

ARTICLE

Invisible Injuries:
Concussive Effects and International Humanitarian Law

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Abstract

The concussive effects of weapons used on the modern battlefield can cause Traumatic Brain Injury (TBI). Indeed, TBI has been termed the "signature wound" of the ongoing conflicts in Iraq and Afghanistan. To date, the injury has not been taken into account by armed forces in their application of international humanitarian law norms regarding attacks that affect civilians. Of particular note in this regard are the rule of proportionality and the requirement to take precautions in attack. This article opens the discussion about this recently discovered consequence of warfare for the civilian population. It examines the state of the science regarding TBI and queries whether the understanding of such injuries has reached the point at which commanders in the field are obligated to begin considering, as a matter of humanitarian law, the risk of causing TBI to civilians when they attack enemy forces. It concludes with a practical assessment of how they might do so.

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Introduction

Traumatic brain injury (TBI) has become the “signature wound” of the conflicts in Iraq and Afghanistan.¹ The highly effective and very frequent use of improvised explosive devices (IEDs) during these conflicts, particularly in roadside attacks against vehicles and in terrorist attacks against individuals, has spurred in-depth medical research into blast exposure and related concussively caused brain injuries. However, consideration of the legal implications of the phenomenon has not kept pace. This Article assesses key international humanitarian law conduct of hostilities rules in light of the current state of the science, which is somewhat tentative albeit improving, regarding concussive effects.

Research into combat-related blast exposure began in earnest after World War I, during which exposure to artillery fire had been common. As a result, many soldiers suffered from what was colloquially known as “shell shock,” the symptoms of which included amnesia, headaches, depression, difficulty concentrating, and insomnia.² Although at the time a number of medical researchers characterized the condition as *commotio cerebri* (concussion, an agitation of the brain induced by shock waves),³ a debate within the medical community ensued because the soldiers appeared otherwise uninjured.

While purely psychological effects may result from exposure to battle, contemporary research is revealing that concussive force generated by blasts physically impacts, and causes injury to, the brain.⁴ Most research on such “invisible”⁵ injuries deals primarily with the diagnosis, treatment, and protection of combatants. However, that research is no less applicable to civilians who are exposed to the concussive force of a blast when, for instance, they are in the vicinity of an attack on a military objective that employs explosive munitions.⁶

¹ Nicholas D. Davenport, *The Chaos of Combat: An Overview of Challenges in Military Mild Traumatic Brain Injury Research*, 7 FRONTIERS IN PSYCHIATRY 1, 1 (2016) (reporting that approximately seventy-five percent of mild TBI events in these conflicts “involved exposure to explosive blast”); see also W. Bradley Fain et al., *Lessons Learned from the Analysis of Soldier Collected Blast Data*, 180 MIL. MED. 201, 201 (2015).

² See Edgar Jones et al., *Shell Shock and Mild Traumatic Brain Injury: A Historical Review*, 164 AM. J. PSYCHIATRY 1641, 1641 (2007); see also F.W. Mott, *Special Discussion on Shell Shock Without Visible Signs of Injury*, 9 PROC. ROYAL SOC’Y MED. i, i–xxiv (1916); F.W. Mott, *The Effects of High Explosives Upon the Central Nervous System: Lecture I & II*, 48 LANCET 331, 336 (1916).

³ Jones, *supra* note 2, at 1641–42.

⁴ See *infra* Part I.

⁵ Some medical literature uses the term “invisible injury” to refer exclusively to cognitive or psychological injuries, while others use it to refer to mild TBI. The authors use it to mean all injuries, including physical injuries that are not apparent without the aid of advanced imaging.

⁶ CTRS. FOR DISEASE CONTROL AND PREVENTION, NAT’L INSTS. OF HEALTH, U.S. DEP’T OF DEF., & U.S. DEP’T OF VETERANS AFF., REPORT TO CONGRESS ON TRAUMATIC BRAIN INJURY IN THE U.S.: UNDERSTANDING THE PUBLIC HEALTH PROBLEM AMONG CURRENT AND FORMER MILITARY PERSONNEL 59 (2013) [hereinafter REP. TO CONG.] (recognizing that “civilian blast injuries are becoming an increasing problem worldwide”).

The potential injury to civilians makes the information now available on the concussive effects of blasts relevant to a state's obligations under international humanitarian law. Although it is not unlawful to inflict concussive effects upon enemy combatants during an attack on them or in pursuit of other military objectives, international humanitarian law is implicated to the extent that civilians are affected by a blast's concussive effects. Proper application and interpretation of international humanitarian law must be based on sensitivity to the foundational balance between military necessity and humanitarian concerns that underpin it, regardless of whether the potential injury to civilians is visible or invisible.⁷ To ignore injuries that result from concussive effects would be to throw the balance askew.

To place the inquiry into the relevant international humanitarian law context, this Article begins in Part I with a description of concussive brain injuries and discusses the state of the science. This Part also highlights certain policy approaches to these injuries. The Article then turns to legal issues in Part II. It first examines the rule of proportionality, which prohibits attacks that are expected to cause excessive injuries to civilians. Even an attack that is consistent with the rule of proportionality is subject to the additional requirement to take precautions in attack, such as selecting weapons that will achieve the desired combat effect while causing the least harm to civilians. Therefore, the application of this rule is likewise examined in Part II. Finally, the Article concludes with the authors' thoughts on possible practical means of incorporating the reality of concussive effects into the targeting process.

I. Concussive Effects

The term "concussive effects" is an acknowledgment that the blast effects of munitions—whether the blast wave itself or blast-induced motion or debris—can include TBIs of varying degrees of severity.⁸ "Traumatic brain injury" denotes a "traumatically induced structural injury or physiological disruption of brain function" caused by an external force,⁹ including those produced by blasts or

⁷ See Michael N. Schmitt, *Military Necessity and Humanity in International Humanitarian Law: Preserving the Delicate Balance*, 50 VA. J. INT'L L. 795, 839 (2010); see also COMMENTARY ON THE ADDITIONAL PROTOCOLS OF 8 JUNE 1977 TO THE GENEVA CONVENTIONS OF 12 AUGUST 1949 ¶ 2206 (Yves Sandoz, Christophe Swinarski & Bruno Zimmermann eds., 1987) [hereinafter ICRC COMMENTARY].

⁸ Though some of the medical literature separates blast-induced brain injury from mild traumatic brain injury (concussion), the definitions often overlap and the two are used interchangeably. This Article uses "concussive effects" to collectively refer to all brain injuries sustained from blast effects (blast wave, blunt trauma, or acceleration/deceleration/rotational movement), and "concussive injury" to refer to all severities of TBI. See generally INST. OF MED., GULF WAR AND HEALTH, VOL. 7: LONG-TERM CONSEQUENCES OF TRAUMATIC BRAIN INJURY 2 (2009), <http://www.nap.edu/catalog/12436.html> [hereinafter IOM REP.].

⁹ Memorandum from Jonathan Woodson, Assistant Sec'y of Def. for Health Aff. to Assistant Sec'y of the Army, Navy, and Air Force (Manpower and Res. Aff.) (Apr. 6, 2015), <http://docplayer.net/49471857-The-assistant-secretary-of-defense-1200-defense-pentagon-washington-dc.html> [<http://perma.cc/TL7P-KHZZ>] [hereinafter OSD Memorandum]. The memo adds that at least one of the following signs immediately follows a TBI: "Any alteration in mental

explosions.¹⁰ Medical literature often describes these forces as the physical cause (or mechanism) of immediate injury.¹¹ The injury occurs at the moment of the concussive event and causes a mechanical alteration of the brain, including tissue destruction—damage to axons or laceration, bleeding, or bruising of the brain—that immediately leads to macroscopic, microscopic, and cellular pathological changes.¹² As the brain moves within the skull, axons (the stretched fibers that provide structure and support to the brain and communicate with the rest of the body) strain and sever. Since the force tears the brain from within, traditional radiological imaging often reveals no apparent structural damage.¹³

When an individual experiences a TBI, a myriad of biomechanical processes in the brain trigger symptoms such as loss of consciousness, headaches, confusion, and amnesia.¹⁴ The injury may also result in “several biologic processes that occur in the minutes to days following TBI.”¹⁵ Inflammation, swelling, or hemorrhage caused by the original injury can lead to further brain damage as the brain pushes against the skull.¹⁶ Additionally, concurrent injuries in other parts of the body may exacerbate the initial brain injury. For example, injuries sustained to other organs might cause blood pressure to drop, which in turn reduces blood flow to the brain.¹⁷ The reduction can exacerbate the extent or severity of the initial brain injury. Severity of the injury and the extent to which it is observable differ depending on such factors as the individual’s position relative to the blast, the impact to or angular rotation of the brain, and pre-existing brain conditions.¹⁸

status (e.g., confusion, disorientation, slowed thinking, etc.). Any loss of memory for events immediately before or after the injury. Any period of loss of or a decreased level of consciousness, observed or self-reported.”

¹⁰ *Id.* at 2; see also Louis M. French et al., *Traumatic Brain Injury*, in CARE OF THE COMBAT AMPUTEE 402–03 (Martha K. Lenhart ed., 2009).

¹¹ REP. TO CONG., *supra* note 6, at 3.

¹² See ERIC SAVITSKY & BRIAN EASTRIDGE, COMBAT CASUALTY CARE: LESSONS LEARNED FROM OEF AND OIF 348 (2012); see also Svetlana A. Dambinova et al., *Functional, Structural, and Neurotoxicity Biomarkers in Integrative Assessment of Concussions*, 7 FRONTIERS IN NEUROLOGY 1, 4 (2016); Edea Khong et al., *Diffusion Tensor Imaging Findings in Post-Concussion Syndrome Patients After Mild Traumatic Brain Injury: A Systematic Review*, 7 FRONTIERS IN NEUROLOGY 1, 2 (2016); REP. TO CONG., *supra* note 6, at 3.

¹³ See Jasmeet P. Hayes et al., *The Nature of White Matter Abnormalities in Blast-Related Mild Traumatic Brain Injury*, 8 NEUROIMAGE: CLINICAL 148, 149 (2015); Christine L. Mac Donald et al., *5-Year Imaging Sequelae of Concussive Blast Injury and Relation to Early Clinical Outcome*, 14 NEUROIMAGE: CLINICAL 371, 371 (2017); see also REP. TO CONG., *supra* note 6, at 5.

¹⁴ Dambinova et al., *supra* note 12, at 2.

