**Psychosocial & Environmental Modifiers Working Group**
**Brief Work Product Draft**
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## Background

TBI presentation and outcome is widely recognized to be influenced not only by the biomechanical characteristics and physiological consequences of brain injury but also by diverse psychosocial and environmental factors (PEFs). PEFs influence the entire injury continuum, from risk for experiencing TBI and other trauma, to acute presentation, clinical course, and long-term outcome. The objectives of the Psychosocial and Environmental Modifiers working group were to evaluate evidence regarding PEFs that influence TBI classification and that should be incorporated into clinical care decisions soon (e.g., in the first two weeks) after injury. We considered a broad array of factors as potentially relevant (**eTable 1**), including

- pre-injury demographics and life experiences (e.g., age, sex, gender, race/racism, ethnicity, culture, language, traumatic and stressful life history, family and social support, personal and environmental socioeconomic resources, mental health, physical health [such as sensory and motor deficits, frailty]) and
- injury-related factors (e.g., context such as nonaccidental/assaultive injury; polytrauma; comorbid medical issues such as neurodegenerative disease; clinical care location and environment).

Given the expertise of our working group, we considered TBI across the lifespan. In future work products, the group is currently planning separate work products to address pediatric and adult TBI to ensure adequate treatment of these topics.

## Role of Psychosocial and Environmental Factors in Presentation and Immediate Care

In considering influences on acute TBI presentation, we focused on factors with reasonable empirical support or clinical suspicion for skewing the accuracy of TBI-related assessments used to recognize or classify injuries, including:

- the Glasgow Coma Scale (GCS),
- other assessments of altered mental status (AMS; e.g., self-report of loss of consciousness [LOC], posttraumatic amnesia [PTA]),
- clinical neuroimaging findings,
- candidate blood-based biomarkers (e.g., GFAP, UCH-L1) that relate to acute outcome, and others which are more informative of recovery (tau, p-tau, NFL), and
- self-report of TBI-related symptoms.

Age and affiliated constructs (developmental level, premorbid neurological health) can dramatically influence the accuracy of acute TBI assessments. Clinical assessments, such as the GCS, interviews about acute injury characteristics (e.g., LOC, PTA), and symptom checklists can be unreliable or unattainable in young children, whose primary TBI signs are typically behavioral changes recognized by parents rather than more widely known TBI symptoms.[1-4] Neuroimaging, although infrequently performed in pediatric acute care settings, requires age-appropriate reference standards to interpret given developmental changes in brain structure (e.g., limited gray-white matter distinctions in infants).[5, 6] In older adults, the GCS often underestimates injury severity (i.e., is high in persons with notable anatomic injury) and,[7-9] conversely, can overestimate severity in the context of premorbid cognitive impairment and AMS due to non-TBI conditions (e.g., delirium, dementia).[10] Normative levels of fluid TBI biomarkers vary across the lifespan, highlighting the need for age-based reference standards.[11, 12]

Alcohol and substance intoxication is extremely common among people presenting to trauma centers[13] and is well recognized clinically to decrease scores on the GCS (especially verbal and motor scales).[10] Scientific support for the influence of alcohol on GCS scores, however, is mixed perhaps due to selection bias in study samples and variation in individual tolerances.[14-16] Some psychiatric disorders likely influence the GCS, although relevant research is limited.[10, 17, 18] Presumably, only serious psychiatric and developmental disorders affecting movement, speech, and behavior would confound clinical assessments and patients' ability to provide relevant history. Such conditions might include, for example, those that cause catatonia or psychosis; that alter or prevent fluent, logical speech; and that markedly affect cooperation.

Co-occurring extracranial injuries can contribute to unrecognized TBI, particularly in persons with subtle brain injuries. Conversely, when extracranial injuries worsen AMS, they can lead to overestimating TBI severity in persons suspected of TBI. For example, polytrauma increases the likelihood of hypoxia (due to pulmonary contusion, pneumothorax) and hemorrhagic shock, which may impact the accuracy of GCS (by contributing to AMS) and fluid biomarkers, and preclude the ability to undertake neuroimaging.[19] Finally, the effects of treatment (e.g., sedation, paralytics, intubation, pain medications including narcotics) confound clinical examinations.[10] While we do not advocate for directly adjusting TBI classification estimates based on PEFs, clinicians must understand the major confounds of acute TBI presentation to avoid delays in care. In cases in which clinical exams are likely to be invalid for estimating the nature of brain injury, the use of objective injury biomarkers (e.g., neuroimaging, blood-based biomarkers where available) is advisable so long as these measures are not substantially confounded by the same factors. For example, extracranial injuries influence the biomarker S100B,[20] and to a lesser extent GFAP and UCH-L1. Neurodegenerative conditions (Alzheimer's, amyotrophic lateral sclerosis) increase levels of GFAP and/or NfL,[21-24] raising the possibility that other neurological or psychiatric disorders could similarly alter biomarker levels.[25]

