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Frequency- And Intensity-Dependent Effects of Noise Exposure on Vestibular Function.

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Disclosure

- **Federica M. Raciti, PhD; Kayla Minesinger, PhD; and Maria Fernanda Yepes, PhD have disclosed no relevant personal or professional financial relationships with proprietary entities that produce healthcare good and services.**
- **Suhrud M. Rajguru , PhD – Chief Scientific Officer, RestorEar Devices, LLC.**

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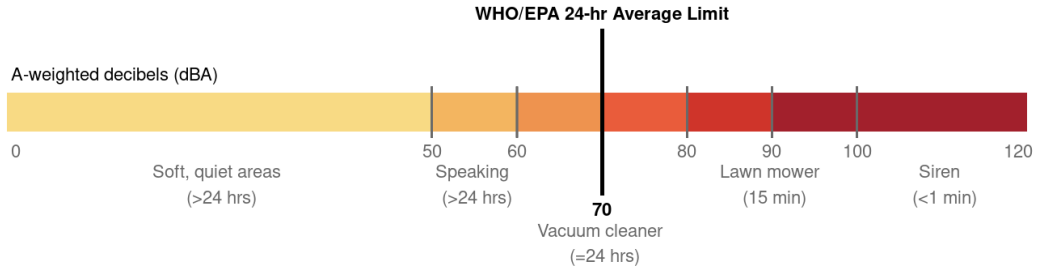
Hazardous Noise Exposure

Noise is an unwanted sound which potential to become harmful depends on characteristics such as **Intensity, Duration,** and **Pattern of Exposure**. Therefore, hazardous level of noise can take different forms.

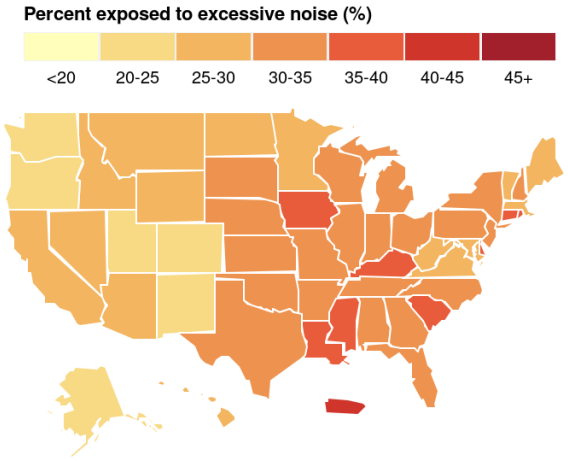


EPA and WHO, 1974

Time to reach 100% noise dose	Exposure level per NIOSH REL
8 hours	85 dB(A)
4 hours	88 dB(A)
2 hours	91 dB(A)
60 minutes	94 dB(A)
30 minutes	97 dB(A)
15 minutes	100 dB(A)

NIOSH, 1998

Hazardous noise is a pervasive public-health threat, placing more than 100 million Americans at risk of adverse health effects.



1 in 3

adult Americans are estimated to be exposed to excessive noise levels

Apple Hearing Study, 2023

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Hazardous Noise Exposure

Service Members represents a unique high-risk population because military duties expose individuals to a particularly diverse and recurrent profile of hazardous noise throughout their careers.

	Vehicle Noise	Ships	Aircraft	Garrison Activities	Flight Lines	Weapon System (Small Arms)	Weapon System (Large Caliber)	Explosion
Intensity (dBA)	85 – 110	87 – 102	90 – 115	120+	126 – 148	140 – 175	125 – 185	175+
Spectral Focus (Hz)	Low-to-mid frequency dominant (<500 Hz)	Predominantly low frequency (<250 Hz)	Broadband (with high/low tonal peaks)	Mixed broadband (low hums + high friction)	Intense broadband (mid-to-high exhaust roar)	High-frequency dominant (>1 kHz)	Deep low-frequency heavy (<100 to 250 Hz)	Mixed broadband (high infrasound weighting)
Temporal Profile	Continuous (while operating)	Extended continuous	Continuous or Intermittent	Complex / Intermittent	Intermittent / Prolonged	Impulsive (<1 msec A-duration)	Impulsive (prolonged B-duration)	Explosive (instant shock + echo decay)

Military noise exposures are intrinsic to the task and cannot be fully avoided.