¹⁵ REP. TO CONG., *supra* note 6, at 3.

¹⁶ See *id.* at 4.

¹⁷ See *id.*

¹⁸ See Dambinova et al., *supra* note 12, at 2; see also Namas Chandra & Aravind Sundaramurthy, *Acute Pathophysiology of Blast Injury—From Biomechanics to Experiments and Computations*, in BRAIN NEUROTRAUMA: MOLECULAR, NEUROPSYCHOLOGICAL, AND REHABILITATION ASPECTS 18.1.2.3 (F.H. Kobeissy ed., 2015) (explaining blast physics in various models); HARVEY LEVIN ET AL., UNDERSTANDING TRAUMATIC BRAIN INJURY: CURRENT RESEARCH AND FUTURE DIRECTIONS 414–17 (2014).

TBIs can cause physical, cognitive, and psychological¹⁹ impairment. While some symptoms manifest immediately, “signs and symptoms may be delayed from days to months (e.g., headaches, subdural hematoma, seizures, hydrocephalus, spasticity, etc.). [They] may occur alone or in varying combinations, and may result in a functional impairment.”²⁰ The consequences may quickly resolve themselves, persist for extended periods, or be permanent.²¹ As discussed below, the psychological symptoms of post-traumatic stress disorder (PTSD) and depression often overlap with the physical symptoms of TBI, making diagnosis and prognosis difficult.²² While recent studies suggest that physical damage to brain circuitry may account for many of the psychological symptoms associated with combat-induced PTSD, the precise relationship between TBI and PTSD is unclear.²³

Irrespective of whether injury results solely from the blast wave or from a combination of blast mechanisms, concussive effects cause brain injury.²⁴ Injury from the blast wave itself is determined by factors such as pressure intensity, duration, and shape (which may be influenced, for instance, by whether the blast occurs in an open field or an urban environment).²⁵ Although the effects of blast overpressure on organs such as the intestinal tract, ears, and lungs are well known, those on the brain are less well understood.²⁶ Two key limitations are the lack of testable living brain tissue and the fact that individuals near a blast may also be affected by other harmful forces, such as fragmentation of the weapon and other blast-induced debris.²⁷ Nevertheless, studies confirm that, at the least, mild traumatic brain injuries are likely to result from blast overpressure.²⁸ They also substantiate the fact that neurological effects, such as deficits in learning, memory, and motor skills, can arise from repeated low-level blast exposure.²⁹

¹⁹ The terms psychological, emotional, behavioral, and mental are sometimes used interchangeably in various contexts by different fields of expertise. This Article refers to all of these concepts as psychological.

²⁰ OSD Memorandum, *supra* note 9, at 2.

²¹ *Id.*

²² U.S. DEP’T OF DEF., LONGITUDINAL STUDY ON TRAUMATIC BRAIN INJURY INCURRED BY MEMBERS OF THE ARMED FORCES IN OPERATION IRAQI FREEDOM AND OPERATION ENDURING FREEDOM 3–4 (2017).

²³ Christine L. Mac Donald et al., *Outcome Trends after US Military Concussive Traumatic Brain Injury*, 34 J. NEUROTRAUMA 2206, 2217–18 (2017).

²⁴ See IOM REP., *supra* note 8, at 3; see also Hailong Song et al., *Linking Blast Physics to Biological Outcomes in Mild Traumatic Brain Injury: Narrative Review and Preliminary Report of an Open-Field Blast Model*, 340 BEHAV. BRAIN RES. 147, 148 (2016).

²⁵ There may be further implications for concussive effects in urban operations, where blast waves reflect off structures, thereby potentially increasing the concussive severity of the blast. See KENNETH CROSS ET AL., ARMAMENT RES. SERV., EXPLOSIVE WEAPONS IN POPULATED AREAS: TECHNICAL CONSIDERATIONS RELEVANT TO THEIR USE AND EFFECTS 14–16 (2015).

²⁶ See IOM REP., *supra* note 8, at 33.

²⁷ See *id.* at 36–39.

²⁸ See *id.* at 8, 36.

²⁹ See *id.* at 8.

The understanding of concussive effects on the brain has been improving dramatically.³⁰ Breakthroughs in advanced imaging techniques are a major contribution.³¹ Also promising is research into the use of brain biomarkers that provide, quite literally, a map of various brain injuries.³² By monitoring biomarkers, the ability to establish patterns between the initial trauma to the brain and mid- to long-term harm is enhanced.³³

However, shortcomings in the knowledge base remain.³⁴ In particular, mild TBIs—the predominant consequence of concussive effects—are underreported and underestimated.³⁵ Studies using advanced brain imaging technologies reveal that mild TBIs do not appear on computerized tomography (CT) or magnetic resonance imaging (MRI) scans.³⁶ Since traditional diagnostic imaging fails to detect pathological changes in the brain caused by a mild concussive injury,³⁷ the most common battlefield brain injuries remain “invisible.” Accordingly, they are usually only identified through self-reporting, which lacks the empirical fidelity necessary for establishing probabilities. Much remains unknown about brain injuries, especially the link between blast overpressure and brain injury and between brain injury and long-term health outcomes.

Despite these limitations, the United States and other states have begun incorporating medical knowledge of concussive effects into military policy and practice. Since 2000, the Department of Defense (DOD), which now defines TBI as an “injury,” has reported approximately 375,230 TBIs, eighty-two percent of which were classified as mild.³⁸ Note that these figures are drawn from a military population that is likely to underreport because of the negative perception within

³⁰ LEVIN ET AL., *supra* note 18, at 4.

³¹ NORTH ATLANTIC TREATY ORGANIZATION, *TRAUMATIC BRAIN INJURY IN A MILITARY OPERATIONAL SETTING 2-2* (2015) [hereinafter NATO REP.].

³² A biomarker is an indicator that assists in identifying the natural or historical pathology of a particular injury, illness, or disorder. Dambinova et al., *supra* note 12, at 5; *see also* Chenggang Yu et al., *A Systems Biology Strategy to Identify Molecular Mechanisms of Action and Protein Indicators of Traumatic Brain Injury*, 93 J. NEUROSCI. RES. 199, 203–12 (2015).

³³ *See* Dambinova et al., *supra* note 12, at 5; NATO REP., *supra* note 31, at 6-29; REP. TO CONG., *supra* note 6, at 5 (noting that these technologies “must be refined and validated” as they evolve).

³⁴ REP. TO CONG., *supra* note 6, at xv.

³⁵ *See id.*; *see also* Sardar Bahadur et al., *Injury Severity at Presentation is not Associated with Long-Term Vocational Outcome in British Military Brain Injury*, 162 J. ROYAL ARMY MED. CORPS 120, 120–21 (2016) (finding the injury-severity scoring systems at the point of the concussive event to be a poor predictor of long-term outcomes).

³⁶ *See* Mac Donald et al., *supra* note 13, at 371–78; NATO REP., *supra* note 31, at 2-2; REP. TO CONG., *supra* note 6, at 5. This is problematic given that to be considered a mild traumatic brain injury, the U.S. DOD requires that conventional CT or MRI scans reveal normal structural neuroimaging. U.S. Dep’t of Def., Instr. 6490.11, DoD Policy Guidance for Management of Mild Traumatic Brain Injury/Concussion in the Deployed Setting 14 (2012) [hereinafter DODI 6490.11].

³⁷ *See* Mac Donald et al., *supra* note 13, at 371–78; NATO REP., *supra* note 31, at 2-2; REP. TO CONG., *supra* note 6, at 5.

³⁸ DEF. AND VETERANS BRAIN INJ. CTR., *DOD NUMBERS FOR TRAUMATIC BRAIN INJURY: WORLDWIDE – TOTALS* (2017), <http://dvbic.dcoe.mil/files/tbi-numbers/WorldwideTotals2000-2017Q1-Q3Nov%2014-2017508.pdf> [<http://perma.cc/4GL4-SH6U>] (totaling TBI injury numbers between 2000 and mid-2017, as of Dec. 10, 2017).

the armed forces of having a behavioral problem.³⁹ Clearly, there is a “fundamental need to better understand and quantify the direct and indirect effects of blast to individuals engaged in modern warfare.”⁴⁰

In response to this need, Congress passed the 2008 Traumatic Brain Injury Act, which requires certain government agencies to examine the incidence and prevalence of TBI and to develop better diagnostic, treatment, and tracking tools.⁴¹ Of particular note, the armed forces incorporated blast sensors (concussion-monitoring devices) into the helmets of thousands of deploying troops.⁴² These sensors are being upgraded to allow for the identification of a brain injury with greater speed and accuracy.⁴³ Concerned with the injury’s “potential for short and long-term effects on the Service member,” DOD also now requires “proper identification, documentation, treatment, and tracking of those Service members who have sustained a TBI.”⁴⁴ An especially telling indicator of DOD’s acknowledgement of TBI as an “injury” is its recognition of even mild TBIs as meriting award of the Purple Heart. The award is made in the event of concussions caused by “enemy-generated explosions” or mild traumatic brain injuries that result in loss of consciousness, persistent symptoms, a clinical finding, or impaired brain function for longer than forty-eight hours.⁴⁵

Global awareness of TBI is rising because of the increased use of IEDs in armed conflict and because of the increase in reported sports-related TBIs. Today, many governments recognize TBI as an injury of significant public health and

³⁹ TERRY TANIELIAN & LISA H. JAYCOX, *INVISIBLE WOUNDS OF WAR: PSYCHOLOGICAL AND COGNITIVE INJURIES, THEIR CONSEQUENCES, AND SERVICES TO ASSIST RECOVERY* 317 (2008). DOD took steps to address this concern in DODI 6490.11, *supra* note 36.

⁴⁰ Fain et al., *supra* note 1, at 201.

⁴¹ National Defense Authorization Act for Fiscal Year 2007, Pub. L. No. 109-364, § 721, 120 Stat. 2083, 2294–95 (2006) (reenacting the TBI Act of 1998). *See also* REP. TO CONG., *supra* note 6, at iv (serving as the third-year, periodic report in response to the law).

