Testimony

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Repeated Exposure to Low-Level Military Occupational Blasts

An Overview of the Research, Critical Gaps, and Recommendations

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Repeated Exposure to Low-Level Military Occupational Blasts: An Overview of the Research, Critical Gaps, and Recommendations

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Before the Senate Armed Services Committee
Subcommittee on Military Personnel
United States Senate

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Chairwoman Warren, Ranking Member Scott, and members of the committee, good afternoon, and thank you for the opportunity to testify today. My name is Dr. Samantha McBirney. I am a biomedical engineer at RAND, a nonprofit, nonpartisan research organization. My research for the past 15 years, not only at RAND but also at the University of California, Berkeley and the University of Southern California, has focused on traumatic brain injury, or TBI—both as the result of blunt impact and as the result of blast overpressure. My comments today are based on research conducted within the Personnel, Readiness, and Health Program within the RAND National Security Research Division, as well as peer-reviewed, published research that has taken place outside RAND in the broader scientific community. For the past eight years, RAND has supported the Department of Defense's (DoD's) Blast Injury Research Coordinating Office in synthesizing recent research and defining the upcoming research agenda on specific topics related to blast. A list of RAND's contributions to this space is available online.[3]

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[3] U.S. Department of Defense Blast Injury Research Coordinating Office, "International State-of-the-Science Meeting Series," webpage, March 31, 2021, https://blastinjuryresearch.health.mil/index.cfm/sos.

Today, I would like to speak with you about repeated exposure to low-level military occupational blasts. These are defined as low-level blast exposures experienced while fulfilling occupational duties (both in combat and in training) that result in subconcussive injuries. These injuries are not immediately detectable and would not qualify as a TBI. I will start by introducing the injury more broadly before delving into critical gaps in the research and potential recommendations DoD could implement to move the needle forward and better protect our service members from the effects of repeated exposure to low-level blast.

Background

As many of us here know, TBI has been called the "signature injury" of both Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF).[4] Hundreds of thousands of TBI diagnoses were made between 2000 and 2015 alone,[5] and upwards of 20 percent of service members returning from deployment suffered a TBI.[6] Improvised explosive devices were often the cause of TBI during OEF and OIF due to widespread use of such weapons. Evidence also suggests that, apart from these injuries, service members are simultaneously exposed to low-level military occupational blasts in the form of blast overpressure (the pressure wave that emanates from the source of an explosion) in both combat and training, which can cause subconcussive injuries. Exposure during training can be due to breaching exercises and the repeated firing of increasingly powerful weapon systems—such as the Carl Gustaf recoilless rifle, the AT4, and the M72 Light Anti-Armor Weapon (LAW)—even when operating these weapons within limits presumed to be safe. To provide some perspective on the level of exposure some service members have, one study found that up to 32 percent of blasts experienced by breaching instructors exceeded the recommended exposure limit.[7] A *New York Times* investigation found that some troops returned from Iraq and Afghanistan having fired tens of thousands of high-explosive shells each over the course of their deployment.[8] Studies have shown that the

[4] Lisa K. Lindquist, Holly C. Love, and Eric B. Elbogen, "Traumatic Brain Injury in Iraq and Afghanistan Veterans: New Results from a National Random Sample Study," *Journal of Neuropsychiatry and Clinical Neurosciences*, Vol. 29, No. 3, Summer 2017.

[5] Military Health System, "DOD TBI Worldwide Numbers," webpage, undated, https://health.mil/Military-Health-Topics/Centers-of-Excellence/Traumatic-Brain-Injury-Center-of-Excellence/DOD-TBI-Worldwide-Numbers.

[6] Terri Tanielian and Lisa H. Jaycox, eds., *Invisible Wounds of War: Psychological and Cognitive Injuries, Their Consequences, and Services to Assist Recovery*, RAND Corporation, MG-720-CCF, 2008, https://www.rand.org/pubs/monographs/MG720.html.

[7] Ann Nakashima, Oshin Vartanian, Shawn Rhind, Kristen King, Catherine Tenn, and Rakesh Jetly, "Repeated Occupational Exposure to Low-Level Blast in the Canadian Armed Forces: Effects on Hearing, Balance, and Ataxia," *Military Medicine*, Vol. 187, No. 1–2, January/February 2022.

