OCCUPATIONS AT HIGH RISK FOR LOW-LEVEL BLAST EXPOSURE AND SUICIDE AMONG UNITED STATES SERVICE MEMBERS AND VETERANS

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SUICIDE WITHIN THE MILITARY

- Suicide remains one of the leading causes of death among those who served in the U.S. military (Howard et al., 2022; DoD, 2023)
- Service members and veterans were more likely to die by suicide by firearms than the general U.S. population (Zhu et al., 2025)
  - Sex-stratified analyses showed female service members were more likely to die by suicide overall
- A better understanding of potential occupational risk factors for suicide may help to inform future policy and intervention efforts aimed at mitigating suicide among military service members and veterans

LOW-LEVEL BLAST EXPOSURE

- **Low-level blast (LLB)** is defined as overpressure waves generated by *outgoing* munitions (e.g., mortars and breaching charges; Belding et al., 2021)
- Most research relies on proxy measures or self-report to assess LLB exposure rather than individualized, objective dosimetry
  - Lack of "gold standard" LLB assessment
- Previous operationalizations have used military occupational specialties (MOS) to identify occupations with a high likelihood of experiencing repeated LLB exposure (e.g., breachers, training instructors, EOD; Belding et al., 2020; 2023; Carr et al., 2015; 2020; Martindale et al., 2023; 2025)
  - Associated with physical and psychological health outcomes (Belding et al., 2023; Martindale et al., 2025)

PRIMARY OBJECTIVE

To examine associations between occupations at high risk of LLB exposure and suicide among U.S. service members and veterans.

PARTICIPANTS AND STUDY DESIGN

- 22 years of longitudinal data from the Millennium Cohort Study
- Since launching in 2001, more than 260,000 service members have been enrolled across 5 panels, and participants are invited to complete follow-up surveys approximately every 3–5 years after enrollment
  - Inclusion criteria of those with at least 5-years of follow-up data
  - **Analytic sample of N=201,408 U.S. service members and veterans**

MILITARY OCCUPATIONAL SPECIALTY (MOS)

- MOS was used as a proxy for occupations with a high risk of exposure to LLB from Defense Manpower Data Center personnel records:
  - Infantry, Gun crews, and Seamanship specialists; Infantry, General; Special Forces; Military Training instructor; Combat engineering, general; Armor and amphibious, general; Artillery and gunnery; Rocket artillery; Missile artillery operating crew; General combat operations control; Expeditionary medical services; Explosive ordnance disposal (EOD)/Underwater demolition team; and Aviation ordnance
- Those who served in these occupations for at least 12 months were categorized as at high-risk of LLB exposure
- Proportion of time in service in these high-risk occupations was calculated (0–100%)

SUICIDE MORTALITY

DoD-VA Defense Mortality Data Repository

- Based on National Death Index Plus data as well as other sources, such as the Defense Casualty Analysis System
- Cause of death ascertained using *International Classification of Diseases*, 10th Revision (ICD-10) codes
- Cause of death as defined by the Centers for Disease Control and Prevention

Armed Forces Medical Examiner System

- Maintained by the Defense Medical Surveillance System of the Armed Forces Health Surveillance Division
- Captures cause of death information for all US active duty and activated Reserve and National Guard personnel, regardless of geographic location, as well as former military members who died during military operations (working as a contractor or civilian)

RESULTS

- Between 2001–2023, 789 service members and veterans died by suicide
- Service members and veterans who were male and non-Hispanic White were more likely to die by suicide

	Died by suicide (N = 789)	No suicide death (N = 200,619)
	% or M	% or M
Sociodemographic characteristics		
Birth cohort		
Pre-1970	17.87	24.62
1970–1979	24.84	24.28
1980–1989	55.39	50.13
1990+	1.90	0.97
Sex		
Male	84.54	69.28
Female	15.46	30.72
Race and ethnicity		
Black, Non-Hispanic	6.97	12.19
Hispanic	7.10	8.39
White, Non-Hispanic	80.23	72.15
AI/AA/PI/Multiracial	5.70	7.25