⁴² Compare Brendan McGarry, *Navy Surgeon General Touts Gains in Concussion Protocols, Treatments*, MILITARY.COM (Oct. 11, 2015), <http://www.military.com/daily-news/2015/10/11/navy-surgeon-general-touts-gains-concussion-protocols-treatment.html> [<https://perma.cc/R8YL-2JTL>], and Laura Landro, *Body Sensors Measure Impact of Blasts on Soldiers*, WALL ST. J., (Nov. 17, 2013), <https://www.wsj.com/articles/body-sensors-measure-impact-of-blasts-on-soldiers-1384544752>, with Letter from Eric K. Fanning, Sec’y of the Army, to Louise M. Slaughter, Congresswoman, U.S. House of Representatives (Nov. 16, 2016) [hereinafter SECARMY Letter] (explaining the discontinued large-scale use of current blast sensors due to sensor-sensitivity issues, and assuring the Congresswoman that new, better sensors are being tested), and Jon Hamilton, *Pentagon Shelves Blast Gauges Meant To Detect Battlefield Brain Injuries*, NAT’L PUB. RADIO (Dec. 20, 2016), <https://www.npr.org/sections/health-shots/2016/12/20/506146595/pentagon-shelves-blast-gauges-meant-to-detect-battlefield-brain-injuries> (providing greater insight into the discontinued use of sensors and discussing the need for, and future use of, such sensors).

⁴³ SECARMY Letter, *supra* note 42; Press Release, Warren Duffie, Office of Naval Research, BLAST: Greater Speed, Accuracy in Recognizing Brain Injury, (Jan. 13, 2017), <https://www.onr.navy.mil/en/Media-Center/Press-Releases/2017/ONR-BLAST-TBI-Protection> [<https://perma.cc/J6MD-FS6B>].

⁴⁴ OSD Memorandum, *supra* note 9, at 1.

⁴⁵ U.S. Dep’t of Army, Reg. 600-8-22, Military Awards para. 2-8 (e), (g)(5–6) (July 25, 2015).

medical concern.⁴⁶ Moreover, the North Atlantic Treaty Organization formed a Task Group in 2009 to identify gaps in the understanding of the injury and to attempt to devise standard diagnostic and treatment practices for deployment-related mild TBIs.⁴⁷

Of particular significance to the legal issues raised below is the fact that TBI-related research involving armed conflict centers on injury to combatants. There is, accordingly, a significant lacuna in the knowledge base regarding the likelihood of TBI to members of the civilian population. Nevertheless, as with combatants, blast injuries among civilian populations are certainly also on the rise in light of such factors as the increasing prevalence of urban warfare and of tactics, such as human shielding, that move armed conflict into the proximity of civilians. Additionally, civilians are especially vulnerable during hostilities because they lack protective equipment such as vests and helmets.⁴⁸ Further complicating matters is the fact that assessing concussive effects among the civilian population is particularly difficult because they are often located in areas under enemy control, lack access to modern medical care, and are not subject to mandatory reporting requirements. And while combatants generally fall into a homogenous group in terms of age and physical fitness, the heterogeneous category of “civilians” includes children, the elderly, and individuals with widely varying physical conditions.⁴⁹ These factors, among others, suggest that the results of research on combatant TBI may not be perfectly transferable to the civilian population.

II. Concussive Effects and International Humanitarian Law

Concussive effects caused by combat have normative implications primarily for the international humanitarian law governing the “conduct of hostilities,” specifically in the law of targeting. Targeting law requires (1) that the weapon used in an attack be lawful *per se* in the sense that it is neither inherently indiscriminate nor of a nature to cause unnecessary suffering or superfluous injury to individuals who may be lawfully targeted;⁵⁰ (2) that the individual or object

⁴⁶ See generally Min Li et al., *Epidemiology of Traumatic Brain Injury over the World: A Systematic Review*, 1 *AUSTIN NEUROLOGY & NEUROSCI.* 1, 1–12 (2016); Bob Roozenbeek et al., *Changing Patterns in the Epidemiology of Traumatic Brain Injury*, 9 *NATURE REV. NEUROLOGY* 231, 231–36 (2013).

⁴⁷ See NATO REP., *supra* note 31, at ES-1. The phrases “deployment-related” and “military” traumatic brain injury include blast-related traumatic brain injury.

⁴⁸ Ramona R. Hicks et al., *Neurological Effects of Blast Injury*, 68.5 *J. TRAUMA* 1257, 1257 (2010).

⁴⁹ See *id.*

⁵⁰ Protocol Additional to the Geneva Conventions of 12 August 1949, and Relating to the Protection of Victims of International Armed Conflicts arts. 35(2), 51(4)(b–c), June 8, 1977, 1125 U.N.T.S. 3 [hereinafter AP I]; see also 1 *CUSTOMARY INTERNATIONAL HUMANITARIAN LAW* Rules 11–13, 70 (Jean-Marie Henckaerts & Louise Doswald-Beck eds., 2005) [hereinafter CIHL STUDY]. Although the United States is not a party to AP I, it generally accepts those provisions thereof that are cited in this Article as reflective of customary international law. See OFF. OF THE GEN. COUNS., U.S. DEP’T OF DEF., *LAW OF WAR MANUAL* §§ 6.6, 6.7 (rev. ed. 2016) [hereinafter DOD LAW OF WAR MANUAL].

targeted qualify as a military objective;⁵¹ (3) that the tactics employed be discriminate;⁵² (4) that the expected harm to civilians and civilian objects not be excessive relative to the anticipated military advantage of the attack, that is, that the attack comply with the rule of proportionality;⁵³ and (5) that precautions be taken by the attacker to minimize harm to civilians and civilian objects.⁵⁴

Since explosive weapons designed to kill are not *per se* unlawful, it is unlikely that the concussive effects of a particular weapon would significantly alter the *per se* lawfulness analysis.⁵⁵ Nor do concussive effects directly bear on the principle of distinction, the requirement that attacks only be directed at military objectives. This is because an attack directed at civilians, civilian objects, or other protected persons or objects is unlawful irrespective of the nature of the harm likely to be caused. Finally, the international humanitarian law rule that tactics must be discriminate likewise has little relevance to the occurrence of concussive effects, for merely failing to aim a weapon (as distinct from aiming it at protected persons or objects) is unlawful regardless of the effects that weapon causes. The same is true with regard to treating a number of targets in a concentration of civilians as a single military objective when it is possible to distinguish among them.

Therefore, concussive effects bear most directly upon the requirements of proportionality and precaution, both of which are designed to ensure an appropriate balance between humanitarian considerations and military necessity. Codified in Articles 51 and 57 of the 1977 Additional Protocol I (AP I), these requirements reflect customary international law applicable in international and non-international armed conflicts and are, accordingly, binding on all states.⁵⁶ Injuries to combatants,

⁵¹ AP I, *supra* note 50, arts. 51(1), 52(2); *see also* CIHL STUDY, *supra* note 50, rules 7–10; DOD LAW OF WAR MANUAL, *supra* note 47, § 5.6.

⁵² AP I, *supra* note 50, art. 51(4); *see also* CIHL STUDY, *supra* note 50, rules 11–13, at 37–45; DOD LAW OF WAR MANUAL, *supra* note 50, § 5.5.

⁵³ AP I, *supra* note 50, arts. 51(5)(b), 57(2)(a)(iii), 57(2)(b); *see also* CIHL STUDY, *supra* note 50, rule 14; PROGRAM ON HUMANITARIAN POL. AND CONFLICT RES., MANUAL ON INTERNATIONAL LAW APPLICABLE TO AIR AND MISSILE WARFARE, Rule 14 (2009) [hereinafter AMW MANUAL]; U.K. MINISTRY OF DEF., THE MANUAL OF THE LAW OF ARMED CONFLICT § 2.6 (2004) [hereinafter U.K. MANUAL]; U.S. NAVY, U.S. MARINE CORPS & U.S. COAST GUARD, NWP 1-14M/MCWP 5-12/COMDTPUB P5800.7A, THE COMMANDER'S HANDBOOK ON THE LAW OF NAVAL OPERATIONS ¶¶ 5.3.3, 8.3.1 (2007) [hereinafter U.S. COMMANDER'S HANDBOOK].

⁵⁴ AP I, *supra* note 50, art. 57; *see also* AMW MANUAL, *supra* note 53, rules 30–40; CIHL STUDY, *supra* note 50, rules 15–19; FRITS KALSHOVEN, REFLECTIONS ON THE LAW OF WAR: COLLECTED ESSAYS 222 (2007); DOD LAW OF WAR MANUAL, *supra* note 50, § 5.2.3.

⁵⁵ The sole situation the authors could conceive of in which this might be the case is a weapon designed primarily to cause concussive effects that manifest well after the likely conclusion of the conflict, for such injuries would yield no military advantage to an attacker and thus cause unnecessary suffering. Obviously, the development and fielding of such a weapon is unlikely.

⁵⁶ *See* CIHL STUDY, *supra* note 50, rules 14–19; *see also* Prosecutor v. Kupreskić, Case No. IT-95-16-T, Judgment, ¶ 524 (Int'l Crim. Trib. for the Former Yugoslavia Jan. 14, 2000); AMW MANUAL, *supra* note 53, § G, ¶ 2; DOD LAW OF WAR MANUAL, *supra* note 50, § 17.7; ICRC COMMENTARY, *supra* note 7, ¶ 4772; MICHAEL N. SCHMITT ET AL., THE MANUAL ON THE LAW OF NON-INTERNATIONAL ARMED CONFLICT WITH COMMENTARY ¶¶ 2.1.1.4, 2.1.2 (2006); TALLINN MANUAL 2.0 ON THE INTERNATIONAL LAW APPLICABLE TO CYBER OPERATIONS Rules 113, 114–20 (Michael

members of organized armed groups, or civilians directly participating in hostilities have no normative significance under international humanitarian law as such individuals may be lethally targeted by the weapons that produce the concussive effects. It is the potential harm to civilians that is relevant to the humanitarian law inquiry.

A. *Proportionality*

The rule of proportionality prohibits attacks that “may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian objects, or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated.”⁵⁷ It acknowledges that the unintended, albeit foreseeable, injury of civilians is permissible when that incidental injury (and collateral damage to civilian objects) is not excessive relative to the military gain that the attacker reasonably expected to achieve from the attack.

The science of blast-induced TBI raises the possibility that those who plan and conduct attacks must consider concussive effects in their proportionality analysis. Such a requirement might be questioned for four reasons. First, concussive injuries are not easily foreseeable. Second, a concussive injury may manifest later in time, raising questions as to its cause. Third, concussive injuries are sometimes characterized as psychological in nature (or intertwined with psychological injuries),⁵⁸ and psychological effects are typically not considered in proportionality calculations.⁵⁹ Finally, concussive injuries might be considered an intangible injury and thus not quantifiable in a proportionality analysis. Addressing these and related matters requires deconstructing the rule of proportionality into its constitutive elements: 1) expectation of harm, 2) causation, 3) qualification as incidental injury, and 4) excessiveness.