[8] Dave Phillips, "A Secret War, Strange New Wounds, and Silence from the Pentagon," *New York Times*, November 5, 2023a; Dave Phillips, "U.S. Troops Still Train on Weapons With Known Risk of Brain Injury," *New York Times*, November 26, 2023c.

cumulative effect of repeated low-level blast exposure in such environments can cause symptoms similar to TBI.[9]

Critical Gaps

A variety of effects have been linked to low-level blast exposure, some more tenuously than others. These include cognitive impairments, sleep disturbances, depression, panic attacks, and posttraumatic stress disorder.[10] However, there is a lack of published, peer-reviewed, scientific evidence linking repeated low-level military occupational blast to injury. Experiments conducted in animals and observational studies of humans in certain high-risk occupations do suggest that cognitive changes can occur. However, animal studies have largely focused on rodent models, yielding results that may not readily translate to humans, and sample sizes for observational studies have remained, for the most part, exceptionally small. Only recently has the research community started conducting longitudinal studies, analyzing data from the Millennium Cohort Study; even still, much of the focus has been on high-level blast.[11]

One reason for the lack of evidence on the relationship between low-level blast exposure and its effects is the difficulty of diagnosis. The very nature of low-level blast exposure, and the fact that it is not one single event that causes an issue but rather the cumulative effect of repeated exposure, complicates injury recognition. Symptoms typically do not manifest immediately, which makes it easy to confuse symptoms with those of other deployment-related injuries and increasingly unlikely that repeated exposure to low-level blast is identified as the cause of any symptoms.[12] Additionally, injury is vastly underreported among service members,[13] and necessary medical care is not consistently sought out. A study conducted in 2020 assessing unreported and untreated TBI among over 5,000 soldiers concluded that, of those who reported a concussion, only 52 percent sought medical care. Of those who did not seek care, 64 percent did

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[9] Walter Carr, Elena Polejaeva, Anna Grome, Beth Crandall, Christina LaValle, Stephanie E. Eonta, and Lee Ann Young, "Relation of Repeated Low-Level Blast Exposure with Symptomology Similar to Concussion," *Journal of Head Trauma Rehabilitation*, Vol. 30, No. 1, January/February 2015.

[10] Peethambaran Arun, Donna M. Wilder, Ondine Eken, Rodrigo Urioste, Andrew Batuure, Sujith Sajja, Stephen Van Albert, Ying Wang, Irene D. Gist, and Joseph B. Long, "Long-Term Effects of Blast Exposure: A Functional Study in Rats Using an Advanced Blast Simulator," *Journal of Neurotrauma*, Vol. 37, No. 4, February 2020; Jeffrey J. Bazarian, Kerry Donnelly, Derick R. Peterson, Gary C. Warner, Tong Zhu, and Jianhui Zhong, "The Relation Between Posttraumatic Stress Disorder and Mild Traumatic Brain Injury Acquired During Operations Enduring Freedom and Iraqi Freedom," *Journal of Head Trauma Rehabilitation*, Vol. 28, No. 1, January/February 2013; Lauren Fish and Paul Scharre, *Protecting Warfighters from Blast Injury*, Center for a New American Security, May 2018, https://www.cnas.org/publications/reports/protecting-warfighters-from-blast-injury; Phillips, 2023a.

[11] Jennifer N. Belding, Claire A. Kolaja, Rudolph P. Rull, and Daniel W. Trone, "Single and Repeated High-Level Blast, Low-Level Blast, and New-Onset Self-Reported Health Conditions in the U.S. Millennium Cohort Study: An Exploratory Investigation," *Frontiers in Neurology*, Vol. 14, March 20, 2023.

[12] Dave Phillips, "Five Takeaways from a Times Investigation of Artillery Blast Exposure," *New York Times*, November 5, 2023b.

[13] Laurel Smith, Richard Westrick, Sarah Sauers, Adam Cooper, Dennis Scofield, Pedro Claro, and Bradley Warr, "Underreporting of Musculoskeletal Injuries in the US Army: Findings from an Infantry Brigade Combat Team Survey Study," *Sports Health*, Vol. 8, No. 6, November/December 2016.

not think the injury required care, while 18 percent were concerned that reporting might have negative repercussions on their careers.[14] If care-seeking is this low for service members experiencing TBI, then one could safely assume that it would be even lower for service members experiencing low-level blast exposure. Lastly, the specific causal mechanism of brain injury for low-level blast remains unclear, only obfuscating the issue of proper diagnosis further.