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Health Consequences of Hazardous Noise

Hazardous Noise Exposure

Sensory Domain

- Hearing loss
- Tinnitus
- Vestibular dysfunction
  - Dizziness
  - Impaired spatial orientation
  - Vestibular hypofunction

Neuropsychological Domain

- Sleep disturbance
- Stress and annoyance
- Fatigue
- Impaired attention and concentration
- Anxiety

Systemic Domain

- Elevated blood pressure
- Cardiovascular disease
- Stress-response activation
- Metabolic dysregulation

Noise-induced sensory deficits can compromise communication, situational awareness, balance, cognitive performance, safety, and operational readiness.

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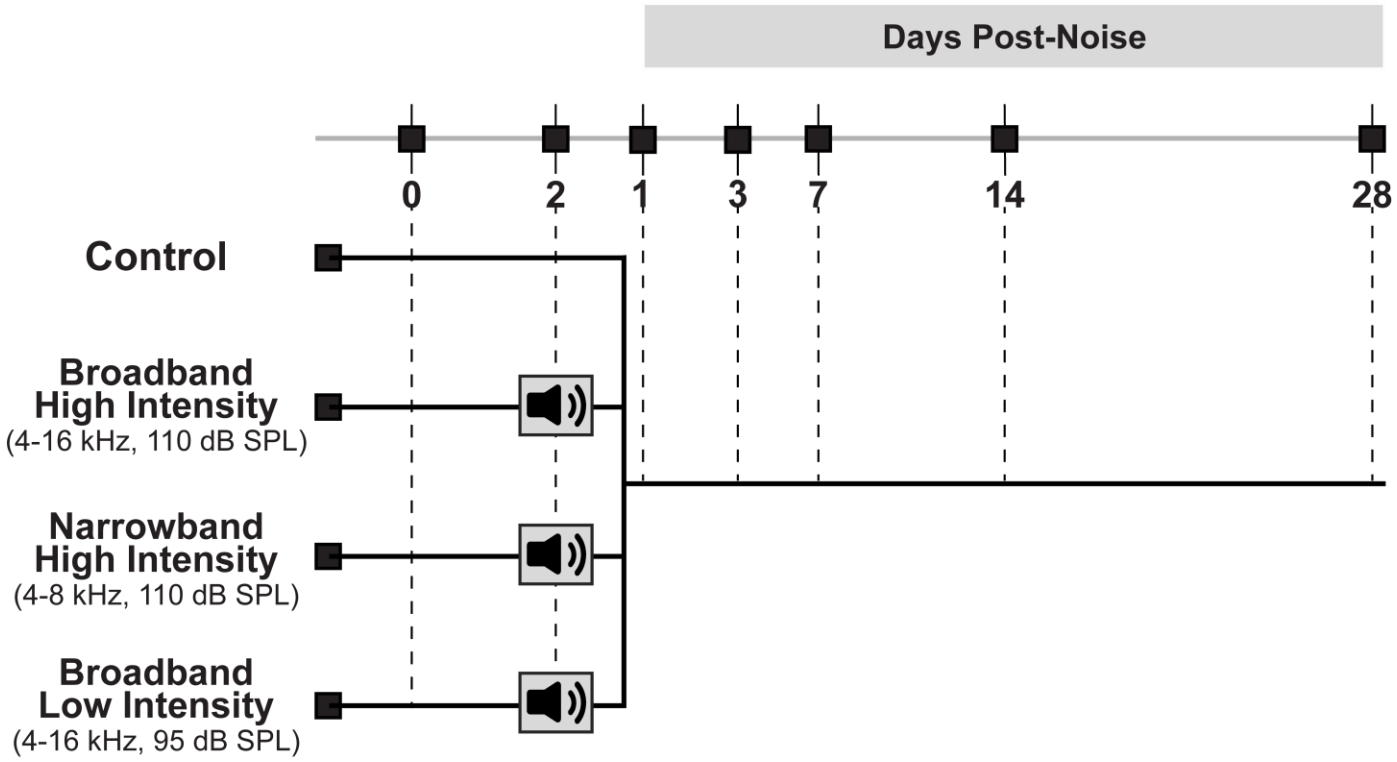
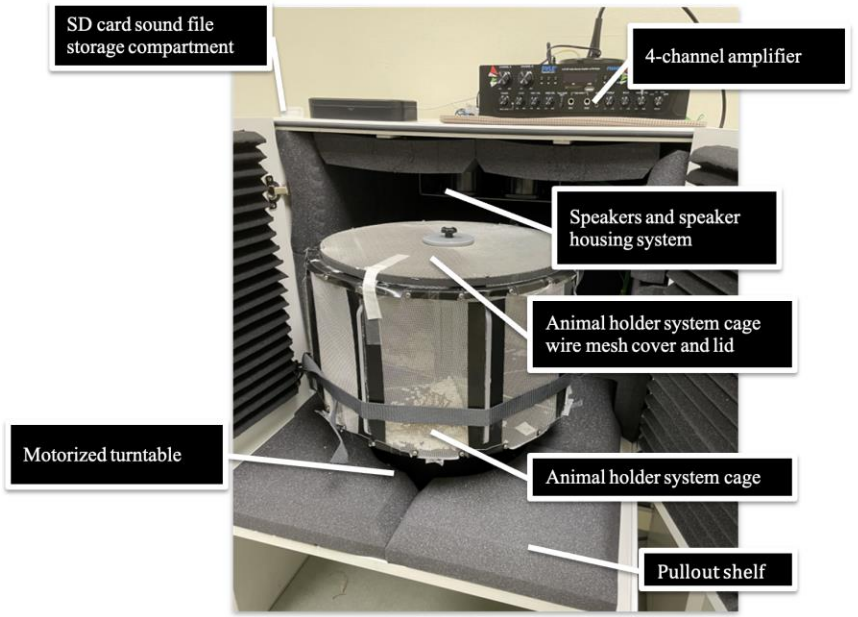
Experimental Design and Method