1. “May be expected”

Proportionality analysis considers only incidental injury to civilians and collateral damage to civilian objects that “may be expected” to result from an attack. From the perspective of a commander planning an attack, then, the inquiry is whether concussive injuries are of a nature to be “expected,” as that term is understood in the context of the rule of proportionality. Pursuant to the Vienna Convention on the Law of Treaties (VCLT), which is generally regarded as setting forth accepted modes of interpretation, “[a] treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in

N. Schmitt ed., 2013) [hereinafter TALLINN MANUAL 2.0]; U.K. MANUAL, *supra* note 53, ¶ 5.23.2; U.S. COMMANDER’S HANDBOOK, *supra* note 53, ¶ 5.3.3.

⁵⁷ AP I, *supra* note 50, arts. 51(5)(b), 57(2)(a)(iii), 57(2)(b); *see also* CIHL STUDY *supra* note 50, rules 14, 18–19.

⁵⁸ Mac Donald et al., *supra* note 23, at 12.

⁵⁹ *See infra* notes 130–132 and accompanying text.

their context and in the light of its object and purpose.”⁶⁰ The dictionary definition of the term “expect” has remained relatively constant since the drafting of AP I. For instance, the 1976 *Concise Oxford Dictionary* defined “expect” as “to regard as likely,”⁶¹ whereas the present *Oxford English Dictionary* explains that the term denotes something “likely to happen.”⁶² The drafting history of AP I also sheds light on the condition that the incidental injury and collateral damage be expected. During the Diplomatic Conference that led to adoption of the treaty, the drafters rejected a suggestion to replace the phrase “which may be expected to cause” with “which risks causing,” opting instead for an explicit standard of foreseeability.⁶³

The term “expected” confirms that proportionality is assessed *ex ante*, not *post factum*.⁶⁴ In other words, compliance with the rule is judged against what those involved in the targeting process foresaw with respect to likely incidental injury and collateral damage, not against what happened in the particular case. The law imposes the objective standard of reasonableness on this inquiry, such that harm that should have been expected in the circumstances will be considered when judging compliance with the rule even if the attacker did not in fact expect it.⁶⁵ Thus, in explicating the standard, some commentators have phrased it as “reasonably foreseeable”⁶⁶ and “probable.”⁶⁷

While it is clear that the incidental injury to be considered in the proportionality assessment must be reasonably foreseeable, the question remains as to how certain the decision-maker must be of the resulting incidental injury before it is foreseeable. As a general legal concept, foreseeability is the point on a continuum of certainty at which responsibility for an act attaches.⁶⁸ If an act’s possible effects fall short of this point, there is no duty, and thus no responsibility, because the actor could not have reasonably foreseen that the act would cause a particular effect. To hold otherwise in the targeting context would impose a form

⁶⁰ Vienna Convention on the Law of Treaties art. 31(1), May 23, 1969, 1155 U.N.T.S. 331 [hereinafter Vienna Convention].

⁶¹ *Expect*, CONCISE OXFORD DICTIONARY OF CURRENT ENGLISH (6th ed. 1976).

⁶² *Expect*, OXFORDDICTIONARIES.COM, <https://en.oxforddictionaries.com/definition/expect> (last visited Nov. 15, 2017).

⁶³ ICRC COMMENTARY, *supra* note 7, ¶ 2209.

⁶⁴ See Schmitt, *supra* note 7, at 826; see also MICHAEL BOTHE ET AL., NEW RULES FOR VICTIMS OF ARMED CONFLICTS: COMMENTARY ON THE TWO 1977 PROTOCOLS ADDITIONAL TO THE GENEVA CONVENTIONS OF 1949 320, 352 (2d ed. 2013) [hereinafter BOTHE COMMENTARY]; KALSHOVEN, *supra* note 54, at 220.

⁶⁵ See Prosecutor v. Galić, Case No. IT-98-29-T, Trial Judgment, ¶ 58 (Int’l Crim. Trib. for the Former Yugoslavia Dec. 5, 2003); INTERNATIONAL CRIMINAL TRIBUNAL FOR THE FORMER YUGOSLAVIA, FINAL REPORT TO THE PROSECUTOR BY THE COMMITTEE ESTABLISHED TO REVIEW THE NATO BOMBING CAMPAIGN AGAINST THE FEDERAL REPUBLIC OF YUGOSLAVIA (2000), reprinted in 39 INT’L LEGAL MATERIALS 1257, at 1271, ¶ 50 (2000); see also BOTHE COMMENTARY, *supra* note 64, at 320, 351–52; DOD LAW OF WAR MANUAL, *supra* note 50, ¶ 5.10.2.2.

⁶⁶ Michael N. Schmitt, *Air Warfare*, in THE OXFORD HANDBOOK OF INTERNATIONAL LAW IN ARMED CONFLICT 139 (Andrew Clapham et al. eds., 2014).

⁶⁷ AMW MANUAL, *supra* note 53, rule 14, ¶ 6.

⁶⁸ See 57A AM. JUR. 2D *Negligence* §§ 413, 416 (2017); see also DOD LAW OF WAR MANUAL, *supra* note 50, § 5.12.2.1 (comparing foreseeable and remote harms).

of absolute liability for all injuries causally linked to an attack. As this would amount to an unworkable and intolerable burden on parties to a conflict, such a rule would run afoul of the balancing of humanitarian concerns and military necessity that underlies international humanitarian law.

In the international humanitarian law context, as in other areas of the law, the ubiquitous standard of reasonableness informs where the point of foreseeability lies.⁶⁹ In other words, a result is foreseeable when a reasonable commander or other person involved in planning, approving, or executing an attack would have foreseen the consequence in question with a reasonable degree of certainty. This has led some states, including the United States, to adopt a standard of “reasonable certainty,”⁷⁰ a standard familiar in other areas of international and domestic law.⁷¹

While reasonableness does not require mathematical certainty, the standard excludes conjecture and speculation.⁷² Reasonable certainty is based instead on rational inferences and probabilities.⁷³ Whether concussive injuries to civilians are reasonably likely to occur, and, therefore, have to be factored into the proportionality analysis depends on the probability that the effects will occur in the attendant circumstances and the state of the current scientific understanding of TBI. It also depends on the extent to which the science can be deemed reasonably available to decision-makers at the time of an attack.

A critical factor in determining whether the science has reached the point where it is appropriate to consider concussive injuries is consistency of consequence. A degree of consistency is necessary to identify causal relationships, as well as the probability ratios from which reasonable expectations that an effect will occur must derive. Such consistency appears to be lacking at present, although as technologies emerge and further research is conducted, this deficiency may be remedied. For example, a 2014 international state-of-the-science conference concluded that, despite the use of soldier-worn blast sensor monitoring devices for a number of years, there is still no “biomedically valid,” clear safe distance from a given blast because the “ability to quantify blast intensity and correlate that data to acute and chronic intracranial effects is limited.”⁷⁴ Based in part on this conclusion,

⁶⁹ See BOTHE COMMENTARY, *supra* note 64, at 320, 351–52; see also AMW MANUAL, *supra* note 53, rule 14, ¶ 4 (equating effects that are “too remote” with those that “cannot be reasonably foreseen”).

⁷⁰ CFLCC ROE Card, *reprinted in* U.S. ARMY, OPERATIONAL LAW HANDBOOK 109 (2015); MNC-I ROE Cards, *reprinted in id.* at 110; see also OFF. OF THE CHIEF OF STAFF, ARMED FORCES OF THE PHIL., AFP STANDING RULES OF ENGAGEMENT § 8f (2005).

⁷¹ See, e.g., Neil Steinkamp, *Understanding Reasonable Certainty in International Arbitration*, LAW360 (May 19, 2015), <https://www.law360.com/articles/654068/understanding-reasonable-certainty-in-int-l-arbitration> [<https://perma.cc/UCR8-BYZW>].

⁷² See *id.*

⁷³ See *id.*

⁷⁴ Summary of Meeting Proceedings, Key Findings, and Expert Panel Recommendations, Dep’t of Def. Blast Injury Res. Program Coordinating Off., International State-of-the-Science Meeting on the Biomedical Basis for Mild Traumatic Brain Injury Environmental Threshold Values, at ii (Nov. 4–6, 2014),

the U.S. Army decided in 2016 that mass deployment of its blast sensors would be unproductive, citing their lack of sensitivity and explaining that the sensors failed to provide consistent data correlating blast overpressure with brain injury.⁷⁵ The Army is now in search of new sensors of greater sensitivity, ones equipped with longer battery life, and wireless data transfer.⁷⁶

Irrespective of such uncertainty, some countries have implemented blast distance thresholds for their soldiers that trigger mandatory TBI screening.⁷⁷ A leader in the field, the U.S. military requires all personnel within fifty meters (indoors or outdoors) of a blast event to undergo TBI screening.⁷⁸ Although this policy reflects the potential for, not necessarily the probability of, concussive effects, it is nonetheless instructive. The United States recognizes that concussive effects, in ways that might not be fully understood yet, lead to brain injury and, accordingly, has set thresholds to protect its combatants despite the lack of precision in the science.

To summarize, the science is not yet at the point where it can be said that the expectation of concussive injury is reasonably certain in any particular attack. It is undeniable that the concussive effects of a blast can cause TBI, but insufficient scientific research exists to determine the probability of injury or the distance within which such effects manifest. Fortunately, there is current research directed at answering these questions.⁷⁹ Although most is focusing on the safety of the armed forces, it would apply *mutatis mutandis* to the expectation that a civilian will suffer an incidental brain injury as a result of an attack. Once the capacity is developed to predict with a reasonable degree of certainty the likelihood of civilian brain injury within a given blast radius, the “to be expected” aspect of the proportionality rule will be satisfied.

2. “To cause”

The expected injury an attacker must factor into the proportionality analysis is limited to that which the attack “causes.” Unfortunately, AP I provides no definition or explanation of causality. Moreover, the treaty’s *travaux préparatoires* and the International Committee of the Red Cross (ICRC) Commentary on the instrument offer no insight. Nevertheless, the prevailing view is that both direct and indirect effects are included as incidental injury (and collateral damage to objects) in the proportionality analysis, so long as they are, as discussed above, foreseeable.⁸⁰

https://blastinjuryresearch.amedd.army.mil/assets/docs/sos/meeting_proceedings/2014_SoS_Meeting_Proceedings.pdf [<https://perma.cc/74QD-R2WM>].

