fewer studies have assessed mortality risks in the long term.

There is consensus that moderate-to-severe injuries have an **enhanced risk of mortality that might persist for many years.**

A puzzling observation is that high mortality rates might be observed **even after mild TBI.**



Long-term mortality after moderate to severe TBI

TBIMS national database was used to **examine survival status of 8,573 TBI patients** who had received inpatient rehabilitation after TBI.

- Patients with TBI were more than twice as likely to die than individuals in the general population (standardized mortality rate [SMR] 2.25; 95% CI 2.10 – 2.40)
- Life expectancy was on average 7 years shorter.
- The greatest relative risk of death after TBI occurred **in younger age groups**.
 - 15 –19 years at injury: the mortality rate was nearly 5x that of matched individuals.
 - More commonly died secondary to accidental injuries- dysexecutive symptoms?
 - Predictors of mortality: disability at discharge and preinjury drug or alcohol abuse

Why increased morbidity/mortality?

Multiple challenges to effective health management:

- Cognitive impairment and behavioral symptoms
- Limited financial resources
- Reduced participation in society
- Variable access to specialized care

Short- and long-term effects on the ANS:

- Chronic inflammation, insulin resistance, and metabolic syndrome
- Dysregulation of emotions and behavior

The intersection of TBI-related impairments with chronic health problems can have a mutually exacerbating effect on overall health and life quality.

Original Investigation | Neurology

Association of Traumatic Brain Injury With the Risk of Developing Chronic Cardiovascular, Endocrine, Neurological, and Psychiatric Disorders

Saef Izzy, MD; Patrick M. Chen, MD; Zabreen Tahir, MD; Rachel Grashow, PhD, MS; Farid Radmanesh, MD, MPH; David J. Cote, MD, PhD; Taha Yahya, BSc; Amar Dhand, MD, DPhil; Herman Taylor, MD; Shirley L. Shih, MD; Omar Albastaki, BA; Craig Rovito, MD; Samuel B. Snider, MD; Michael Whalen, MD; David M. Nathan, MD; Karen K. Miller, MD; Frank E. Speizer, MD; Aaron Baggish, MD; Marc G. Weisskopf, PhD, ScD; Ross Zafonte, DO

JAMA Network Open. 2022;5(4):e229478. doi:10.1001/jamanetworkopen.2022.9478

TBI and increased comorbidities

Large observational age-, race-, and sex-frequency–matched cohort study over a 10-year period:

> To assess the **risk and time to cardiovascular, endocrine, psychiatric, and neurological diagnoses** in individuals with **mild TBI (mTBI) and moderate to severe TBI (msTBI)** compared with individuals **without head injury**

> Evaluate the association between post-TBI comorbidities and mortality after hospital discharge.

TBI and increased risk for comorbidities

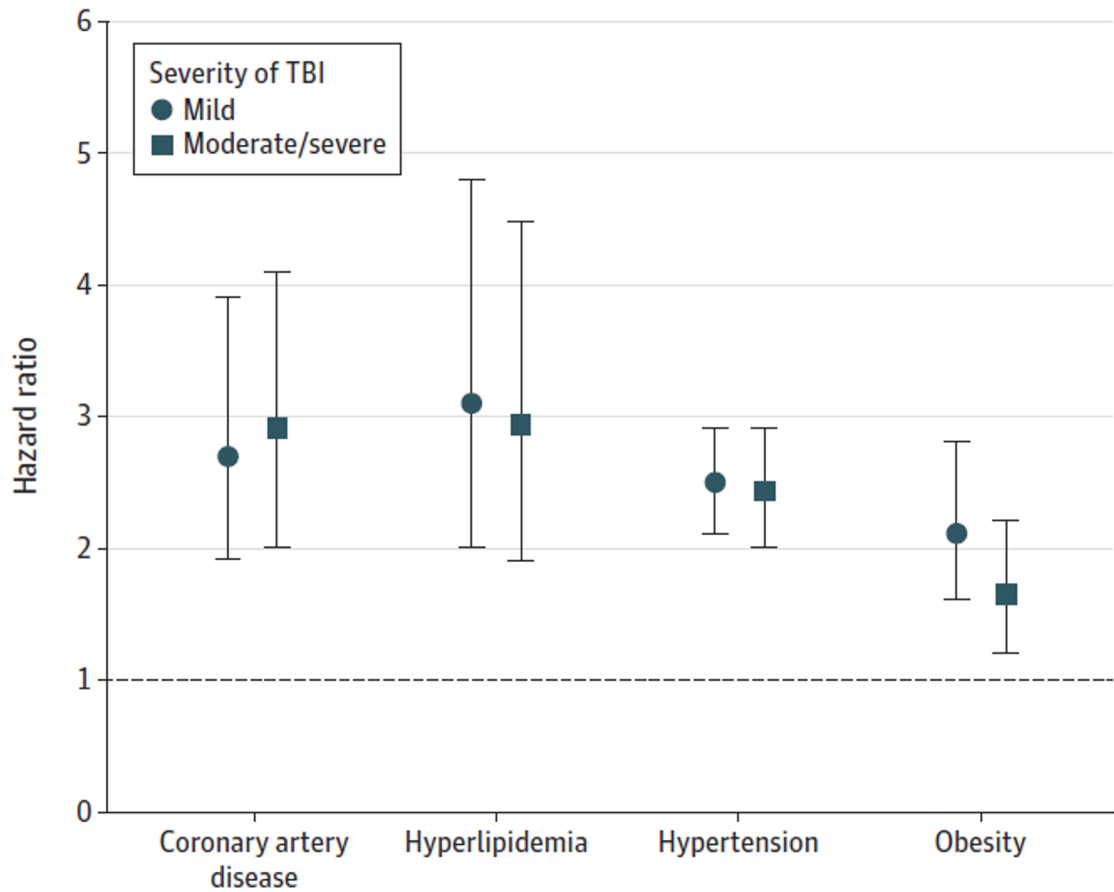
Using a large data pool of patients:

- Found 49 000 patients with TBI between 2000 and 2015.
- Selected 4351 with **mTBI** without prior comorbidities
- Selected patients diagnosed with **msTBI** without prior comorbidities
age-, sex-, and race-frequency–matched
- Selected unexposed group **without TBI** and without comorbidities
age-, sex-, and race-frequency–matched

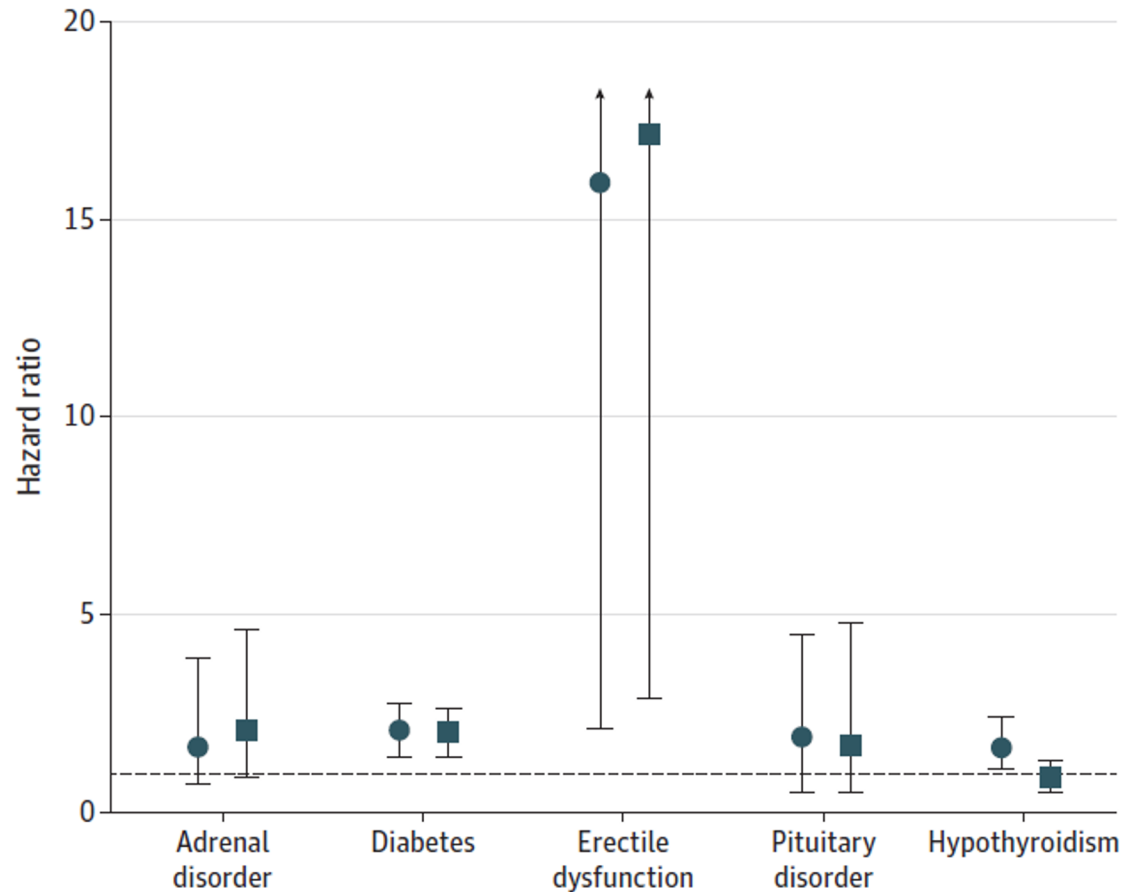


Figure 1. Risks of Multisystemic Comorbidities After Traumatic Brain Injury (TBI) Stratified by Severity