n = 4 to 6 ♂ per group (Brown Norway rats, 14 – 18 weeks)



Noise Exposure Paradigm: single exposure lasting 60 min

Noise Delivery



	Cell 1 (Mean ± SD)	Cell 2 (Mean ± SD)	Cell 3 (Mean ± SD)	Cell 4 (Mean ± SD)
Position 1	111.15±0.38	111.89±0.57	111.40±0.78	111.62±0.66
Position 2	114.89±0.11	114.29±0.71	114.24±0.51	112.04±0.28
Position 3	112.64±0.20	112.25±0.71	112.89±0.37	112.49±0.49
Position 4	112.11±1.67	112.29±1.40	111.48±0.18	110.48±0.95

The rotating chamber ensured uniform acoustic delivery, while awake conditions better approximated real-world noise environments.

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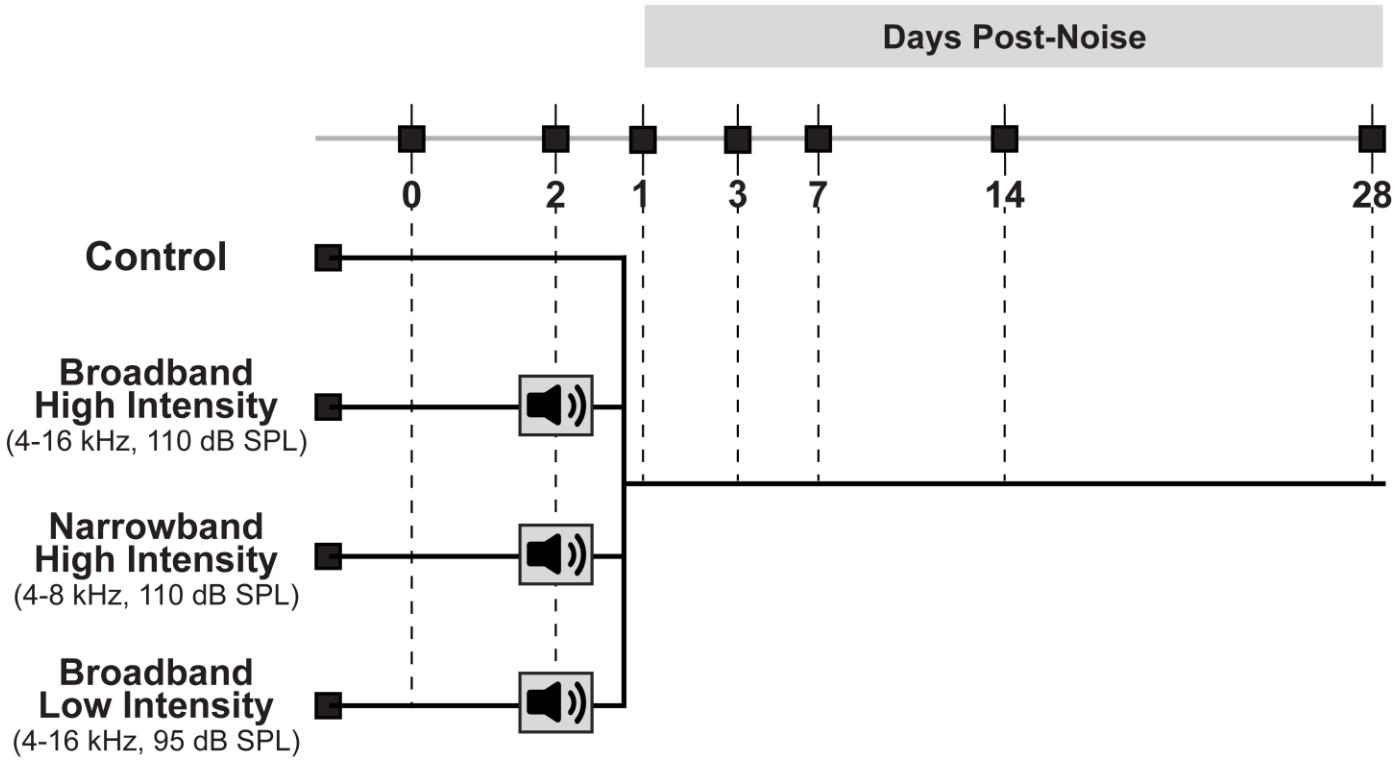