There is also a lack of research about the military occupational specialties at greatest risk of exposure to low-level blast. While there is no doubt that certain occupational specialties are more frequently exposed to low-level blast than others (e.g., breachers, munitions range instructors), there is little to no research to support these hypotheses. So, there remains a lack of understanding of the direct impact that repeated exposure to low-level blast has on the health of service members in different military occupational specialties.[15]

Recommendations

"If the preventive intervention is perfectly effective but cannot be delivered in time, it is not useful."[16] This quote from a 2019 RAND report on the neurological effects of repeated exposure to military occupational blast perfectly describes the current state within DoD and the reason many of us are here today. As a research community, we clearly see that additional research needs to be done. However, there are steps DoD can take now to better protect service members against blast-induced injury. These recommendations, drawn from previously published RAND work and a 2018 report by the Center for a New American Security, are outlined below.

Expand Existing Blast Surveillance Programs

Current blast surveillance programs could be expanded through the use of devices, such as blast gauges, to monitor, record, and maintain data on service members' blast pressure exposure, whether in training or in combat.[17] Blast gauges are devices that are placed on a service member's uniform and measure the intensity of blast waves in the vicinity. These devices are not new to DoD: In fact, over a decade ago, they were used to gather data from over 11,000 personnel deployed in Afghanistan.[18] The devices produced evidence that many service members are exposed to harmful levels of low-level blast simply caused by proximity to a heavy weapon when fired. The program was ultimately discontinued, primarily due to the device's failure to

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[14] Sandra M. Escolas, Margie Luton, Hamid Ferdosi, Bianca D. Chavez, and Scot D. Engel, "Traumatic Brain Injuries: Unreported and Untreated in an Army Population," *Military Medicine*, Vol. 185, Supp. 1, January–February 2020.

[15] Charles C. Engel, Emily Hoch, and Molly M. Simmons, *The Neurological Effects of Repeated Exposure to Military Occupational Blast: Implications for Prevention and Health: Proceedings, Findings, and Expert Recommendations from the Seventh Annual Department of Defense State-of-the-Science Meeting*, RAND Corporation, CF-380/1-A, 2019, https://www.rand.org/pubs/conf_proceedings/CF380z1.html.

[16] Engel, Hoch, and Simmons, 2019, p. 7.

[17] Fish and Scharre, 2018.

[18] Defense Advanced Research Projects Agency (DARPA), "Blast Gauge," webpage, undated, https://www.darpa.mil/about-us/timeline/blast-gauge.

provide reliable information on whether an individual experienced enough exposure to sustain an injury.[19] However, the technology has since evolved,[20] meaning such devices (or similar ones) could yield useful information. The use of such devices would likely reduce the underreporting of injuries, as the responsibility of reporting would no longer be placed on the individual. Additionally, linking the device data to personnel administrative files and/or other DoD longitudinal datasets would provide much-needed information on which occupational specialties are more frequently exposed to low-level blast.

Create and Maintain Blast Exposure Records

Blast exposure records could be created and maintained as part of a member's service records. Records should include (but not be limited to) the number of previous exposures (including the number of exposures per unit of time); any residual physical, mental, or emotional effects resulting from blast exposure; and the context of the exposure (e.g., training, deployed). This would allow DoD to better track the frequency of low-level blast exposure, assess the occurrence among high-risk occupational specialties, determine the connection between exposure and health outcomes, and develop strategies to mitigate low-level blast exposure in training environments. Ultimately, in-depth blast exposure records could be used to develop an index score to gauge an individual's combat readiness and potential health risks.[21]

Update Weapon System–Specific Information to Include Blast-Related Characteristics

To properly assess blast exposure risk, more information is needed about the use of weapon systems in both training and deployed environments. A central repository of blast-related characteristics (e.g., pressure profiles, common blast loads) associated with specific systems and the environments they are used in would better inform the service members, researchers, and DoD safety programs about the risk of exposure to low-level blasts. This repository could also be used to map weapon systems and blast environments to various health risks.[22]