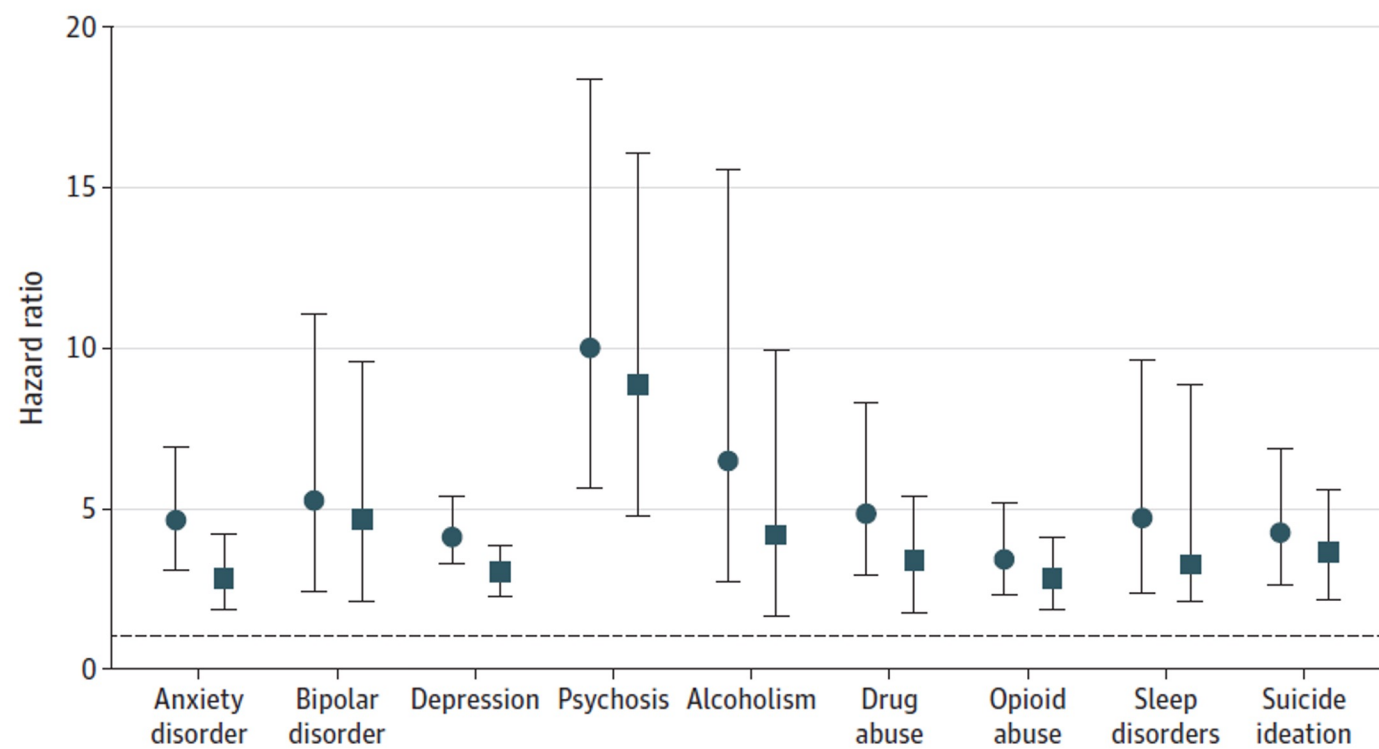
A Cardiovascular disorders



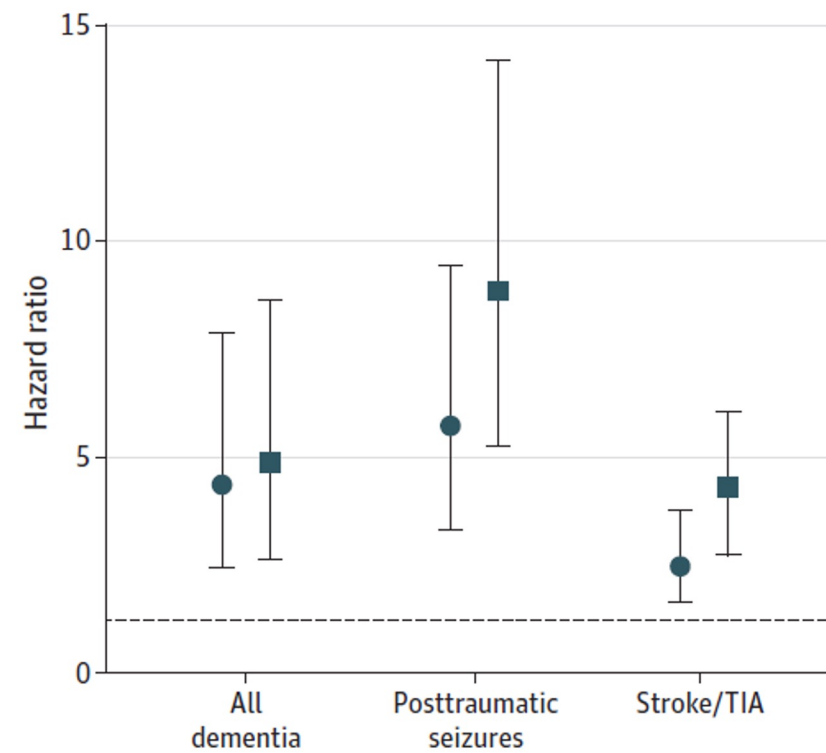
B Endocrine disorders



C Psychiatric disorders