Numerous factors tend to increase the likelihood and severity of neurobehavioral symptoms reported after trauma and TBI with GCS 13–15, including pre-injury psychiatric histories, female sex, female gender, traumatic/violent injury mechanisms (although underreporting symptoms to mask injury is also possible), and more severe polytrauma.[26-29] Other factors, such as mistrust of healthcare providers or variable reasons for symptom denial, can reduce symptom reporting.[30, 31] Early symptom burden is among the strongest and most widely replicated predictors of symptom recovery,[32-34] suggesting it is a valid prognostic factor valuable to recognize clinically rather than a factor to dismiss in persons with psychosocial risk factors for unusually high symptom burden.

Culture and health literacy, while understudied, appear to affect care seeking and symptom reporting.[35] For example, cultures that value stoicism in the face of adversity or that tend to attribute symptoms to supernatural causes may have different symptoms or clinical presentations.[35, 36] Finally, providers may not adequately clinically assess patients who do not appear to speak the provider's language, such as by not confirming their primary language and not completing injury interviews and clinical (GCS) assessments.[37]

The injury context (e.g., emotional trauma/perceived life threat) and features of one's environment (e.g., accessibility of high-quality healthcare) can also affect acute TBI presentation. Pediatric abusive head trauma, the leading cause of TBI in children less than 2 years old, may not be detectable due to misleading history, lack of physical exam findings, and variable, nonspecific symptoms on presentation. Abusive head trauma is further complicated by caregivers' failure to seek care for repeated injuries that are non-fatal. Peritraumatic dissociation reportedly causes amnesia and other signs of AMS, but more prospective research is needed to verify how it presents in acute care settings and to what degree it confounds TBI classification.[38, 39] Environmental factors (e.g., living in a rural area or in a developing country) are associated with delays in care, which increase mortality and morbidity and may result from numerous patient (e.g., health literacy and financial concerns that delay care) and environmental factors (e.g., time to get to a suitable hospital).[40-43] **Box 1** provides our clinical and research recommendations regarding the consideration of PEFs in early TBI assessments and care.

**Box 1**. Recommendations for considering psychosocial and environmental factors in TBI presentation and assessment

**Recommendations for Clinical Practice**

- Take age/developmental status into account in assessments of TBI.
- Avoid assuming that high GCS scores reflect low-severity TBIs, especially for older adults for whom GCS has been found to underestimate anatomic injury severity.
- Conversely, be aware that various PEFs can contribute to under- or over-estimating TBI severity via clinical assessment, including intoxication, dementia, and other comorbid conditions (e.g., polytrauma, some psychiatric conditions).
- Engage multidisciplinary team-based assessment for children with suspected nonaccidental injury, which is difficult to reliably differentiate from accidental injury.
- Strive to provide trauma-informed care, considering the broader emotional and social context in which injuries may have occurred and making recommendations where available to minimize associated problems, such as PTSD and repeated violence exposure.
- Build capacity to provide culturally-informed care, assessing patients in their native language whenever possible and recognizing cultural factors that may influence presentation.
- Monitor pre-hospital and hospital care systems to ensure timely, appropriate triage and care of persons with TBI.

**Recommendations for Future Research**

- Identify strategies for detecting and classifying TBI more reliably in infants, young children and older adults.
- Develop reference standards for fluid biomarkers of TBI and confirm sufficient validity for target populations (e.g., infants; children; older adults; and individuals with neurodegenerative disorder, polytrauma, and other acute medical comorbidities); see also the Biomarker Working Group summary.
- Validate clinical assessments of TBI in more diverse (e.g., non-Western) cultures.
- Advance understanding of how and when possible confounding factors (e.g., acute intoxication, emotional response to trauma) influence acute presentation, such as clinical signs of AMS.
- Identify and remedy patient and environmental factors that contribute to delays in acute care.

