RETROSPECTIVE COHORT STUDY OF PURE TONE AUDIOMETRY THRESHOLD SHIFTS FROM OTOTOXIC SUBSTANCE, CONTINUOUS NOISE, AND IMPULSE NOISE EXPOSURES AT TINKER AIR FORCE BASE FROM 2005 TO 2019

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Overview

- Growing research indicates that ototoxic substances commonly found in occupational settings could potentially affect hearing loss independently, additively, or synergistically when combined with noise exposures [1]-[4].
- Recently, the United States Department of Defense [5] directed services to evaluate ototoxic exposures to determine their relation to the risk of occupational hearing loss.
- Currently, there is not an existing model or methodology in the Department of Defense (DoD) that joins occupational exposure data from the Defense Occupational and Environmental Readiness System – Industrial Hygiene (DOEHRS-IH) and pure tone audiometric data from Defense Occupational and Environmental Readiness System – Hearing Conservation (DOEHRS-HC).
- An integrated data model can provide clarity regarding potential exposure combinations with excessive risk compared to continuous noise exposure alone and assist in identifying threshold shift warning signs for utilization in hearing conservation programs.
- The results of this research could direct future DoD efforts and inform resource allocation to effectively mitigate occupational injury.

Objectives

- Identify the optimal usage of existing DOEHR-IH and DOEHRS-HC data to create individual longitudinal exposure records.
- Establish the comparative risks and potential indicators of hearing loss associated with combinations of ototoxic substances, impulse noise, and continuous noise exposure.

Methodology

- Researchers limited DOEHRS-HC and DOEHRS-IH data collection from 2005 to 2019 to Tinker Air Force Base (AFB), near Oklahoma City, Oklahoma. Tinker AFB is the site of the largest of three depot installations within AF Material Command (AFMC) and is the location of extensive maintenance activity for C/KC-135, B-1B, B-52, and E-3 airframes.
- Impulse noise classification determined by DOEHRS-IH data for individual equipment assessed at a location by sound level meter with dBA measurements and qualitative classification of the source as "impact/impulse"
- DOEHRS-IH data quality required assessing ototoxic substances (metal or solvent) and continuous noise exposure only by dichotomous, presence or absence, exposure.
- The basic methodology for utilizing DOEHRS-HC data was to establish a baseline record by identifying an individual's oldest recorded audiogram and comparing it to an individual's most recent recorded audiogram. following set inclusion or exclusion criteria.
- Records were only accepted and grouped into the model if >3 years of audiometric test dates and exposure to a specific category were applicable.

Exposure	Metal	Operator	Solvent	Operator	Continuous	Operator	Impulse
Continuous	0	AND	0	AND	>=3	AND	0
Continuous_Impulse	0	AND	0	AND	>=3	AND	>=3
Metal	>=3	AND	0	AND	0	AND	0
Solvent	0	AND	>=3	AND	0	AND	0
Metal_Continous	>=3	AND	0	AND	>=3	AND	0
Metal_Continuous Impulse	>=3	AND	0	AND	>=3	AND	>=3
Solvent_Continuous	0	AND	>=3	AND	>=3	AND	0
Solvent_Continuous Impulse	0	AND	>=3	AND	>=3	AND	>=3
Metal_Solvent Continuous	>=3	AND	>=3	AND	>=3	AND	0
Metal_Solvent Continuous_Impulse	>=3	AND	>=3	AND	>=3	AND	>=3
NoExposure	0	AND	0	AND	0	AND	0
*Exposures represented in years							

- Following the creation of a combined single data source, researchers conducted a quantitative assessment of individual longitudinal exposure records for hearing threshold shifts across all frequencies unadjusted for age and with OSHA 29 CFR 1910.95 Appendix F age corrections.
- Multiple definitions of indicators of hearing loss [6] utilized to evaluate pure tone audiometry (PTA) data with Microsoft Access and Python.