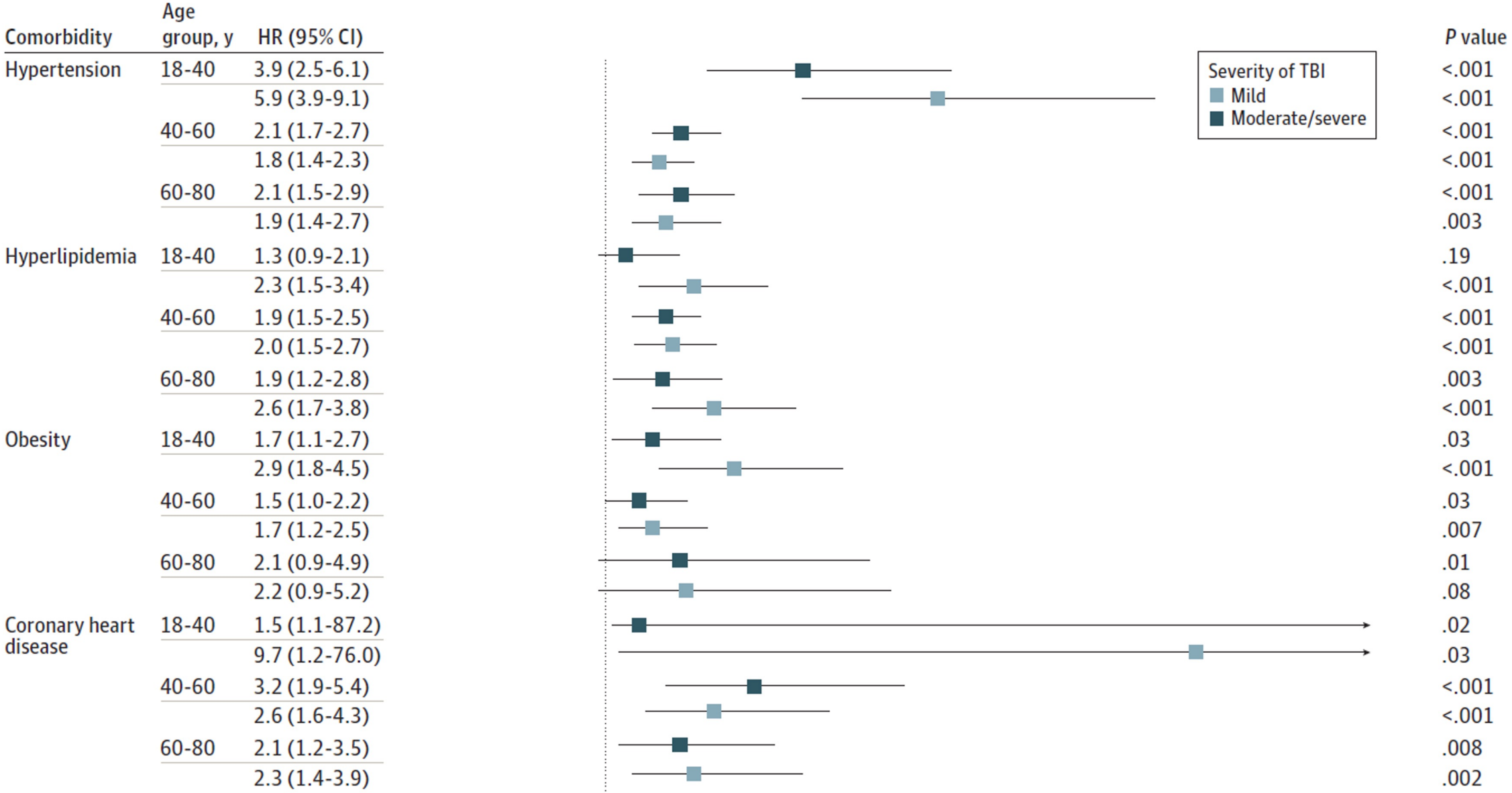


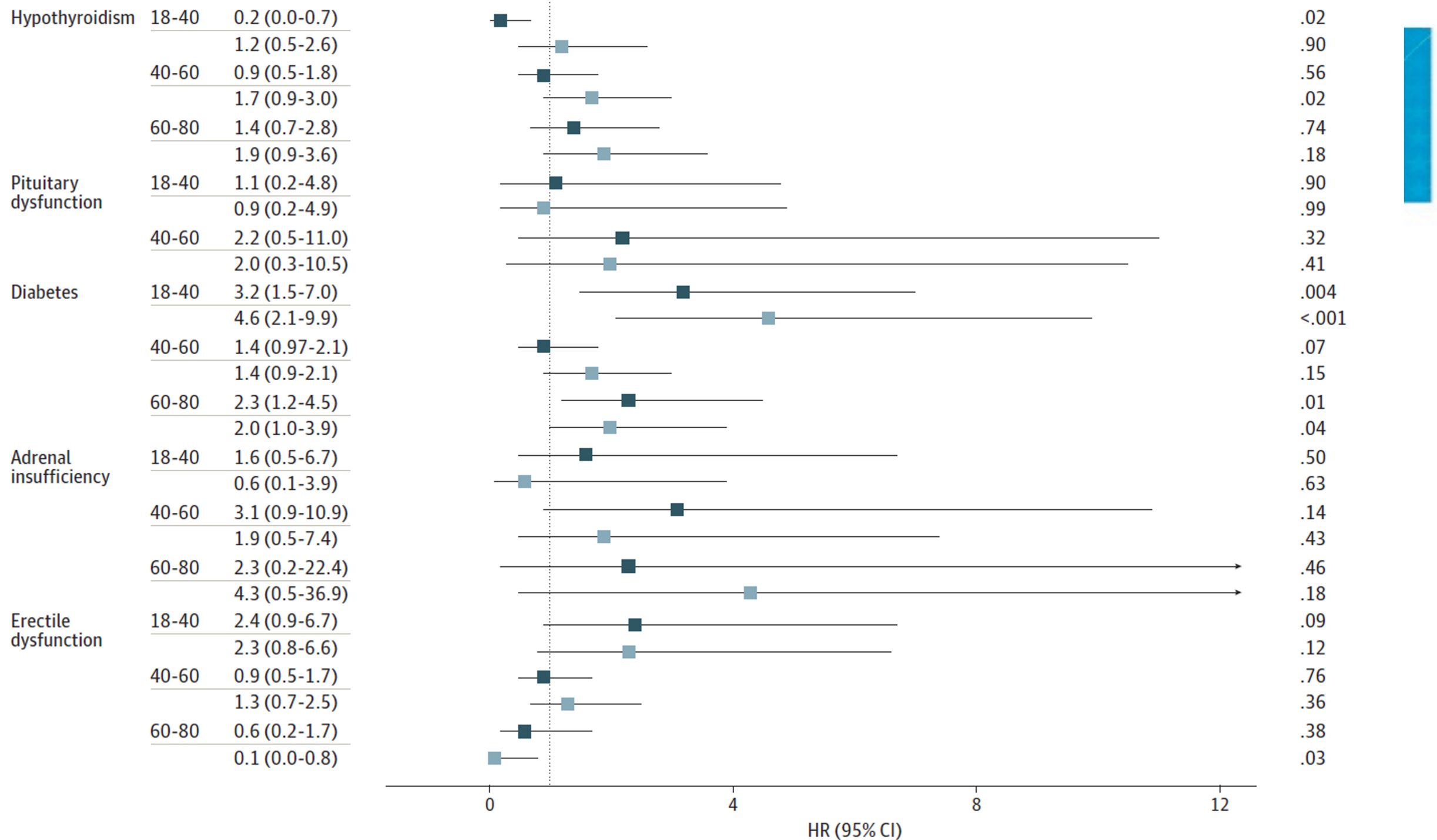
D Neurologic disorders



Whiskers indicate 95% CIs; TIA, transient ischemic attack.