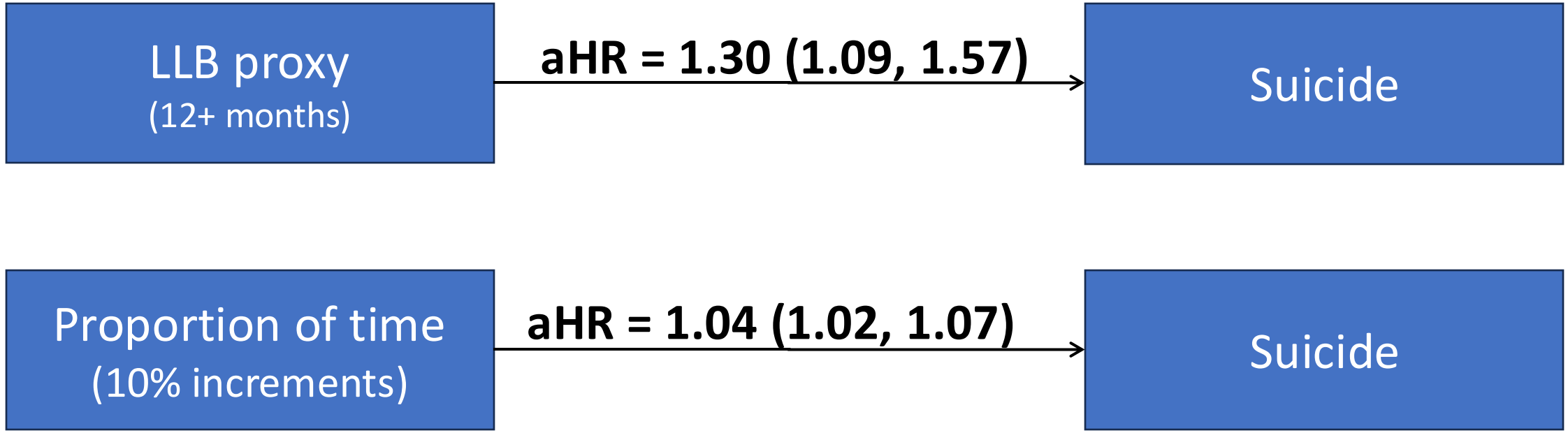
Notes. AA, Asian American; AI, American Indian or Alaska native; LLB proxy, Military Occupational Specialty derived low-level blast; PI, Pacific Islander; R/NG, Reserve/National Guard. All values are rounded up to two decimal places. Not all values add up to 100% due to missing data patterns for the following variables: race and ethnicity (N = 55) and educational attainment (N = 37).

RESULTS

- Among those who died by suicide, 24% served in occupations at high risk of LLB exposure
- Among those who did not die by suicide, 13% served in occupations at high risk of LLB exposure
- Service members and veterans who were active duty, enlisted personnel, in the Army, and deployed with combat were more likely to die by suicide

	Died by suicide (N = 789)	No suicide death (N = 200,619)
	% or M	% or M
% LLB proxy	23.95	13.31
Average follow-up (years)	9.75	17.61
Military characteristics		
Service component		
Reserve/National Guard	30.29	33.81
Active duty	69.71	66.19
Service Branch		
Army	51.96	44.56
Navy/Coast Guard	11.53	17.80
Marine Corps	13.94	8.94
Air Force	22.56	28.70
Paygrade		
Enlisted	91.63	82.99
Officer	8.37	17.01
Combat deployment history		
No deployment	30.80	32.25
Deployed, no combat	14.83	21.64
Deployed, with combat	52.34	45.19
Deployed, combat unknown	2.03	0.91

OCCUPATIONAL LLB-SUICIDE FINDINGS



BLUF: **Service members who served in occupations at high risk of LLB for 12 months or greater had 30% increased risk of suicide than those who did not. Those who spent more time in these occupations had increased risk of suicide.**

Note. aHR = Adjusted Hazard Ratio, CI = Confidence Intervals. Models were adjusted for birth cohort, sex, race, ethnicity, educational attainment, service branch, pay grade, service component, combat deployment history.

STRATIFIED BY DEPLOYMENT HISTORY

Adjusted HRs for LLB Proxy and Death by Suicide Models Stratified by Deployment History				
	Deployers (N = 134583)		**Non-deployers (N = 64896)**	
	N = 530 suicide deaths		N = 243 suicide deaths	
	HR	95% CI	HR	95% CI
LLB proxy	1.23	(.99, 1.51)	1.43	(1.00, 2.05)
Proportion of LLB service (10% increments)	**1.04**	**(1.02, 1.07)**	1.03	(.99, 1.08)

Notes. LLB proxy, Military Occupational Specialty derived low-level blast. All models adjusted for the following covariates = birth cohort, sex, race, ethnicity, educational attainment, service branch, pay grade, service component, combat deployment history, with the exception of non-deployer models not adjusting for combat exposure.