## Role of Psychosocial and Environmental Factors in Clinical Outcomes

PEFs play a major role in recovery and outcomes from all types of TBI, making them potentially important to consider in early TBI care. For example, PEFs may have a role in clinical decision support tools that stratify patients into groups based on risk for different outcomes, in order to facilitate clinical management tailored to individual characteristics or risks. PEFs may also be direct targets of intervention, such as the goal of hospital-based violence interruption programs;[44, 45] mental health screening and treatment; physician communication skills training to improve patients' health literacy; and efforts to identify and offer social services for food access, housing, transportation, and financial problems.[46, 47]

However, nuances and gaps in the prognostic literature preclude simple summarization and definitive recommendations about how to incorporate PEFs in early clinical care. This is because the factors that predict outcomes vary by subpopulation of TBI (e.g., pediatric vs. adult; civilian vs. military vs. sport; GCS 13–15 vs. GCS 3–8), type of outcome measure (e.g., access to post-acute rehabilitation; functional limitations; symptoms; quality of life), and likely the structure (e.g., healthcare economics) of different systems of care. In patients with GCS 13–15, the contribution of various factors has not replicated well across samples,[26, 32, 48] highlighting heterogeneity in this group and the need to verify prognostic findings for intended subpopulations and contexts. Moreover, many factors have not been measured in sufficient depth or in relation to each other to establish their independent prognostic value or their mediating/moderating roles. Nevertheless, below we summarize findings on the role of select PEFs in clinical outcomes and make clinical and research recommendations that fit the state of the science on this topic.

Among samples with GCS 13–15, PEFs are more consistently associated with clinical outcomes than many injury variables. Numerous PEFs are well established to predict one or more outcomes of GCS 13–15 TBI, with pre-injury psychiatric disorders, gender or sex, and education among the most widely studied and replicated predictors.[26, 48-50] Other prognostic factors include but are not limited to: age, pre-injury employment status, race, health insurance (in the U.S.), family environmental/social support, environmental factors (e.g., neighborhood-level socioeconomic position [SEP]),[27, 51] and cultural background.[42, 51-53] The primary subpopulations and outcomes considered across these PEFs has varied. For example, age has been an independent predictor of functional (Glasgow Outcome Scale) outcome in a number of adult studies but does not consistently predict symptom outcomes.[48-50] In general, research is limited on recovery following TBI in pediatric and elderly samples, and outcome is more difficult to measure in these populations because of the need to consider normative development in infants and children and the increasingly common pre-injury comorbidities in the elderly, respectively.[54-56] Cultural factors, while understudied, also appear important to patient outcomes including treatment adherence and symptom outcomes.[35, 36, 57]

Adults with TBI have elevated rates of pre-injury psychiatric disorders, which contribute to poorer functional,[48, 49, 58] symptom,[26, 58, 59] and mental health outcomes.[60, 61] TBI and trauma exposure are also risk factors for new-onset psychiatric disorders.[60-62] Understanding of the mechanisms by which psychiatric history contributes to poor TBI outcome is extremely limited. While data on alcohol use and outcomes after GCS 13–15 TBI are mixed,[63, 64] findings that consumption tends to decrease after TBI may support the acute injury period as a window of opportunity to identify and treat problematic substance use.[65]

Race and ethnicity are other social variables that have been associated with diverse clinical (e.g., functional limitations, PTSD)[27, 66] and healthcare outcomes (e.g., rates of hospitalization, mortality, referral to inpatient rehabilitation) across TBI severity groups.[67-71] However, the putative mechanisms mediating racial and ethnic disparities in TBI outcome, such as discrimination and cultural incongruence, have been insufficiently studied. For example, structural racism, which refers to social mechanisms of fostering racial discrimination via mutually reinforcing systems of inequity,[72] is a determinant of inferior health outcomes in disenfranchised racial groups such as Black Americans; however, its role in TBI severity and outcome disparities remains inadequately understood.[73, 74]

Among persons with more severe TBI (e.g., GCS 3–12 or inpatient rehabilitation samples), age is a commonly identified predictor of mortality and functional disability, which in some samples appears accounted for by elevated rates of medical comorbidities/frailty in older individuals.[75-77] Moreover, SEP, demographic factors associated with SEP, and regional healthcare resources have important impacts on the amount and quality of rehabilitation that can be accessed,[69, 70, 78, 79] which may partly explain health disparities in clinical outcomes.[80, 81] Health literacy is commonly low,[82] may be further reduced by TBI, and impacts patient decision making (e.g., selecting rehabilitation) and other health outcomes.[83-85] Problematic alcohol use is common and has numerous negative consequences, including increased seizure risk, lower cognitive functioning and mood, and increased risk of re-injury, justifying the recommendation to reduce or abstain from alcohol, particularly among persons undergoing TBI rehabilitation.[65, 86, 87] Environmental factors (e.g., rural vs. urban dwelling; availability of acute healthcare post-acute rehabilitation) also contribute greatly to mortality, morbidity, and clinical care outcome (e.g., hospital re-admissions, length of rehabilitation stay).[42, 43, 52, 53, 88]