Figure 2. Risk of Cardiovascular and Endocrine Comorbidities After Traumatic Brain Injury (TBI) Stratified by Age





TBI and increased risk for comorbidities

The younger age group (18-40 years) demonstrated significantly higher risk for:

- cardiovascular diseases: in particular, hypertension risk for both mTBI (HR, 5.9) and msTBI (HR, 3.9)
- hyperlipidemia (HR, 2.3) and diabetes (HR, 4.6) were increased in the mTBI group
- posttraumatic seizures, and psychiatric disorders in both mTBI and msTBI groups

The middle-aged (41-60 years) group, demonstrated significantly higher risk for:

- cardiovascular, psychiatric, and neurological disorders after mTBI and msTBI
- patient with msTBI had higher risk of ischemic stroke and transient ischemic attack

The patients older than 60 years, demonstrated significantly higher risk for:

- cardiovascular and neuropsychiatric comorbidities in both TBI subgroups
- patients with mTBI also had a significant higher risk of anxiety disorder
- patients with msTBI was associated with a higher risk of psychosis and seizures

TBI and increased risk for mortality

Patients with msTBI, but not those with mTBI, were at higher risk of mortality compared with the unexposed group ($P < .001$)

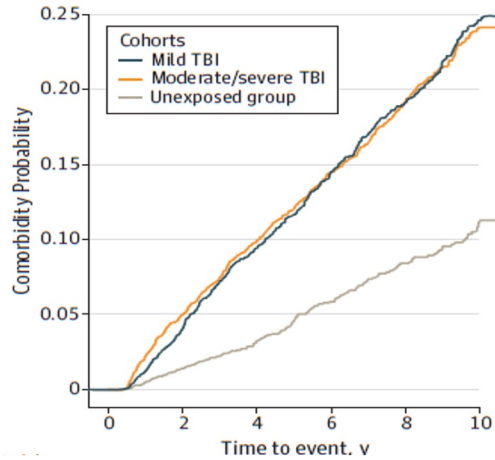
**Table 2. Logistic Regression Analysis of Associations
Between Post-Traumatic Brain Injury Comorbidities and Mortality**

Comorbidities	Odds ratio (95% CI)
Cardiovascular disorders	
Hypertension	1.3 (1.1-1.7)
Hyperlipidemia	0.8 (0.6-1.1)
Obesity	0.4 (0.2-0.8)
Coronary heart disease	2.2 (1.6-3.0)
Endocrine disorders	
Hypothyroidism	0.5 (0.2-1.0)
Pituitary dysfunction	1.2 (0.1-6)
Diabetes	1.3 (0.8-1.9)
Adrenal insufficiency	6.2 (2.8-13.0)
Erectile dysfunction	0.5 (0.1-1.4)

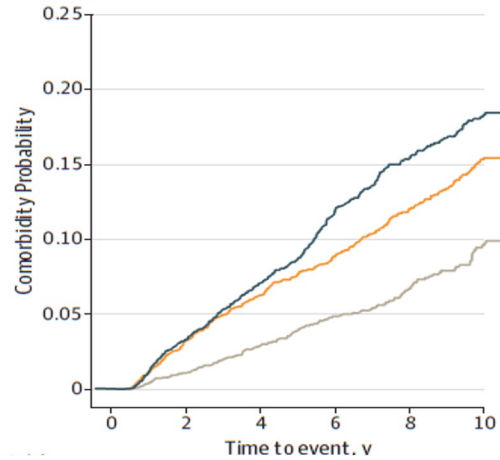
Psychiatric disorders	
Depression	1.3 (0.9-1.8)
Bipolar disorder	2.0 (0.8-4.1)
Schizophrenia or psychosis	3.0 (2.1-4.4)
Anxiety disorder	1.4 (1.1-1.9)
Sleep disorder	1.1 (0.7-1.6)
Suicide ideation, intent, or attempt	2.4 (1.1-4.6)
Substance misuse	3.7 (2.2-5.9)
Opioid misuse	3.7 (2.0-6.0)
Alcohol misuse	2.5 (1.6-3.8)
Neurological disorders	
Ischemic stroke or transient ischemic attack	1.6 (1.1-2.4)
Seizure disorder	3.4 (2.3-4.8)
Dementia	3.0 (2.0-4.5)