⁷⁵ SECARMY Letter, *supra* note 42, at 1.

⁷⁶ *Id.*

⁷⁷ See NATO REP., *supra* note 31, ¶¶ 6.2.2, 6.3.4.1.

⁷⁸ See DODI 6490.11, *supra* note 36, at 9.

⁷⁹ See SECARMY Letter, *supra* note 42, at 1–2.

⁸⁰ INT’L LAW ASS’N STUDY GRP. ON THE CONDUCT OF HOSTILITIES IN THE 21ST CENTURY, THE CONDUCT OF HOSTILITIES AND INTERNATIONAL HUMANITARIAN LAW: CHALLENGES OF 21ST

Direct effects are “the immediate, first-order consequences of a military action . . . unaltered by intervening events or mechanisms. They are usually immediate and easily recognizable.”⁸¹ Indirect effects are “the delayed and/or displaced second-, third-, and higher-order consequences of action, created through intermediate events or mechanisms.”⁸² Although direct effects are typically immediate and easily recognizable, they need not be, as is the case with injuries to internal organs.⁸³ The concussive effect on the brain is such a direct effect, whereas, for instance, an automobile accident occurring later because the brain injury caused a loss of consciousness would be an indirect effect.

The legal challenge with regard to TBIs and causation in the proportionality context is two-fold. First, symptoms of the brain injury may not be identified or fully develop until well after the attack. Indeed, research is increasingly linking longer-term injuries and symptoms to TBIs. The findings of one recent study indicate that “a substantial number (74%) of concussive blast TBI service members were found to have” brain imaging abnormalities five years after the concussive event.⁸⁴ Conventional imaging taken closer to the concussive event had not revealed the abnormalities.⁸⁵ However, remoteness in time is not a barrier to causation. AP I places no temporal limitation on the proportionality rule despite calls for such limits at the time of drafting.⁸⁶ There is no basis for suggesting that customary law deviates from its treaty counterpart in this regard. Therefore, the mere lapse of time, even if measured in years, does not bar consideration of a TBI in the proportionality analysis. Rather, the issues are the foreseeability of that harm, discussed above, and actual causation.

The second challenge is more daunting. To be considered an incidental injury, there must be an unbroken causal chain between the attack and the harm suffered. In some cases, the individual concerned might have developed the condition even without having suffered the brain injury. In others, the attack might produce a condition wherein unforeseeable intervening causes interact to produce an injury. For example, a concussive brain injury caused by blast exposure might later be exacerbated by subsequent, independent brain trauma. In these situations,

CENTURY WARFARE (2016), *reprinted in* 93 INT’L L. STUD. 322, 352–55 (2017); TALLINN MANUAL 2.0, *supra* note 56, rule 113, ¶ 6; *see also* DOD LAW OF WAR MANUAL, *supra* note 50, § 5.12.2.1 (framing the discussion in terms of remote harms rather than direct and indirect effects).

⁸¹ U.S. CHAIRMAN & JOINT CHIEFS OF STAFF, JP 3-60, JOINT TARGETING, II-35–36, ¶ 5(e)(1) (2013) [hereinafter JP 3-60].

⁸² *Id.* at II-36, ¶ 5(e)(2).

⁸³ *See, e.g.,* Cassie Barrett & Danny Smith, *Recognition and Management of Abdominal Injuries at Athletic Events*, 7 INT’L J. SPORTS PHYSICAL THERAPY 448, 450 (2012).

⁸⁴ Mac Donald et al., *supra* note 13, at 375–76.

⁸⁵ *See id.* at 374 (arguing that what advanced imaging detected was not simple brain anatomy atrophy, but, rather, “degradation of the [brain’s] white matter”); *see also* Dambinova et al., *supra* note 12, at 4.

⁸⁶ BOTHE COMMENTARY, *supra* note 64, at 406, ¶ 2.6.2. This is in contrast to the treatment of military advantage, which was conditioned by the adjectives “concrete and direct.”

causal attenuation or rupture would bar characterization of the ensuing condition as incidental injury for the purposes of the proportionality rule.

However, research is increasingly confirming that many mid- to long-term effects are foreseeable sequelae—a medical term denoting a chronic pathological condition that is different from, but nonetheless a consequence of, the initial injury.⁸⁷ Of particular note is PTSD, which has been linked recently to concussive injury. In a study examining six-to-twelve month trends following concussive effects, for example, a “substantial majority” of subjects experienced greater depression and more severe PTSD than control groups.⁸⁸ This result reinforced the findings of a 2014 longitudinal study that found increased PTSD severity three months post-deployment among active-duty U.S. Marines who sustained concussive injuries while deployed.⁸⁹ However, and of particular relevance in the legal context, while the findings identify a “strong link” between concussive injury and PTSD, the study was quick to note that the “causality . . . cannot be determined from the current results.”⁹⁰

Brain injuries are increasingly also believed to be related to a wide array of other conditions. For example, a 2009 Institute of Medicine (IOM) report linked TBI to long-term conditions like unprovoked seizures, Alzheimer-type dementia, Parkinsonism, endocrine dysfunction, growth hormone insufficiency, depression, aggressive behaviors, and post-concussion symptoms such as concentration and memory loss, dizziness, and headaches.⁹¹ The study categorized the relationship between TBI and specific symptoms into causal relationships,⁹² consistent associations,⁹³ and suggestive evidence of an association.⁹⁴ Moreover, all of the relevant research that the study located found an association between TBI and those secondary adverse effects or illnesses studied.⁹⁵

These findings induced changes to U.S. law regarding illnesses that are “proximately due” to TBI and deemed service-connected for veterans’ claims purposes. The following illnesses are labeled as proximately resulting from a service-connected moderate or severe brain injury: Parkinson’s disease,

⁸⁷ *Sequela*, OXFORDDICTIONARIES.COM, <https://en.oxforddictionaries.com/definition/us/sequela> (last visited Nov. 15, 2017).

⁸⁸ Mac Donald et al., *supra* note 23, at 2206, 2216.

⁸⁹ *Id.* at 2216.

⁹⁰ *Id.* at 2218.

⁹¹ IOM REP., *supra* note 8, at 11.

⁹² *Id.* at 112 (defining causal relationship as sufficient evidence of a positive association in human studies between brain injury and a specific health outcome and also satisfying a number of factors “used to assess causality: strength of association, dose-response relationship, consistency of association, temporal relationship, specificity of association, and biologic plausibility”).

⁹³ *Id.* (defining consistent association as sufficient evidence of a positive association in human studies between brain injury and a specific health outcome where “chance and bias, including confounding, could be ruled out with reasonable confidence”).

⁹⁴ *Id.* (defining association as suggestive evidence of a positive association in human studies between brain injury and a specific health outcome because “chance, bias, and confounding could not be ruled out with reasonable confidence”).

⁹⁵ *See id.* at 112–13.

unprovoked seizures, various dementias (manifested within fifteen years of brain injury), depression (manifested within three years of brain injury), and hormone deficiency diseases (manifested within one year of brain injury).⁹⁶ The law also designates mild TBI as the proximate cause of depression that manifests within one year of the initial injury.⁹⁷

It must be cautioned that the government noted that it was not, as a matter of law, establishing a regulatory presumption of a causal nexus between service-connected brain injury and these long-term illnesses. Rather, it indicated that the IOM report evidence was sufficient to infer a causal nexus. In other words, the government was merely codifying “sound medical principles recognized in the IOM Report.”⁹⁸ Moreover, most recent research examined by the report is now over a decade old. While subsequent research has strengthened the associations that the IOM report noted, no additional comprehensive state-of-the-science studies have been completed.⁹⁹

The research increasingly suggests a causal link between concussive injuries and harm that occurs later. And, plainly, brain trauma is now an accepted result of concussive effects. But sufficient granularity is lacking to establish a definitive chain of causation for injuries beyond the immediate trauma, much less a causal chain that is foreseeable, at least with respect to that degree of causality required for application of the rule of proportionality. Recent breakthrough studies into mild TBI, for example, contain caveats such as “the long-term impact of [mild TBI] is just beginning to be appreciated” (2017);¹⁰⁰ “the long-term . . . impact . . . remains incompletely described” (2016);¹⁰¹ “the long-term effects . . . are more complex” (2016);¹⁰² and “the long-term health consequences . . . are not yet well known” (2015).¹⁰³ Additionally, the more time that elapses between the initial injury and its manifestation, the greater the opportunity for intervening causes or unforeseen exacerbating conditions.

The requisite causal connection between concussive effects and certain mid- or long-term conditions remains tenuous in the contemporary scientific literature. Eventually, though, that connection is likely to be reliably established.

⁹⁶ 38 C.F.R. § 3.310(d)(i–iv) (2017).

⁹⁷ *Id.* § 3.310(d)(iv).

⁹⁸ Response to Comments on Proposed Rule related to Secondary Service Connection for Diagnosable Illnesses Associated with Traumatic Brain Injury, 78 Fed. Reg. 76201, 76206 (Dec. 17, 2013), <https://www.federalregister.gov/documents/2013/12/17/2013-29911/secondary-service-connection-for-diagnosable-illnesses-associated-with-traumatic-brain-injury> [<https://perma.cc/MTL5-AR49>].

⁹⁹ DOD’s executive agent for blast-related injuries has hosted a number of international state-of-the-science conferences since 2009, but they focused on narrow topics. See *International State-of-the-Science Meetings*, BLAST INJ. RES. PROGRAM COORDINATING OFF., U.S. DEP’T OF DEF., <https://blastinjuryresearch.amedd.army.mil/index.cfm/sos> [<https://perma.cc/BFF2-BJSK>] (last visited Nov. 17, 2017).

¹⁰⁰ Mac Donald et al., *supra* note 13, at 371.

¹⁰¹ Mac Donald et al., *supra* note 23, at 2206.

¹⁰² Davenport, *supra* note 1, at 2.

¹⁰³ Hayes et al., *supra* note 13, at 149.

Further research will also likely determine the probability of such conditions manifesting. Such probability data are important not only to establish foreseeability (relevant to the condition that the incidental injury be “expected”), but also with respect to whether an attack will cause future harm as a factual matter. Once it is reasonably available, the causal condition precedent to applying the proportionality rule to an attack having concussive effects will be satisfied.

