

# The Blast Exposure Likelihood Level (BELL) Scale: A Novel Framework Supporting Longitudinal Efforts to Monitor Warfighter Health



Samia M. Abdallah<sup>1-3</sup>, Patrick R. Smith<sup>1-3</sup>, Suzanne Waddingham<sup>1-3</sup>, Daniel P. Perl<sup>1,2</sup>, David S. Priemer<sup>1,2</sup>

<sup>1</sup>Department of War/Uniformed Services University Brain Tissue Repository, Bethesda, MD; <sup>2</sup>F. Edward Hébert School of Medicine, Uniformed Services University, Bethesda, MD; <sup>3</sup>The Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc., Bethesda, MD



## BACKGROUND, METHODS, AND SUMMARY

Postmortem neuropathological investigation into long-term effects of blast overpressure exposure is frequently hindered by knowledge gaps regarding donors’ lifetime exposure history. The absence of prospective, first-person accounts requires navigating numerous challenges, such as documentation disparities and gaps, memory variance inherent to proxy-informant (historian) interviews, and the insufficiency of relying on military occupation as an isolated proxy for blast exposure. The Department of War/Uniformed Services University Brain Tissue Repository (DoW/USU BTR) proposes the Blast Exposure Likelihood Level (BELL) scale as a semi-quantitative framework to address these challenges. The BELL provides a standardized approach, integrating seven core categories of service and medical history into a weighted ordinal scoring system that assesses a military career to determine the associated likelihood of repetitive occupational blast exposure, identified blast events, and/or blast injury. This triangulation approach is thus designed to cross-reference available objective records with supplemental subjective information provided by historians, providing composite assessments that facilitate comprehensive stratification of exposure probability and enable clinicopathological correlation in human brain

| Scoring Guide |                  |                                                                                                                                                                |
|---------------|------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Score Range   | Risk Level       | Score Interpretation                                                                                                                                           |
| 0-4           | Unknown/Unlikely | Available evidence indicates blast exposure is unlikely, or the information provided is insufficient for the determination of blast exposure likelihood.       |
| 5-9           | Limited/Minimal  | Available evidence indicates a low likelihood of blast exposure, including minimal exposure to blast event(s) and/or repetitive occupational exposures.        |
| 10-14         | Likely           | Available evidence indicates blast exposure is more likely than not, including reasonable suspicion of blast event(s) and/or repetitive occupational exposure. |
| 15-18         | Highly Likely    | Available evidence indicates a high likelihood of blast exposure, including identifiable blast event(s) and/or repetitive occupational exposure.               |
| 19+           | Confirmed        | Definitive data and available evidence confirm blast exposure, including significant blast event(s) and/or repetitive occupational exposure.                   |

| EXAMPLE CASE 1                     |                                    |                                                                                                                                                        |                                    |                                    |                                                                                                                                                                |
|------------------------------------|------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RATING                             | UNKNOWN/<br>UNLIKELY               | LIMITED/<br>MINIMAL                                                                                                                                    | LIKELY                             | HIGHLY<br>LIKELY                   | ADDITIONAL INFORMATION:<br>Select “YES” to indicate confirmed blast injury and/or repetitive occupational blast exposure                                       |
| 1. Military Occupation             | <input type="checkbox"/> 0         | <input checked="" type="radio"/> 1                                                                                                                     | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Occupation code: PHA10, 10 years; occupation code: HS, 8 years</i>                             |
| 2. Time in Service                 | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                             | <input type="checkbox"/> 2         | <input checked="" type="radio"/> 3 | <u>Notes:</u> <i>18 years total</i>                                                                                                                            |
| 3. Era of Service                  | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                             | <input checked="" type="radio"/> 2 | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>2000’s-2020’s</i>                                                                              |
| 4. Deployment History              | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                             | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>No deployment</i>                                                                              |
| 5. Combat Exposure                 | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                             | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u>                                                                                                   |
| 6. Campaign Citations              | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                             | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u>                                                                                                   |
| 7. Military and/or Medical Records | <input type="checkbox"/> 0         | <input checked="" type="radio"/> 1                                                                                                                     | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Death certificate, form DD214, additional military records, historian interview completed.</i> |
| <b>TOTAL:</b>                      | <b>7/21</b>                        | Available evidence indicates a low likelihood of blast exposure, including minimal exposure to blast event(s) and/or repetitive occupational exposure. |                                    |                                    |                                                                                                                                                                |