Noise Exposure Paradigm: single exposure lasting 60 min

For Repeated Noise Exposure Visit Poster #1612 on Wednesday @ 10 am

Functional Signatures of Noise-Induced Vestibular Loss (NIVL)

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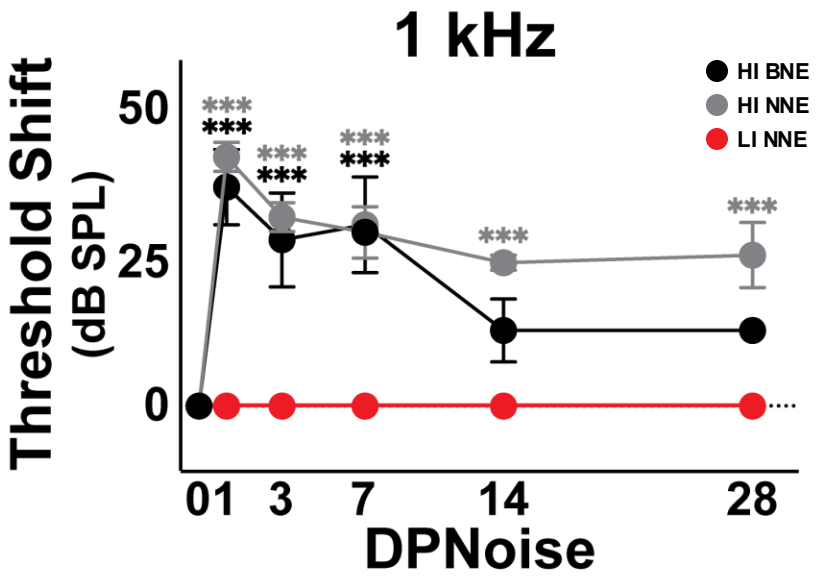
Longitudinal Changes in Saccular Activity

(From Baseline to Day 28 Post Noise Exposure)



Saccular responses were differentially affected by the acoustic features of the noise paradigm, with the magnitude and pattern of dysfunction varying as a function of both exposure frequency and intensity.

n = 6, LMMs and Post-Hoc Tukey's Test, *p<0.05

Morphological and Molecular Signatures of Noise-Induced Vestibular Loss (NIVL)

