Hearing Loss among World Trade Center Firefighters and Emergency Medical Services Workers: A 10-year Longitudinal Analysis

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Overall project description

- September 11th, 2001 attack
  - Massive dust cloud followed by fires that burned for months
  - Over 15,000 Fire Department of the City of New York (FDNY) rescue/recovery/cleanup workers were exposed to dust, fires, and other hazardous conditions
  - Nearly all FDNY firefighters and emergency medical service (EMS) arrived at WTC site within the first 48 hours
  - 343 FDNY firefighters and EMS died

- FDNY World Trade Center Health Program
  - Provides free monitoring and treatment exams to over 15,000 enrollees
  - Monitoring exams include audiograms, pulmonary function tests, blood work, physician assessments, and physical and mental health questionnaires
FDNY Cohort Timeline

- Prior to 9/11, active firefighters and EMS workers received medical monitoring and treatment through the occupational health service at FDNY's Bureau of Health Services
- Most data captured electronically beginning in the early 1990s
- 9/11/2001: Treatment for WTC related injuries began
- 10/1/2001: WTC medical monitoring began, including self-administered questionnaire (WTC exposure and current symptoms)
- 7/24/2002: End of recovery operations at the WTC site
- 2002: 1st WTC-related study published by Dr. David Prezant and the FDNY WTC research team
- 2006: WTC exposed retirees were invited to continue medical monitoring and treatment (previously limited to actives)
- 2011: Zadroga 9/11 Health and Compensation Act enacted
- Medical care for WTC-related conditions including respiratory, mental health and cancer
- 2015: Zadroga 9/11 Health and Compensation Act reauthorized for 75 years

Motivation for Longitudinal Study

- Noise, dust, and toxic chemicals were present at the World Trade Center site.
- Community-based studies revealed increased hearing problems among those with greater exposure.
- Analyses of occupational audiometry data can inform the interpretation of those results.
- Assessments of ambient noise indicated that ambient noise levels were suitable for analyses

Research questions

1. Do changes in hearing thresholds vary as a function of exposure group in the years shortly after 9/11?
2. Are there significant differences in risk of changes in hearing thresholds as a function of exposure group during the following 15 years?
Participants

- Firefighters and emergency medical services workers (N = 8623)
  - Firefighter n=7360 (85%)
  - Age on 9/11: 39 years (SD: 7.64)
  - Mean exams per participant: 8.2 (SD: 4)
  - Duration at site included 1 month (29%), 2-5 months (47%), and 6-10 months (24%)
  - Arrival times varied

Method

- Audiometry
  - Automated modified Hughson-Westlake
  - Frequencies: 0.5, 1, 2, 3, 4, 6, 8 kHz
  - Sufficient ambient noise for analysis

- Data review
  - Algorithm-driven
  - Electronic transfer errors
  - Erratic responses
  - Frequency-specific linear regression
  - Changes > 70 dB at neighboring frequencies
  - Asymmetry > 40 dB

Ambient noise measures re: Flamme & Wilson, NCHA 2018
Analyses

- **Logistic regression**
  - **Outcome:** Single 15 dB increase (primary)
    - Single 15 dB increase, persistent 5 dB increase thereafter
  - **Exposure:** Arrival on morning of 9/11 v. after
  - **Covariates:** Age on 9/11, non-Hispanic Black race/ethnicity, occupation (firefighter or EMS worker)

- **Exponential Time-to-Event ("Survival")**
  - **Outcome:** Two consecutive 15 dB shifts from baseline within frequency group
    - 0.5, 1, 2 kHz or 3, 4, 6 kHz
  - **Exposure groups:**
  - **Covariates:** Age at exam, race/ethnicity, occupation
    - Time-varying covariates accommodated (e.g., duration, age)

Cumulative incidence

- Hearing loss was observed in 4% of participants before 9/11/2002
  - 85% arrived on 9/11 or 9/12/2001
- After 1 year, crude incidence trends suggest higher risks in some exposure groups
  - Early arrival
    - 9/11 or 9/12
  - Longer work duration on site
Trans-9/11 outcomes
- First test after 9/11
- Arrival effects in both frequency ranges
  - High OR = 1.16
  - Low OR = 1.24
- Race/ethnicity difference observed in high frequencies
- Sensitivity test:
  - Similar arrival effects

15-year outcomes
High Frequencies
- More risk with early arrival and increased time spent at site
- More risk with increased age at time of exam
- Less risk of hearing change among people with non-Hispanic Black race/ethnicity
- Slightly more risk for firefighters

Low Frequencies
- Early arrival possibly more predictive of hearing loss
- More risk with increased age at time of exam
- Less risk of hearing change among people with non-Hispanic Black race/ethnicity
- No significant difference by occupational group.
Discussion

- Increased risk of hearing loss among World Trade Center rescue and recovery workers
  - Coincides with increased hearing trouble in community members
  - Found during the first couple of years. Then persisted through the subsequent 15 years.
  - Low-frequency involvement is not consistent with the sole effects of noise.
    - Future analyses could differentiate arrival time from duration
    - Middle-ear status might be affected

- Increased risk of hearing loss with age
  - Cumulative exposure v. presbycusis

- Lower risk of hearing loss among people with non-Hispanic Black ethnicity
  - Longitudinal reduction in hearing sensitivity

- Future analyses could differentiate arrival time from duration

- Middle-ear status might be affected

Implications

- Hearing loss is associated with exposure to the 9/11 attacks
  - Current audiometric evidence
  - Increased hearing trouble among workers and community members

- Need for careful hearing conservation programs for emergency responders

- Disaster plans should include exposure assessment, risk mitigation, and health monitoring of emergency responders and recovery workers.
  - Monitoring should extend well beyond the end of recovery operations

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