**Box 2**. Recommendations for considering psychosocial and environmental factors in discharge planning and clinical follow-up, based on their contribution to clinical outcomes of TBI

**Recommendations for Clinical Practice**

- Consider the clinical encounter for TBI to be an opportunity to recognize and address psychosocial and environmental barriers to injury recovery, repeat injury, and general health and wellbeing. While such programming may benefit from implementation support, refinement, and ongoing validation for any given context and goal, actions may include:
  - screening for mental health issues (including problematic substance use) and offering relevant interventions,
  - identifying and addressing socioeconomic barriers (e.g., food insecurity, housing, transportation barriers, low social support, financial concerns) with available resources and social services,[46, 47] and
  - building or further refining evidence-based injury prevention programs such as violence interruption programs for persons exposed to assaultive/nonaccidental trauma, strategies to identify and address pediatric and elder abuse, and fall prevention initiatives for persons at heightened risk of falls.[44, 45]
- Monitor patient case mix, clinical practices, and care pathways to identify inequities in care and patient outcomes.

**Recommendations for Future Research**

- Advance understanding of underlying mechanisms by which PEFs/social determinants of health (SDoH) contribute to diverse clinical and healthcare outcomes, e.g.,
  - language barriers in healthcare access, patient communication; the validity and relevance of outcome measures across languages and cultures,
  - role of health literacy in patient decision making and health outcomes,
  - SDoH (including varying forms of racism) that explain racial disparities in TBI outcomes,
  - neurobiological and psychosocial mediators of the relationship between psychiatric function and outcomes, and

- further develop the science around substance use and TBI recovery, including studying the effect of early interventions to minimize use and treat substance use disorders.

- Identify interventions and strategies for clinical implementation to optimize individual patient outcomes of TBI and minimize health disparities in TBI outcomes. Ideally, efforts would engage with and incorporate the priorities of target TBI subpopulations. Examples of PEFs and intervention topics include:
  - interventions targeting vulnerable populations (e.g., unhoused people, victims of intimate partner violence, prisoners, persons who do not speak the native language of the healthcare system in which they are treated, persons with low health literacy) and
  - continue to refine and validate screening, hospital-based, and other early intervention programs targeting the issues identified under "Recommendations for Clinical Practice."
    - Decision support tools (such as those embedded into the electronic health record) may facilitate such screening, but there are many considerations to make such efforts successful. For example, such tools should be (a) validated for the intended local target population, (b) targeted to specific goals (e.g., increasing detection of TBI, promoting healthcare access, improving functional or symptom outcomes), (c) relevant to the local culture/context of use, (d) implemented intentionally and with monitoring to maximize successful use, (e) monitored and refined to ensure tools have the positive effects they intend to have while avoiding or minimizing negative, unintended consequences.
- Develop and refine tools for measuring psychosocial and environmental factors and achieve consensus on common methods of assessment, while identifying when and how it is important to modify outcomes for specific subpopulations of TBI, contexts, and cultures.

**Appendix**

**eTable 1**. List of major psychosocial and environmental factors considered by the working group.

| Category | Factor |
|---|---|
| Demographics/Pre-injury life experiences | Age |
| | Gender, sex |
| | Race/racism |
| | Employment status |
| | Education |
| | Health literacy |
| | Culture, ethnicity, language |
| | Social support, family environment |
| | Individual socioeconomic position |
| | Neighborhood socioeconomic position |
| | History of trauma, stress, injury exposure |
| Pre-injury health | Pre-injury medications |
| | Mental health |
| | Physical and neurologic health (e.g., frailty; sensory/motor deficits) |
| Injury context and associated factors | Alcohol & substance intoxication |
| | Polytrauma |
| | Injury context (e.g., assaultive/nonaccidental) |
| | Environmental context (rural/urban; region/country and affiliated factors such as healthcare economics and accessibility of care) |

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