Significant Threshold Shift (STS)	>=10 dB HL threshold shift average shift at 2,000, 3,000, 4000 Hz
Significant Threshold Shift Age-Adjusted (STS-A)	>=10 dB HL threshold shift age-adjusted average shift at 2,000, 3,000, 4000 Hz
NISOH Material Hearing Impairment	>=25 dB HL threshold average at 1,000, 2,000, 3,000, 4,000 Hz
NISOH Significant Threshold Shift (NSTS)	>=15db HL threshold shift at any frequency 500, 1,000, 2,000, 3,000, 4,000, 6,000 Hz
All Frequency Threshold Average	>=25 dB HL threshold average at 500, 1,000, 2,000, 3,000, 4,000, 6,000 Hz

Results

- Final study population totaled 2,372 individuals with average duration of 8 years of average duration between first and last audiogram.
- 86% of the study had exposure to an ototoxic substance
- Identified combinations of ototoxic substances appeared to have slight combined effects in almost all modeling, with the exception of the DoD STS model where effects were reduced to an RR<1.
- NIOSH STS method demonstrated the highest potential for hearing loss indicators from ototoxic exposure.

		PTA Evaluation Method									
		DoD STS		STS OSHA Age Adjusted		NIOSH Material Hearing Impairment		Average 500-6,000 Hz		NIOSH STS	
Exposure	n	IR	RR (CI)	IR	RR (CI)	IR	RR (CI)	IR	RR (CI)	IR	RR (CI)
Continuous (reference)	310	0.2	1	0.06	1	0.05	1	0.05	1 (-)	0.56	1
Continuous_Impulse	21	0.19	0.97 (0.39-2.4)	0.19	3.11 (1.16-8.31)	0.14	3.16 (0.99-10.15)	0.1	1.85 (0.45-7.5)	0.43	0.77 (0.46-1.27)
Metal_Continuous	266	0.14	0.73 (0.5-1.05)	0.06	1.04 (0.55-1.96)	0.03	0.75 (0.33-1.7)	0.03	0.66 (0.29-1.46)	0.58	1.04 (0.9-1.2)
Metal_Continuous_Impulse	12	0.08	0.42 (0.06-2.8)	0	0 (-)	0	0 (-)	0.08	1.61 (0.23-11.19)	0.5	0.9 (0.5-1.59)
Solvent_Continuous	491	0.18	0.91 (0.68-1.22)	0.08	1.33 (0.78-2.25)	0.05	1.08 (0.57-2.06)	0.05	1.03 (0.56-1.88)	0.57	1.03 (0.9-1.16)
Solvent_Continuous_Impulse	48	0.17	0.85 (0.43-1.66)	0.08	1.36 (0.48-3.83)	0.02	0.46 (0.06-3.43)	0.02	0.4 (0.05-2.97)	0.6	1.08 (0.84-1.39)
Metal_Solvent_Continuous	872	0.17	0.89 (0.68-1.16)	0.07	1.07 (0.65-1.76)	0.05	1.02 (0.56-1.84)	0.05	0.89 (0.51-1.56)	0.57	1.01 (0.9-1.14)
Metal_Solvent_Continuous_Impulse	352	0.18	0.92 (0.67-1.27)	0.09	1.44 (0.83-2.49)	0.07	1.57 (0.83-2.97)	0.06	1.21 (0.65-2.26)	0.62	1.12 (0.99-1.27)

Conclusions

- Results indicate continuous noise exposure may dominate higher frequencies, and therefore the combined effects of concomitant exposure to ototoxic substances to continuous noise are only noticeable at lower frequencies.
- Explanation difficult given dichotomous exposure at metal/solvent level and weighting of data.
- Post data analysis indicated the Metal/Solvent/Continuous exposure group had an average of 28% higher duration of exposure to continuous noise and therefore the observed significant difference of the Metal/Solvent/Continuous exposure group could be a result of longer duration exposure to noise.

References

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