3. “Incidental injury”

As noted, the rule of proportionality requires incidental injury to be “expected,” and it must be “caused” by the concussive effect. However, a perhaps more-central question is the meaning of “incidental injury.” It is a difficult question in this context because brain injury produces one or more of physical,¹⁰⁴ cognitive,¹⁰⁵ or psychological¹⁰⁶ consequences.¹⁰⁷

The term “incidental” indicates that the injury is unintended, albeit expected.¹⁰⁸ However, the meaning of “injury” is less clear, especially with respect to cognitive or psychological injuries. No accepted definition of injury exists in treaty or customary international humanitarian law. The negotiating history of AP I captures debates over qualification as “superfluous injury” under Article 35¹⁰⁹ and “serious injury” for purposes of accountability under Article 85,¹¹⁰ but there was no discussion of the meaning of “incidental injury” as the term appears in Articles 51 or 57. The 1987 ICRC Commentary and case law are similarly unhelpful.

It may be that the drafters intentionally left the meaning of the term unaddressed. This was the case with respect to the related term “wounded and sick” in Article 12 of the 1949 Geneva Convention I. The ICRC’s Commentary on the article noted:

No attempt has ever been made in the Geneva Convention to define what is meant by a “wounded or sick” combatant; nor has there ever

¹⁰⁴ For example, sensory loss, headache, dizziness, sleep disturbances, uncontrollable muscle contraction, inability to understand or express speech, to swallow properly, and seizure, balance, and coordination disorders. OSD Memorandum, *supra* note 9, at 2.

¹⁰⁵ For example, deficits in the mental processes of memory, perception, judgment, comprehension, reasoning, learning, production of language, and executive function. *Id.*

¹⁰⁶ For example, those conditions associated with behavior and emotion, like stress, anxiety, depression, irritability, and aggression. *Id.*

¹⁰⁷ Although cognitive deficits may result from either physical or psychological injuries, such deficits after a concussive effect commonly result from physical damage or alteration in the brain; however, until recently, the underlying mechanism between the physical damage and the cognitive deficit was not well understood. *See, e.g.,* Kirsi Maria Kinnunen et al., *White Matter Damage and Cognitive Impairment after Traumatic Brain Injury*, 134 BRAIN 449, 449–50 (2011).

¹⁰⁸ AMW MANUAL, *supra* note 53, rule 1(1), ¶ 3.

¹⁰⁹ ICRC COMMENTARY, *supra* note 7, ¶ 1429; *see also* DOD LAW OF WAR MANUAL, *supra* note 50, § 6.6.1.

¹¹⁰ AP I, *supra* note 50, art. 85; ICRC COMMENTARY, *supra* note 7, ¶ 3474; *see also* Convention (III) Relative to the Treatment of Prisoners of War art. 121, Aug. 12, 1949, 6 U.S.T. 3316, 75 U.N.T.S. 135 [hereinafter Geneva Convention III].

been any definition of the degree of severity of a wound or a sickness entitling the wounded or sick combatant to respect. That is as well; for any definition would necessarily be restrictive in character, and would thereby open the door to every kind of misinterpretation and abuse. The meaning of the words “wounded and sick” is a matter of common sense and good faith.¹¹¹

In fact, the lack of qualifying or interpretive guidance in this instance points to an ordinary reading of the term consistent with the interpretive guidance found in the VCLT.¹¹²

The ordinary meaning of injury is “hurt, damage, or loss sustained.”¹¹³ Numerous expert and military manuals support a broad definition by referring to incidental injury as *harm*, without reference to the nature or severity thereof.¹¹⁴ Moreover, while the text of the rule of proportionality expressly limits anticipated military advantage to that which is “concrete and direct,” it imposes no limitations on the nature of the incidental injury that qualifies for inclusion in the proportionality calculation.¹¹⁵ This being so, and although serious illness and disease may not have been discussed at the Diplomatic Conference with respect to incidental injury, there is no reason to exclude them from the scope of the term

¹¹¹ INT’L COMM. FOR THE RED CROSS, COMMENTARY TO GENEVA CONVENTION I FOR THE AMELIORATION OF THE CONDITION OF THE WOUNDED AND SICK IN THE ARMED FORCES IN THE FIELD 136, art. 12, ¶ 1.C (Jean Pictet ed., 1952). Though AP I subsequently provided a definition of “wounded and sick,” the definition necessarily focused on the scope of the protection rather than the ordinary meaning of the terms. Article 8 of AP I defines “wounded and sick” as military or civilian personnel in need of medical assistance due to “trauma, disease or other physical or mental disorder or disability,” and who refrain from hostile acts. This definition explicitly includes pregnant women, young children, and the elderly. AP I, *supra* note 50, art. 8.

¹¹² Vienna Convention, *supra* note 60, art. 31.

¹¹³ *Injury*, MERRIAM-WEBSTER.COM, <https://www.merriam-webster.com/dictionary/injury> [HTTPS://PERMA.CC/C7AR-F3UX] (last visited Nov. 17, 2017); *see also Injury*, WEBSTER’S SEVENTH NEW COLLEGIATE DICTIONARY 435 (1967).

¹¹⁴ *See, e.g.*, AMW MANUAL, *supra* note 53, rule 1(1), ¶ 4; CHIEF OF THE GEN. STAFF (CAN.), B-GJ-005-104/FP-021, LAW OF ARMED CONFLICT AT THE OPERATIONAL AND TACTICAL LEVELS ¶ 204.5 (2001) (describing incidental injury as “adverse effect upon civilians”); DOD LAW OF WAR MANUAL, *supra* note 50, § 5.12; TALLINN MANUAL 2.0, *supra* note 56, rule 113, ¶ 2. In those publications, discussions regarding severity or nature of injury thresholds generally surround only the meaning of superfluous injury under Article 35, *see* AMW MANUAL, *supra* note 53, rule 5(b), ¶ 4; DOD LAW OF WAR MANUAL, *supra* note 50, §§ 6.6.1-6.6.3; ICRC COMMENTARY, *supra* note 7, ¶ 1439, or “attack” in the conduct of hostilities rules, though the latter is usually limited to damage to objects, *see* AP I, *supra* note 50, art. 49; TALLINN MANUAL 2.0, *supra* note 56, rule 92, ¶ 4.

¹¹⁵ AP I, *supra* note 50, arts. 51, 57; *see also* CIHL STUDY, *supra* note 50, rules 14–21.

“injury,” especially since illness is accounted for in Geneva Conventions I,¹¹⁶ II,¹¹⁷ III,¹¹⁸ and IV,¹¹⁹ as well as in Additional Protocols I¹²⁰ and II.¹²¹

Given this broad definition, and interpreting the term teleologically in light of international humanitarian law’s humanitarian object and purpose, its scope would logically extend to known sequelae of TBIs.¹²² As will be explained, there is no convincing rationale for omitting cognitive or psychological consequences of a brain injury from “injury.” Further, the exclusion of “inconvenience, irritation, stress, or fear” from the broader category of collateral damage by some expert manuals, while correct, does not discount such sequelae, for the exclusions relate to the general conduct of civilian life, rather than to particular physiologies.¹²³

Yet, the term could not be interpreted to encompass purely psychological harm unrelated to TBI, at least in the current state of the law. While some have argued for inclusion based either on analogy to Article 51(2)’s prohibition on the spread of terror¹²⁴ or teleological interpretation,¹²⁵ their suggested approach is aspirational in character. As noted in the *travaux préparatoires*, the prohibition on the intentional infliction of psychological harm (terror) in Article 51(2) “is directed to intentional conduct specifically directed toward the spreading of terror and excludes terror which was not intended by a belligerent and terror that is merely an

¹¹⁶ See Convention (I) for the Amelioration of the Condition of the Wounded and Sick in the Armed Forces in the Field art. 12, Aug. 12, 1949, 6 U.S.T. 3114, 75 U.N.T.S. 31; see also INT’L COMM. FOR THE RED CROSS, COMMENTARY TO GENEVA CONVENTION I FOR THE AMELIORATION OF THE CONDITION OF THE WOUNDED AND SICK IN THE ARMED FORCES IN THE FIELD ¶¶ 1342–1343 (2d ed. 2016).

¹¹⁷ See Convention (II) for the Amelioration of the Condition of the Wounded, Sick, and Shipwrecked Members of Armed Forces at Sea art. 12, Aug. 12, 1949, 6 U.S.T. 3217, 75 U.N.T.S. 85; see also INT’L COMM. FOR THE RED CROSS, COMMENTARY TO GENEVA CONVENTION II FOR THE AMELIORATION OF THE CONDITION OF THE WOUNDED, SICK AND SHIPWRECKED MEMBERS OF ARMED FORCES AT SEA ¶¶ 1380–1382 (2d ed. 2017).

¹¹⁸ See Geneva Convention III, *supra* note 110, art. 30; see also INT’L COMM. FOR THE RED CROSS, COMMENTARY TO GENEVA CONVENTION III RELATIVE TO THE TREATMENT OF PRISONERS OF WAR 211, ¶ 2 (Jean Pictet ed., 1960).

¹¹⁹ See Convention (IV) Relative to the Protection of Civilian Persons in Time of War art. 16, Aug. 12, 1949, 6 U.S.T. 3516, 75 U.N.T.S. 287; see also OSCAR M. UHLER ET AL., COMMENTARY TO GENEVA CONVENTION IV RELATIVE TO THE PROTECTION OF CIVILIAN PERSONS IN TIME OF WAR art. 16, ¶ 1 (1958).

¹²⁰ AP I, *supra* note 50, art. 8.

¹²¹ Protocol Additional to the Geneva Conventions of August 12, 1949, and Relating to the Protection of Victims of Non-International Armed Conflicts art. 7, June 8, 1977, 1125 U.N.T.S. 609; see also ICRC COMMENTARY, *supra* note 7, ¶¶ 4636–37.

¹²² See TALLINN MANUAL 2.0, *supra* note 56, rule 92, ¶ 8.

¹²³ AMW MANUAL, *supra* note 53, rule 14, ¶ 2; TALLINN MANUAL 2.0, *supra* note 56, rule 113, ¶ 5. Recognizing this distinction, the DOD Law of War Manual juxtaposes, very appropriately, inconvenience and temporary disruption of civilian life in general with civilian loss of life, injury, and damage to objects. DOD LAW OF WAR MANUAL, *supra* note 50, § 5.12.1.2.