| EXAMPLE CASE 2                     |                                    |                                                                                                                                                                |                                    |                                    |                                                                                                                                                                                 |
|------------------------------------|------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RATING                             | UNKNOWN/<br>UNLIKELY               | LIMITED/<br>MINIMAL                                                                                                                                            | LIKELY                             | HIGHLY<br>LIKELY                   | ADDITIONAL INFORMATION:<br>Select “YES” to indicate confirmed blast injury and/or repetitive occupational blast exposure                                                        |
| 1. Military Occupation             | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Occupation code: 35D, 16.5 years; Occupation code: 11A, 11 years</i>                                            |
| 2. Time in Service                 | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input checked="" type="radio"/> 3 | <u>Notes:</u> <i>27.5 years total</i>                                                                                                                                           |
| 3. Era of Service                  | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                                     | <input checked="" type="radio"/> 2 | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>1980’s-2010’s</i>                                                                                               |
| 4. Deployment History              | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>No deployment</i>                                                                                               |
| 5. Combat Exposure                 | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u>                                                                                                                    |
| 6. Campaign Citations              | <input checked="" type="radio"/> 0 | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input type="checkbox"/> 3         | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u>                                                                                                                    |
| 7. Military and/or Medical Records | <input type="checkbox"/> 0         | <input type="checkbox"/> 1                                                                                                                                     | <input type="checkbox"/> 2         | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Death certificate, medical records, form DD214, additional military records, historian interview completed.</i> |
| <b>TOTAL:</b>                      | <b>11/21</b>                       | Available evidence indicates blast exposure is more likely than not, including reasonable suspicion of blast event(s) and/or repetitive occupational exposure. |                                    |                                    |                                                                                                                                                                                 |

| EXAMPLE CASE 3                     |                            |                                                                                                                                                                                                                  |                            |                                    |                                                                                                                                                             |
|------------------------------------|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| RATING                             | UNKNOWN/<br>UNLIKELY       | LIMITED/<br>MINIMAL                                                                                                                                                                                              | LIKELY                     | HIGHLY<br>LIKELY                   | ADDITIONAL INFORMATION:<br>Select “YES” to indicate confirmed blast injury and/or repetitive occupational blast exposure                                    |
| 1. Military Occupation             | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Occupation code: 0341, 10 years; Occupation code: 0931, 5 years</i>                         |
| 2. Time in Service                 | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <u>Notes:</u> <i>15 years total</i>                                                                                                                         |
| 3. Era of Service                  | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>2000’s-2010’s</i>                                                                           |
| 4. Deployment History              | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Iraq (1 deployment) and Afghanistan (2 deployments)</i>                                     |
| 5. Combat Exposure                 | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Active combat theater deployments and combat-related injuries</i>                           |
| 6. Campaign Citations              | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>ICM, ACM, CAR (Afghanistan)</i>                                                             |
| 7. Military and/or Medical Records | <input type="checkbox"/> 0 | <input type="checkbox"/> 1                                                                                                                                                                                       | <input type="checkbox"/> 2 | <input checked="" type="radio"/> 3 | <input checked="" type="checkbox"/> <b>Yes</b> <u>Notes:</u> <i>Autopsy report, form DD214, additional military records, historian interview completed.</i> |
| <b>TOTAL:</b>                      | <b>21/21</b>               | Definitive data and available evidence confirm blast exposure, including significant blast events and/or repetitive occupational exposure. (i.e., multiple TBIs, documented IED events, combat-related injuries) |                            |                                    |                                                                                                                                                             |

## DISCUSSION AND CONCLUSION

The DoW/USU BTR proposes the BELL scale as a reproducible methodology to bridge the gaps between military service, clinical history, and pathological findings in retrospective human research, particularly in post-mortem brain banking. By accounting for nuanced factors often overlooked by traditional classification systems, and characterizing exposure via a standardized multi-categorical approach to stratify exposure probability, this framework is designed to promote unified collaboration among researchers. This scalable framework thus may support the utilization of human data towards efforts to improve the prevention, mitigation, diagnosis, and treatment of blast-related injuries. Limitations in this proposed framework include missing data, such as unrecorded exposures that cannot be accounted for in available records, classified records, and unreliable accounts from historians. While this framework accounts for the possibility of some of these pitfalls, in some cases a complete assessment may not be achieved. Another limitation exists with regard to categorizing types of blast exposure, in that the composite score provided by the framework uniformly accounts for all types (e.g., exposures in training versus live combat, exposures of varying magnitude, etc.). However, in the use of this score by the DoW/USU BTR, these factors are documented on the assessment for internal reference and utilization in research.

DISCLAIMERS: The authors report no conflicts of interest. The information, content, opinions, and/or conclusions herein are solely those of the authors and do not reflect the official position or policy of, nor should any official endorsement be inferred on the part of, the Uniformed Services University (USU), the Department of War (DoW), the United States Government, the Henry M. Jackson Foundation for the Advancement of Military Medicine, Inc. Copyright 2026 by HJF for the benefit of USU. All rights reserved. For inquiries about using the BELL Scale, please contact Patrick Smith by email at patrick.smith.ctr@usuhs.edu.