Time to Development of Comorbidities Following TBI

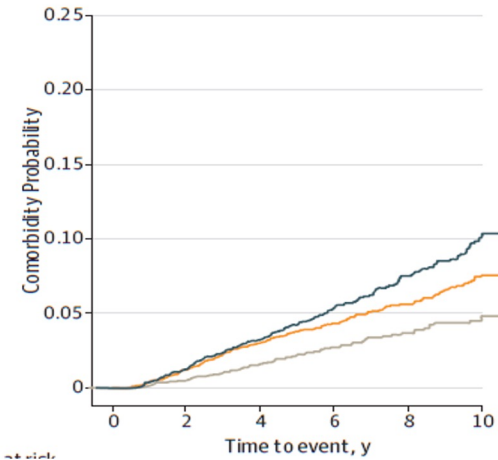
A Hypertension



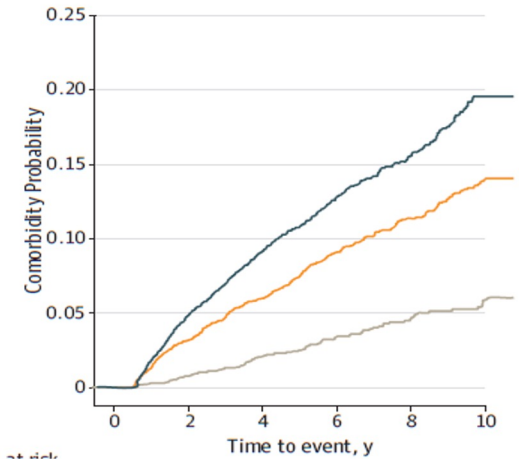
B Hyperlipidemia



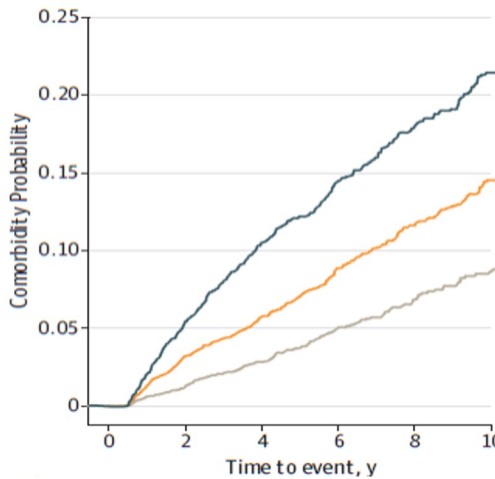
C Obesity



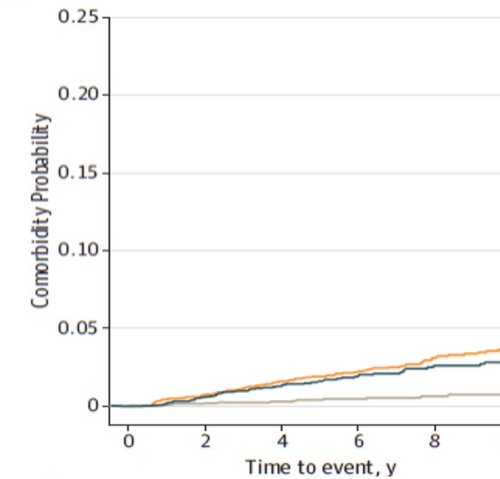
D Depression



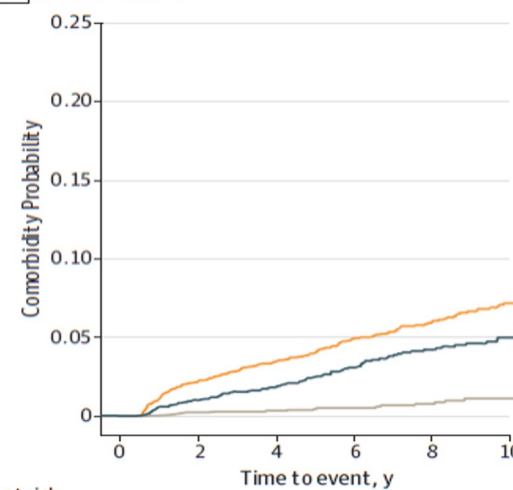
E Sleep disorder



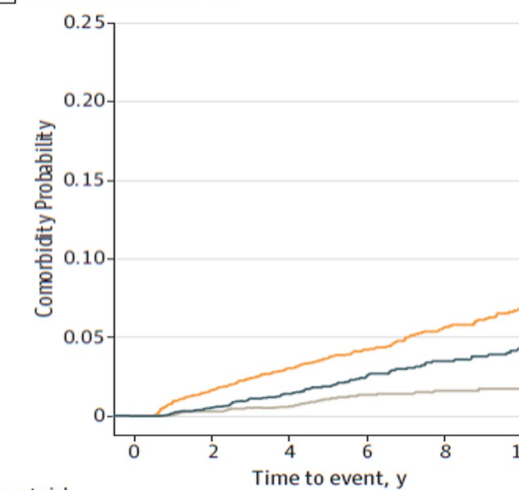
F Anxiety disorder



G Seizure disorder



H Ischemic stroke or TIA



TBI and post-traumatic hypopituitarism (PTH)

- A TBI can impact any of the hormones produced from the pituitary or regulated by the pituitary axis.
- The clinical manifestations of hormone deficiencies can be quite subtle or overtly obvious.
- The clinical consequences of these deficiencies may be minor, severe, or they may be fatal—and they can be masked by the signs and symptoms from the injuries to other structures of the brain.
- Therefore, the diagnosis and treatment of post-traumatic hypopituitarism (PTH) has a significant role in recovery from brain injury

TBI and post-traumatic hypopituitarism (PTH)

Incidence: varies across clinical sites!

Aimaretti and colleagues

-At the 3-month interval: **32.8%**

-At 1-year retesting: 22.7%.

Schneider and colleagues

-5 months post injury: at least one hormonal abnormality was detected in **38%** of the patients.

Krahulik and colleagues

Their studies suggested that:

- Early pituitary deficits may recover over time, and conversely, normal pituitary function early after injury may become abnormal at 3–12 months, suggesting a failure of pituitary reserve.

- Early panhypopituitarism does not recover and is permanent.

TBI and post-traumatic hypopituitarism (PTH)

Metabolic effects of growth hormone deficiency

- Decreased lean body mass and bone mass: higher risk of bone fractures
- Increased visceral and subcutaneous fat: increased lipid levels
- Impaired left ventricular (LV) ejection fraction as well as reduced LV mass: decreased exercise capacity.