Additionally, firing limits for shoulder-fired heavy weapons known to be blast-intensive could be reviewed and updated. According to a report published by the Center for a New American Security in 2018, "Firing limits should: be revised downward to a level such that allowable exposures are not associated with cognitive deficits after firing; cover exposures across a longer time period, on the order of 72 to 96 hours; include a minimum safe distance for observers and instructors; account for the possibility of multiple types of heavy weapons being fired in a single day; and include cumulative annual and lifetime limits for blast exposure in training."[23]

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[19] Jon Hamilton, "Pentagon Shelves Blast Gauges Meant to Detect Battlefield Brain Injuries," *National Public Radio*, December 20, 2016, https://www.npr.org/sections/health-shots/2016/12/20/506146595/pentagon-shelves-blast-gauges-meant-to-detect-battlefield-brain-injuries.

[20] Blast Gauge System, "The Wireless Blast Gauge® System," webpage, undated, https://blastgauge.com/.

[21] Engel, Hoch, and Simmons, 2019; Fish and Scharre, 2018.

[22] Engel, Hoch, and Simmons, 2019.

[23] Fish and Scharre, 2018, p. 3.

Consider Embedding Researchers Within Training and Deployed Units

Embedding researchers (e.g., biomedical engineers, neuroscientists, neuropsychologists, clinician-researchers) within units could yield multiple benefits. First, researchers could improve the depth and diversity of data collected and used in studies that examine the impact of low-level blast exposure on service members.[24] Second, they could assist with identifying specific military occupational specialties that are more frequently exposed to low-level blast. Embedding researchers ensures that research will remain focused on real-world questions and contexts,[25] thereby improving the usefulness of the work being conducted while minimizing the burden placed on the members of the unit themselves.[26] It is important to note that none of this is accomplished by researchers merely being physically present. Embedded researchers must focus on building rapport and establishing collaborative relationships with teams.[27] This practice not only will guarantee the sustainability of the research being conducted but also will increase DoD's capacity to conduct research and inform policy and practice.[28]

Conclusion

As U.S. weapon systems continue to become more advanced and increasingly powerful, low-level military occupational blasts will remain an enduring challenge for service members. Addressing the issue of repeated exposure to low-level blasts necessitates action and collaboration between DoD and the research community. DoD should consider expanding existing blast surveillance programs, creating and maintaining blast exposure records, and updating weapon system–specific information to include blast-related characteristics. Moreover, embedding researchers within training and deployed units can significantly enhance data collection and our understanding of the real-world impact that repeated low-level blast exposure has on service members. By implementing these recommendations, alongside continued research efforts to close the substantial knowledge gaps highlighted here, DoD can take significant strides toward better protecting the health and well-being of our service members.

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[24] Valerie Jenness, "Pluto, Prisons, and Plaintiffs: Notes on Systematic Back-Translation from an Embedded Researcher," *Social Problems*, Vol. 55, No. 1, February 2008; Harriet Rowley, "Going Beyond Procedure: Engaging with the Ethical Complexities of Being an Embedded Researcher," *Management in Education*, Vol. 28, No. 1, January 2014.

[25] Edward J. Hackett and Diana R. Rhoten, "Engaged, Embedded, Enjoined: Science and Technology Studies in the National Science Foundation," *Science and Engineering Ethics*, Vol. 17, No. 4, December 2011.

[26] Engel, Hoch, and Simmons, 2019.

[27] Cecilia Vindrola-Padros, Tom Pape, Martin Utley, and Naomi J. Fulop, "The Role of Embedded Research in Quality Improvement: A Narrative Review," *BMJ Quality & Safety*, Vol. 26, No. 1, January 2017.

[28] Nicole Mockler and Susan Groundwater-Smith, "The Knowledge Building School: From the Outside In, from the Inside Out," *Change: Transformations in Education*, Vol. 5, No. 2, November 2002; Sandie Wong, "Tales from the Frontline: The Experiences of Early Childhood Practitioners Working with an 'Embedded' Research Team," *Evaluation and Program Planning,* Vol. 32, No. 2, May 2009.