¹²⁴ TALLINN MANUAL 2.0, *supra* note 56, rule 92, ¶ 8.

¹²⁵ Eliav Lieblich, *Beyond Life and Limb: Exploring Incidental Mental Harm under International Humanitarian Law*, in APPLYING INTERNATIONAL HUMANITARIAN LAW IN JUDICIAL AND QUASI-JUDICIAL BODIES: INTERNATIONAL AND NATIONAL ASPECTS 185 (Derek Jinks et al. eds., 2014).

incidental effect of acts of warfare which have another primary object and are in all other respects lawful.”¹²⁶

That said, cognitive or psychological conditions should be understood to be encompassed within the “incidental injury” when they are caused by physical brain trauma, which undeniably qualifies as incidental injury for the purpose of the rule of proportionality when suffered by a civilian. The IOM report mentioned earlier, for example, found consistent association between all brain injury severities, depression, and aggressive behaviors.¹²⁷ Post-concussive effect symptoms—such as memory and vision impairment, confusion, and a loss of balance—are also now explained through biomechanical processes resulting from “variable degrees of injury to neurons, glia, the blood-brain barrier, and vascular structures, leading to transitory ionic functional disturbances with clinical manifestations.”¹²⁸ Other studies involving blast-exposed patients have demonstrated that abnormalities in the brain’s white matter were “significantly” or “directly” associated with physical post-concussive symptom severity, albeit not with emotional post-concussive symptoms.¹²⁹

In fact, physical brain injuries and psychological injuries may “interact in a synergistic fashion to worsen outcomes; TBI may damage the brain’s emotional regulation circuitry, and the trauma-associated psychopathology may interfere with recovery from TBI.”¹³⁰ Studies have revealed hyperactivity in the brain’s emotional processing circuitry in blast-exposed veterans suffering from major depressive disorders.¹³¹ Blast-induced mild TBI patients also “exhibited a diminished interhemispheric coordination of brain activity, which was not the consequence of combat-stress symptoms (PTSD or depression) or commonly prescribed medications.”¹³²

Establishing clear-cut distinctions between physical and psychological harms for combat-related brain injuries will require further research into the relevant brain circuitry affected by concussive effects, if such distinctions are possible.¹³³ Scientists anticipate that brain mapping with the use of the biomarkers discussed above could allow for better discrimination between cognitive deficits and psychological manifestations of physical brain injury on the one hand and, on the other, psychological harms in the classic sense. Distinguishing between them

¹²⁶ XV OFFICIAL RECORDS OF THE DIPLOMATIC CONFERENCE ON THE REAFFIRMATION AND DEVELOPMENT OF INTERNATIONAL HUMANITARIAN LAW APPLICABLE IN ARMED CONFLICTS 274, ¶ 51 (1978).

¹²⁷ IOM REP., *supra* note 8, at 11.

¹²⁸ Dambinova et al., *supra* note 12, at 2.

¹²⁹ Danielle Miller et al., *White Matter Abnormalities are Associated with Chronic Postconcussion Symptoms in Blast-Related Mild Traumatic Brain Injury*, 37 HUMAN BRAIN MAPPING 220, 221–22, 226–29 (2017).

¹³⁰ Mac Donald et al., *supra* note 23, at 2218.

¹³¹ See NATO REP., *supra* note 31, at 7-2.

¹³² *Id.*

¹³³ See REP. TO CONG., *supra* note 6, at 74; see also Mac Donald et al., *supra* note 23, at 13.

will remain somewhat contentious until an international medical testing standard for physical brain injury induced consequences is adopted.¹³⁴

Regardless, the law is clear. All direct physical consequences of a brain injury qualify as incidental injury to civilians regardless of the level of severity or permanence. There may be obstacles to considering them during the proportionality analysis due to the “expected” criterion discussed above, but to the extent that science demonstrates that they are “caused” as a result of the brain injury, they would constitute incidental injury.

Incidental injury to civilians is only one factor in the proportionality analysis. The injury, in addition to being “expected” and “caused,” must also be weighed against anticipated military advantage in a test of excessiveness.

4. “Excessive”

Whether expected injuries to civilians are “excessive” in relation to expected military advantage is the central question of the principle of proportionality.¹³⁵ Although international humanitarian law provides no definition of “excessive,” most commentators agree that excessive does not merely equate to “extensive;” injury is compared to advantage, not considered in absolute terms.¹³⁶ For example, minor concussive injuries may be excessive if the anticipated military advantage is slight, whereas very serious, and even widespread, concussive injuries to civilians may be lawful where a sufficiently significant “concrete and direct” military advantage is anticipated to result from the attack.¹³⁷

The practical difficulty that arises from concussive effects is how to “value” them in the proportionality analysis, especially the cognitive or psychological manifestations of a brain injury. This difficulty is not limited to such effects; indeed, proportionality always involves comparing dissimilar values—harm to civilians and civilian property against military advantage. Therefore, the challenge of “valuing” concussive effects and their consequences presents no unique legal obstacle to application of the rule of proportionality. To the extent that concussive effects meet the other conditions of the rule of proportionality, discussed above, their weight against military advantage will be determined by a “reasonable

¹³⁴ NATO REP., *supra* note 31, at 1–9.

¹³⁵ Schmitt, *supra* note 7, at 804–805.

¹³⁶ See AMW MANUAL, *supra* note 53, rule 14; see also ICRC COMMENTARY, *supra* note 7, ¶ 1980 (“[E]ven if they are very high, civilian losses and damages may be justified if the military advantage is of great importance.”); Michael N. Schmitt, *Precision Attack and International Humanitarian Law*, 87 INT’L REV. RED CROSS 445, 457 (2005); Robert D. Sloane, *Puzzles of Proportion and the “Reasonable Military Commander”: Reflections on the Law, Ethics, and Geopolitics of Proportionality*, 6 HARV. NAT’L SEC. J. 299, 316–17 (2015).

¹³⁷ See AP I, *supra* note 50, arts. 51(5)(b), 57(2)(a)(iii), 57(2)(b); see also CIHL STUDY, *supra* note 50, rules 14, 18–19.

commander” standard.¹³⁸ The notional “reasonable commander” will assess the value of the concussive effects that an attack is foreseeably expected to cause.

B. *Precautions in Attack*

Even an attack against a lawful military objective expected to result only in incidental injury and collateral damage that is not excessive relative to its anticipated concrete and direct military advantage is subject to the additional requirement that all feasible precautions be taken to avoid, or at least minimize, that injury or damage. Codified in Article 57 of AP I, the obligation is recognized as customary international law.¹³⁹ It requires an attacker to consider every feasible option for avoiding harm to civilians and civilian property in achieving the intended military advantage. Thus, the attacker must consider, *inter alia*, weapons, tactics, and target options, and must, when possible under the circumstances, warn a civilian population of attacks that may affect it.¹⁴⁰

Article 57 begins by imposing a requirement that, “[i]n the conduct of military operations, constant care shall be taken to spare the civilian population, civilians, and civilian objects.”¹⁴¹ Constant care is a humanitarian law principle that informs the practical application of the various precautionary requirements that follow it in Article 57 (and their customary law counterparts). It also imposes a general duty of care on parties to the conflict.¹⁴² Although some, like DOD, have asserted that the constant care requirement is limited to “planning and conducting attacks,”¹⁴³ the better view is that the duty extends to all military operations, not just those that qualify as attacks under international humanitarian law.¹⁴⁴ Accordingly, the requirement to take constant care requires parties to a conflict to consider the possibility of harmful concussive effects during operations like ordnance disposal, mine clearing, engineering demolition operations, and other activities generating concussive effects that may affect civilians negatively.

Moreover, “constant care” requires military personnel to avoid any harm to civilians, not just that which qualifies as incidental injury or collateral damage

¹³⁸ See *Galić*, IT-98-29-T, Trial Judgment, ¶ 58.

¹³⁹ See CIHL STUDY, *supra* note 50, rules 15–21; see also Michael J. Matheson, *Session One: The United States Position on the Relation of Customary International Law to the 1977 Protocols Additional to the 1949 Geneva Conventions*, 2 AM. U. J. INT’L L. & POL’Y 419, 427 (1987).

¹⁴⁰ AP I, *supra* note 50, arts. 57(2)(a)(ii), 57(2)(c), 57(3); see also CIHL STUDY *supra* note 50, rules 15–21; DOD LAW OF WAR MANUAL, *supra* note 50, § 5.3.

¹⁴¹ AP I, *supra* note 50, art. 57(1); see also CIHL STUDY, *supra* note 50, rule 15; ICRC COMMENTARY, *supra* note 7, ¶ 2191.

¹⁴² ICRC COMMENTARY, *supra* note 7, ¶ 2191.

¹⁴³ See DOD LAW OF WAR MANUAL, *supra* note 50, § 5.3.3. An attack is defined in international humanitarian law as an act of “violence against the adversary, whether in offense or defense.” AP I, *supra* note 50, art. 49(1). Not all military operations qualify as attacks. See AMW MANUAL, *supra* note 53, rule 1(e).

¹⁴⁴ See Jean-François Quéguiner, *Precautions Under the Law Governing the Conduct of Hostilities*, 88 INT’L REV. RED CROSS 793, 797 (2006); see also U.S. COMMANDER’S HANDBOOK, *supra* note 53, at 8-1.

pursuant to the rule of proportionality.¹⁴⁵ Therefore, the issue of whether concussive effects qualify as incidental injury is not relevant with respect to precautions in attack. Nor is there a requirement of either definitive expectation of harm or the establishment of causation that is not overly attenuated. To the extent that an operation may place civilians at risk, the obligation attaches.¹⁴⁶ While this obligation may sound onerous, some militaries are already taking such care with respect to their troops.¹⁴⁷

Most of the remaining precautions requirements, set forth in Article 57(2–3), apply only to attacks. These include choice of weapon system, tactic, and target, as well as a duty to warn. All are subject to a condition of feasibility.¹⁴⁸ Feasible precautions are “those precautions which are practicable or practically possible taking into account all circumstances ruling at the time, including humanitarian and military considerations.”¹⁴⁹ The obligation is to act with due diligence and in good faith in attempting to avoid harming civilians.¹⁵⁰ However, the precautionary obligations to consider alternative weapons, tactics, and targets apply only in cases in which incidental injury is expected, as those terms were described above.¹⁵¹ Despite this limitation in the text, the requirement to take constant care nevertheless obligates the attacker to avoid negative effects generally on the civilian population.