BLUF: **Stratified analyses by deployment history revealed a consistent pattern, though findings had reduced precision among non-deployers.**

INDIVIDUAL MOS CATEGORIES

Adjusted Hazard Ratios and 95% Confidence Intervals for Specific Military Occupations at High-risk of LLB Exposure and Death by Suicide Models (N = 201317)												
	Infantry		**EOD**		**Combat engineers**		**Artillery**		**Combat control**		**LLB proxy, Except Infantry**	
	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI	HR	95% CI
LLB proxy	**1.33**	**(1.06, 1.67)**	.83	(.47, 1.47)	1.39	(.93, 2.09)	1.16	(.79, 1.70)	1.01	(.66, 1.55)	1.14	(.92, 1.42)
Proportion of LLB service (10%)	**1.05**	**(1.02, 1.07)**	.98	(.92, 1.06)	1.05	(1.00, 1.10)	1.03	(.98, 1.08)	1.02	(.96, 1.07)	**1.03**	**(1.01, 1.06)**

Notes. EOD, Explosive Ordnance Disposal; LLB proxy, Military Occupational Specialty derived low-level blast. Models covariates = birth cohort, sex, race, ethnicity, educational attainment, service branch, pay grade, service component, combat deployment history.

BLUF: **When MOS categorized as high risk were broken down into individual categories, only the infantry category was significantly more likely to die by suicide. Time spent in high-risk MOS, excluding the infantry category, was associated with increased suicide risk.**

DISCUSSION

- Occupations at high risk of LLB were associated with suicide among U.S. service members and veterans

- Increased suicide risk in infantry
  - Prior occupational report found that infantry MOS had the highest risk of suicide (U.S. Congress. House Committee on Armed Services, 2024)

- Based on occupational risk, less consistent associations for other individual MOS categories (e.g., EOD, combat engineers)
  - Prior research also found no increased suicide risk among EOD personnel (U.S. Congress. House Committee on Armed Services, 2025)

MECHANISMS AND MEASUREMENT CONSIDERATIONS

- Multiple physiological or psychological mechanisms:
  - Executive dysregulation (Bjork et al., 2016; Schindler et al., 2017)
  - Mental health conditions (Belding et al., 2023; Martindale et al., 2025)
  - Neuroinflammation & neuroendocrine changes (Stone et al., 2024; Thanapaul et al., 2025)
- MOS as a proxy for LLB exposure, which *cannot* disentangle from other factors:
  - Selection effects (e.g., pre-service differences)
  - Exposure to traumatic and/or occupational experiences (e.g., combat)
  - Firearms familiarity and training associated with these MOS

FUTURE DIRECTIONS

- Although MOS as a proxy for LLB has been previously validated, future work that more comprehensively assesses LLB exposure and suicidal behaviors within military populations is needed
  - Objectively measured LLB exposure
  - Refinement of self-reported LLB questionnaire for prospective longitudinal research

QUESTIONS?

Email usn.nhrc-MilcohortInfo@health.mil for questions about Millennium Cohort Program studies or to be added to our distribution list

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BACK UP SLIDES

LOW-LEVEL BLAST EXPOSURE: ASSOCIATIONS

- Within the Millennium Cohort Study, U.S. service members and veterans who were identified as having high occupational risk of LLB exposure through MOS had increased risk of multiple physical and psychological health conditions:
  - **Service members and veterans**: Hearing loss, tinnitus, chronic fatigue syndrome, neuropathy-caused sensation in hands and feet, vision loss, sinusitis, reflux and anemia, PTSD, and depression (Belding et al., 2023)
  - **Among VHA Users**: Moderate TBI, adjustment disorder, PTSD, tinnitus, memory loss, sleep disruption/movement disorders, headache, cognitive problems, memory loss, and communication disorders (Martindale et al., 2025).

SENSITIVITY ANALYSIS

Adjusted Hazard Ratios for LLB proxy and Death By Suicide Models Adjusting for Baseline Mental Health						
	Total population (N = 195457) N = 753 suicide deaths		Deployers (N = 131768) N = 519 suicide deaths		Non-deployers (N = 63344) N = 232 suicide deaths	
	HR	95% CI	HR	95% CI	HR	95% CI
LLB proxy	**1.27**	**(1.06, 1.53)**	1.21	(.98, 1.49)	1.42	(.98, 2.04)
Proportion of LLB service (10% increment)	**1.04**	**(1.02, 1.06)**	**1.04**	**(1.02, 1.07)**	1.03	(.99, 1.08)

Notes. LLB proxy, Military Occupational Specialty derived low-level blast. All models adjusted for the following covariates = birth cohort, sex, race, ethnicity, educational attainment, service branch, pay grade, service component, combat deployment history, baseline mental component score (SF-36V) with the exception of non-deployer models not adjusting for combat exposure.

BLUF: **Controlling for baseline mental health made no substantiative difference on the pattern of findings between the LLB proxy and risk of suicide mortality.**