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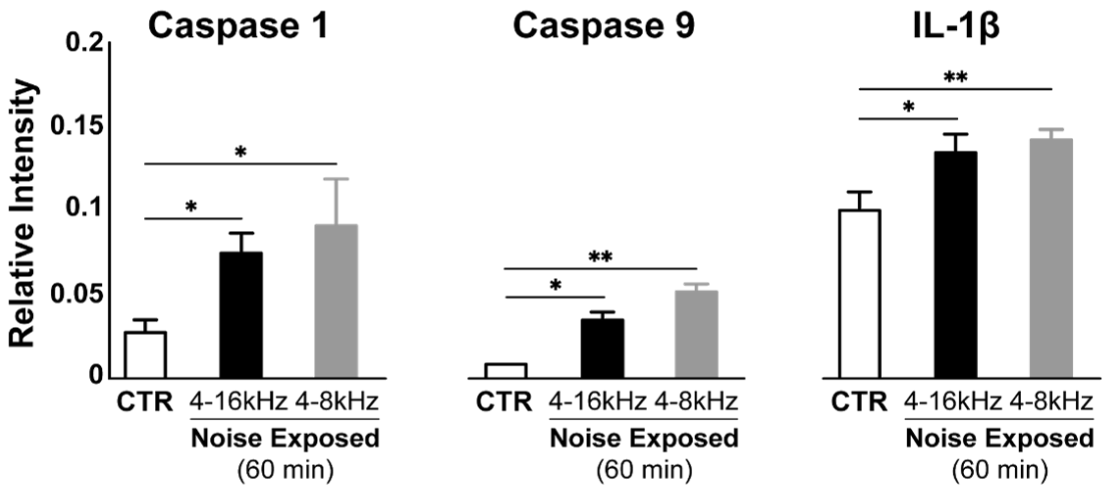
Early Molecular Responses

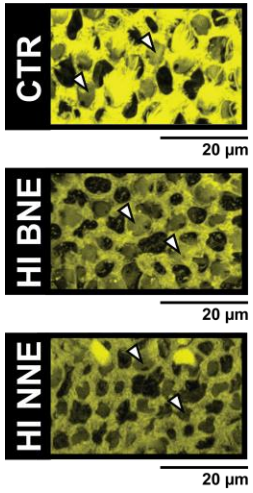
(Day 7 Post Noise Exposure)

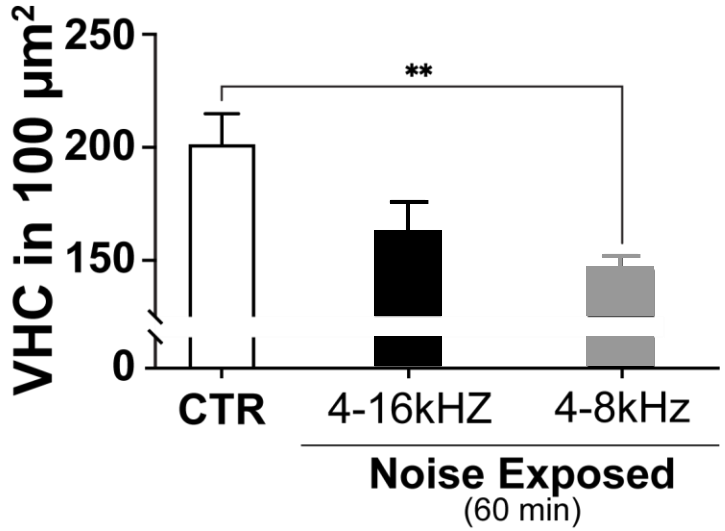


High-intensity noise exposure exhibited similar early molecular signatures of cellular stress and injury in the inner ear

Long-term Morphological Changes

(Day 28 Post Noise Exposure)





Noise paradigms associated with permanent reduction in cVEMP thresholds caused significant vestibular hair cell loss.

n = 4 to 6, LMMs and Post-Hoc Tukey's Test, *p<0.05

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Conclusion

Noise-Induced Vestibular Loss is exposure-dependent, with each acoustic trauma paradigm producing distinct Functional, Molecular, and Morphological profiles of injury

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Defining how these effects differ and evolve over time can support more targeted protection strategies, exposure standards, and preventive monitoring for Service Members.

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