¹⁴⁵ The distinction is clear from the absence of a reference in Article 57(1) to any type of harm. By contrast, Article 57(2), which imposes the requirement to take “feasible precautions” in an attack, refers to “loss of civilian life, injury to civilians and damage to civilian objects,” that is, the type of harm that must be considered in the proportionality assessment. *See* ICRC COMMENTARY, *supra* note 7, ¶ 2191; U.S. COMMANDER’S HANDBOOK, *supra* note 53, at 8-1.

¹⁴⁶ The text of Article 57(1) simply requires parties to the conflict to take “constant care . . . to spare the civilian population, civilians and civilian objects.” AP I, *supra* note 50, Art. 57(1). *See also* ICRC COMMENTARY, *supra* note 7, ¶ 2191; U.S. COMMANDER’S HANDBOOK, *supra* note 53, at 8-1.

¹⁴⁷ *See* DODI 6490.11, *supra* note 36 (establishing procedures for the management of concussive injuries in the deployed setting); *see also* BLAST INJ. RES. PROGRAM COORDINATING OFF., U.S. DEP’T OF DEF., PREVENTION, MITIGATION, & TREATMENT OF BLAST INJURIES: FY 15 REPORT TO THE EXECUTIVE AGENT 113 (2015) (detailing the development of sensors to assist commanders in determining when service members have reached a concussive injury “safety limit of exposure that would put them at risk for long-term [mild] TBI-related medical conditions”).

¹⁴⁸ *See* G.A. Res. 2675 (XXV), at 76 (Dec. 9, 1970) (“In the conduct of military operations, every effort should be made to spare the civilian populations from the ravages of war, and all necessary precautions should be taken to avoid injury, loss or damage to civilian populations.”); DOD LAW OF WAR MANUAL, *supra* note 50, § 5.3.3; Matheson, *supra* note 139, at 426–27 (“We support the principle that all practicable precautions, taking into account military and humanitarian considerations, be taken in the conduct of military operations to minimize incidental death, injury, and damage to civilians and civilian objects, and that effective advance warning be given of attacks which may affect the civilian population, unless circumstances do not permit.”).

¹⁴⁹ Protocol on Prohibitions or Restrictions on the Use of Mines, Booby-Traps and Other Devices as amended on 3 May 1996 art. 3(10), May 3, 1996, S. TREATY DOC. NO. 105-1 (1997), 2048 U.N.T.S. 93; *see also* BOTHE COMMENTARY, *supra* note 64, at 404; ICRC COMMENTARY, *supra* note 7, ¶ 2198.

¹⁵⁰ *See* Michael Bothe, *Legal Restraints on Targeting: Protection of Civilian Population and the Changing Faces of Modern Conflicts*, 31 *ISR. Y.B. ON HUM. RTS.* 35, 45 (2001); ICRC COMMENTARY, *supra* note 7, ¶ 2208.

¹⁵¹ *See* AP I, *supra* note 50, art. 57(2)(a)(ii); CIHL STUDY, *supra* note 50, rule 17.

Feasibility depends on context. The extent of information available to an attacker, the weapons systems that can be used to conduct the attack, the need to protect the attacker's forces, and the extent of civilian presence in the target area are, *inter alia*, factors bearing on the feasibility of taking precautions.¹⁵² Precautions are contingent in that a soldier must take them only if doing so is reasonable in the attendant circumstances.

To illustrate, if an attack is likely to cause concussive effects, the attacker may need to consider the use of more precise weaponry, weapons with lesser blast effect, or advanced intelligence, surveillance, and reconnaissance assets to help reduce the risk of concussive injury to civilians. For instance, consider an attack with conventional weapons that is likely to cause concussive effects that can be expected to result in incidental injury to civilians, but not otherwise physically harm them. If it is feasible to neutralize the target through cyber means, and doing so would sacrifice no military advantage, the attacker would be obligated to employ a cyber weapon as a matter of law. Other factors that might reduce concussive effects include angle at which the target is struck, altitude of release, fusing, munition release heading adjustment, and terrain implications. The attacker should also consider the possibility of striking alternative targets to achieve the same or a similar military advantage if concussive effects are less likely to result from a strike on them.

International humanitarian law also requires an effective advanced warning of an attack when it "may affect the civilian population."¹⁵³ If one is reasonably certain that concussive injuries to civilians are going to be caused by an attack, such warnings are required, albeit only to the extent practicable in the circumstances.¹⁵⁴ The active warning area would depend on the likelihood of concussive injury occurring, based on the munition used. Note that the warning requirement applies whenever the attack will "affect" the civilian population. This being so, the issue of whether the concussive injuries qualify as incidental injury is irrelevant; so long as it can be expected that the civilian population will be affected, the obligation attaches.

Finally, the defending party has an obligation to take "passive" precautions against the effects of an attack.¹⁵⁵ Concussive effects would clearly be included in the effects that this duty is meant to avoid.¹⁵⁶ In fact, the party in control of the territory upon which the civilian population is situated is well-positioned to minimize concussive injury by avoiding the placement of military objectives near civilians or by moving civilians from the vicinity of such objectives.¹⁵⁷ Of course,

¹⁵² See AP I, *supra* note 50, art. 57(2)(a)(ii); CIHL STUDY, *supra* note 50, rule 17.

¹⁵³ AP I, *supra* note 50, art. 57(2)(c); see CIHL STUDY, *supra* note 50, rule 20.

¹⁵⁴ See DOD LAW OF WAR MANUAL, *supra* note 50, § 5.11.1. See generally Pnina Sharvit Baruch & Noam Neuman, *Warning Civilians Prior to Attack Under International Law: Theory and Practice*, 87 INT'L L. STUD. 359, 388 (2011).

¹⁵⁵ See AP I, *supra* note 50, art. 58; CIHL STUDY, *supra* note 50, rules 22–24.

¹⁵⁶ See AP I, *supra* note 50, art. 58; CIHL STUDY, *supra* note 50, rules 22–24.

¹⁵⁷ See DOD LAW OF WAR MANUAL, *supra* note 50, § 5.3.1.

as noted throughout this Article, the ability of a party in conflict to comply effectively with this and other legal obligations depends on the quality of information regarding concussive effects that is available to them.

Conclusion

Given the current state of science, it is arguably premature to impose a legal requirement to consider TBIs, especially their mid- and long-term consequences, in proportionality analysis and relevant aspects of the requirement to take precautions in attack. Yet, it is clear that as science advances, particularly if progress is made in the understanding of concussive effects on the civilian population, parties to a conflict could be required to do so as a matter of law.

Minimizing the harm caused by concussive effects will depend on sound and robust operational planning and execution, particularly with respect to targeting. Presently, most militaries do not treat concussive injury as incidental injury in their prescribed proportionality calculation methodologies. For instance, the collateral damage estimation methodology (CDEM) employed by U.S. forces addresses the probability of injury to persons within a certain blast radius as a result of such factors as primary blast, fragmentation, secondary debris from crater ejecta, and blunt trauma from building collapse, but it does not account for effects on the brain.¹⁵⁸

However, as the science is refined, reliable threshold values for the probability of mild, moderate, and severe TBI within a given blast zone could be developed and included in the CDEM to assist in mitigating such injuries. To illustrate, a collateral effects radius (CER) with respect to concussive effects could be calculated for particular classes of munitions or individual types of munitions.¹⁵⁹ Using a CER, a collateral hazard area—an area within which an unacceptable probability of injury exists—can be calculated and assigned a casualty factor.¹⁶⁰

And once greater understanding of concussive effects is acquired, targeting processes can accommodate them. Because military attack decisions often occur under significant time, space, force, and informational constraints, incidental civilian-injury expectations are embedded into rules of engagement and tactics, techniques, and procedure protocols.¹⁶¹ The decision-maker is meant to use these tools in good faith, under the attendant circumstances, based on all information

¹⁵⁸ See Chairman, Joint Chiefs of Staff, Instr. 3160.01B, No-Strike and the Collateral Damage Estimation Methodology (Dec. 11, 2015).

¹⁵⁹ See *id.* at E-3 (noting that a collateral effects radius is a value that includes total error probable and the radius of primary warhead effects).

¹⁶⁰ A collateral hazard area is formed by measuring the CER from either an aim point or the edge of a target area and drawing a circle around the target. *Id.*

¹⁶¹ BOTHE COMMENTARY, *supra* note 64, at 352 (arguing that tailored rules of engagement and observer-controlled training exercises best prepare military commanders for the sensitivities involved in conducting a proportionality analysis).

reasonably available, to assist in complying with his or her legal obligations.¹⁶² Such tools are designed to ingrain best practices, identify collateral concerns, employ mitigation techniques, and assess risk to determine an appropriate approval authority for the attack. Due to the “invisible” nature of concussive injury, it will be especially critical to account for them in such processes and methodologies.

While the science continues to develop, concussive effects still must be considered to the extent reasonable in the circumstances and in light of the current state of the science when conducting military operations because of the obligation to take constant care. Indeed, U.S. targeting doctrine encourages planners to “consider . . . second-, third-, and higher order effects,” both pre- and post-attack.¹⁶³ The doctrine accounts for various categories of effects, including direct, indirect, cumulative, cascading, and unintended.¹⁶⁴ Moreover, target-development standards require taking note of non-physical “collateral effects such as impact on communications, electrical power, and other infrastructure.”¹⁶⁵ Irrespective of any further legal requirement, then, the United States may consider in targeting the potential effects of concussive injuries as a matter of policy and good operational sense.

Finally, while technological development may increase the effectiveness of attacks and their capacity to cause concussive effects on individuals, it may also help clarify the obligations of states under international humanitarian law. As the understanding of concussive effects grows, so too will the clarity and granularity of relevant obligations under international humanitarian law. At present, states are striving to better understand brain injury to their combatants. But the knowledge they acquire also will bear fully on their obligations to protect civilians on the battlefield, obligations that they must be preparing to shoulder.

¹⁶² See JOINT TARGETING SCH. STUDENT GUIDE 38, 140–41 (2017), http://www.jcs.mil/Portals/36/Documents/Doctrine/training/jts/jts_studentguide.pdf?ver=2017-12-29-171316-067 [<http://perma.cc/9HVB-DY7W>].

¹⁶³ JP 3-60, *supra* note 81, at II-36.

¹⁶⁴ See *id.*

¹⁶⁵ Chairman, Joint Chiefs of Staff, Instr. 3370.01B, Target Development Standards, at D-B-5 (May 6, 2016).