Cognitive issues of growth hormone deficiency

- Greater deficits in simple attention
- More intrusions and repetitions on a memory task
- Increased reaction time
- Greater emotional disruption.
- Short- and long-term memory deficits
- Paranoid ideation
- Somatization

TBI and post-traumatic hypopituitarism (PTH)

Abnormal thyroid function after TBI

The literature after brain injury is sparse.

Cognitive effects of thyroid dysfunction appear to mimic deficits observed after a TBI:

- Deficits in speed of information processing and memory.
- Deficits in attention, some aspects of executive functioning, and verbal and visual memory

Hypogonadism after TBI

Age of onset will dictate clinical presentation.

Postpubertal: decreased libido, sarcopenia and osteopenia.

Hohl and colleagues

Reviewed sex steroid deficiencies post-TBI and noted the relevance of testosterone in blood cell count, coagulation mechanisms, muscle tone, bone mineral density, sexual function, and cognitive/mood abilities.

Females may develop premature menopause

TBI + risk of All-Cause dementia

Systematic reviews have found that traumatic brain injury (TBI) of any severity is associated with a **63%–96% increased risk of All-Cause dementia.**

Of the four largest studies to date: hazard ratios (95% CI) for development of dementia range from 1.35 to 3.77.

A retrospective population cohort study of ~40,000 working-age adults identified an association between moderate/severe TBI exposure and increased risk of developing all-cause dementia as compared with those who sustained a mild TBI (mTBI), but **TBI was not a significant risk factor for any dementia subtype when specific dementia subtypes were examined.**

Mechanisms associating TBI and neurodegenerative dx

Many pathological processes have been proposed to contribute to neurodegenerative disease in general and also in association with TBI exposure.

1. Axonal Injury, White Matter Changes, and Potential Degeneration

Chronic, progressive changes of white matter following TBI are supported in multiple studies:

1st - Axonal damage > with extensive axonal severance (i.e., axotomy) and secondary axonal swelling and disruption of axonal transport in more severe injuries.

2nd - Over time, this manifests as degeneration of white matter with severe loss of neurons and alterations in glial populations.

Mechanisms associating TBI and neurodegenerative dx

1. Axonal Injury, White Matter Changes, and Potential Degeneration

Microstructural alterations occur in the absence of macroscopic pathology

-Inverse correlation with cognitive and functional outcomes.

- There is evidence of progressive white matter changes (i.e., decline in white matter neurite density) among patients with lower injury severity (mTBI).

Mechanisms associating TBI and neurodegenerative dx

2. Acutely Upregulated Amyloid Precursor Protein Evolving to Amyloid-b Plaques

The upregulation of amyloid precursor protein (APP) days to months after TBI is well established

Studies of severe TBI ranging from 4 hours to 2.5 years after injury have reported a prevalence of 30%–38% of postmortem and surgical tissues containing the presence of Ab plaques.

A potential link between TBI and Alzheimer Disease (AD) is clear, but still it is not known whether this can lead to AD

Mechanisms associating TBI and neurodegenerative dx

3. Acute Hyperphosphorylation of Tau Evolving to Neurofibrillary Tangles

1st - Liberation of microtubule-associated tau, from axonal shearing injury and potentially other TBI-related mechanisms

2nd - Hyperphosphorylation and accumulation of pathogenic tau proteoforms

These processes have been observed acutely (24 hours) and up to 7 days after TBI in experimental models and postmortem samples.

Mechanisms associating TBI and neurodegenerative dx

4. Inflammatory and Immune Response After TBI (Acute to Chronic)

Persistent neuroinflammation has been observed for up to 1 year after TBI in animal studies.

Persistent glial inflammation or glia priming following TBI may adversely affect the ability of microglia to appropriately respond to future immune challenges, such as infection (producing higher levels of inflammatory cytokines).

Important to consider when we are following TBI in humans:

-Secondary insults across the life span can include a repeat head injury, peripheral immune challenge, or even aging related changes and preclinical neurodegenerative disease.

Part 2: Aging With TBI

Effects of injury can be different in older adults:

Common TBI sequelae can have more effect on function in older adults

due to combination of aging-related effects and TBI-related effects

Effects of injury can be different in older adults:

- Cognition
- Mental health issues
- Balance, vestibular
- Vision
- Hearing
- Sensory (including impaired smell and taste, position sense)
- Motor
- Bowel and bladder incontinence
- Medication effects/ side effects/ interactions

Late TBI sequelae

Cognitive issues (Lewy body dementia, other dementia)

Motor issues (Parkinsonism)

Possible compound effects of multiple injuries

Mental health challenges (including sleep)

Ongoing issues related to factors like hydrocephalus, seizures, headaches

Medication effects/side effects/ interactions

Common age-related changes

- Cardiac (including orthostasis, rhythm disturbances)
- Pulmonary
- Hearing/vision (including cataracts)
- Brain volume loss
- Cognitive (including neurodegenerative changes like Alzheimers)
- Sleep changes
- Energy changes
- Muscle mass changes
- Musculoskeletal injuries (including changes in foot structure)
- GU changes (eg BPH, urinary)
- Endocrine changes

New illnesses/ injuries

- strokes
- Cardiac/ pulmonary
- Cancers
- Neuropathy
- New injuries (falls, fractures)

What we can do

- Help prevent new injuries (falls prevention efforts with PT, home adaptations, vision/hearing optimization, update equipment etc).
- Primary and secondary prevention for health problems like vascular disease, stroke. Continue an exercise program and have some attention to nutrition.
- Find and maintain connections and activities (pets, community groups, family, others)
- Ensure mental health care and support is available.

Part 3: Applying Chronic Illness Model to TBI Care

Our Interdisciplinary Team

- Provider
- Nurse
- Physical Therapist
- Occupational Therapist
- Speech Therapist
- Social Worker
- Psychologist/Neuropsychologist
- Recreational Therapist
- Vision Therapist (often OT)
- Driver's Rehabilitation Specialist (often OT)
- Vocational Rehabilitation Specialist

Common Referrals

- Neurology
- Neurosurgery
- Orthopedics/Prosthetics
- Orthopedics
- Pain Clinic
- Musculoskeletal

Our Continuum of Care

- The Outpatient Brain Injury Clinic
– Primary Care & Rehabilitation Follow-up
– TBI Rehabilitation Track
– Wellness Track
- Polytrauma Transitional Rehabilitation Program
- Inpatient Dynamic Assessment Stays

Common Psychosocial Considerations

- Does their current living environment need to be adjusted to support their needs? Is the support their loved ones can give them enough? Do they need a new living environment?
- Does their current living environment need to be adjusted to support their needs? Is the support their loved ones can give them enough? Do they need a new living environment?
- How can we support their loved ones/caregivers?
- How has their ability to work been affected? How does this affect their finances?
- How has their mental health been affected?
- How has their ability to meaningfully engage in their leisure and recreational activities been affected?
- Are there other chemical health/legal/cultural/vulnerable adult concerns we need to consider? consider?

Lifestyle Redesign

- What's the "new normal?"
- Provider appointments with referral to services as needed
- Setting up systems and structure for Goal Setting
 - Remembering appointments and other necessities
 - Apathy/lack of motivation to attend to appointments and ADLs/IADLs
 - Reinforcing diet, exercise, hydration, structure
 - Monitoring mental health and referring to psychology services as appropriate
 - Addressing comorbid health conditions

Resources: Financial

- The VA is unique in that there are several streams of money we can look at for disabled veterans
 - Service-connection – VA disability income for injuries sustained or exacerbated in the service
 - Aid and Attendance
 - Vocational Rehabilitation Services for job assistance
 - Non-profits: County Veteran Service Office Grants, Minnesota Assistance Council for Veterans
 - Fiduciary Services for veterans cognitively unable to manage their service connection
- We look at savings, social security disability and retirement, pensions, and consider medical assistance if needed as well

Resources: Housing

- Veterans 60% for 1 condition or 70% service connected or on hospice are eligible for nursing home coverage paid for through the VA. **VA does not cover assisted living care.**
- Many of the veterans we work with, especially younger veterans, are more appropriate for home settings with supports, group homes, and assisted living facilities rather nursing homes
- The VA has some Medical Foster Homes. Caregiver and veteran fit is important to look at when considering this level of care
- We frequently rely on experiences with past veterans and county waiver workers to find TBI-educated settings. We partner closely with facilities to help them meet the individualized needs of each veteran.
 - Shout-outs to the following group home agencies for their work with our veterans living with brain injuries: Restart, REM, Howry Homes

Resources: Caregiver

Program of General Caregiver Support Services (PGCSS)

- Provides resources, education and support to caregivers of Veterans. The Veteran does not need to have a service-connected condition for which the caregiver is needed, and may have served during any era.
- Caregivers who enroll in PGCSS have access to education and training, including courses at the Minneapolis VA Medical Center. Additionally, caregivers can participate in support services and take advantage of VA home and community-based care.

Program of Comprehensive Assistance for Family Caregivers (PCAFC)

- The Program of Comprehensive Assistance for Family Caregivers is for eligible Veterans who have incurred, or aggravated a serious injury, in the line of duty on or before May 7, 1975 or on or after September 11, 2001. This program provides many services to caregivers of eligible Veterans to include, but not limited to: resources, education, support, a financial stipend, mental health counseling, respite care, health insurance (if eligible) and certain beneficiary travel (if eligible).

VA Caregiver Support Line | Ph: 855-260-3274

- The Caregiver Support Line is available if you need support outside of the Minneapolis region, have questions about caregiver support services nationwide, or just need someone to listen right now.

Additional Resources

Home Care – Skilled nursing, Home Health Aide, Housekeepers, Therapies

Adult Day Programming – Every veteran entitled to 2 days per week

Respite Care – Every veteran entitled to 30 days per year. Either with home care agency in the home, at a contracted nursing home, or extra adult day health care days.

Patient Examples

Milo Pete – 38 year old male that lives in a group home. He has home-based primary care come in to the group home. He receives Acupuncture and chiropractic services in the community, paid for through the VA for pain and anxiety. He has several specialty appointments and unrelenting nausea that are thought to be migranous in nature. Social work helps him track his appointment, clarify goals of care, encourage prompting for adls/iadls with group home staff, and helps with a behavioral support plan.

Theodore Hamler- 78 year old male with severe TBI from motor vehicle accident. He lives at home with daughter, goes to ADHC 3x a week, using his ADHC days and respire, has home health aide coming in 2 days per week, Skilled nurse comes every two weeks, TBI provider sees every 6-12 months, social work case management calls quarterly to check in on comorbid mental health and physical health concerns. Social work also helps communicate with veteran's medical providers as veteran is not an accurate historian. Veteran will move to assisted living soon as daughter's health is failing. Writer will help fill out application and support veteran mentally as he adjusts to new level of care

George Henry – At home with wife, caregiver stipend program

Summary

Session Description

TBI is often classified as a single event, but a chronic illness model is more appropriate for many survivors.

Addressing issues through use of a chronic illness model could help survivors successfully implement post-injury adaptations and optimize quality of life.

Programs like the VA's Wellness clinic try to anticipate and prevent complications, including medication non-adherence, falls, and housing issues, using a chronic illness model.

Thank you!

Contact: Diane.Mortimer@va.gov