Are the OSHA age corrections correct? Evidence from NHANES and longitudinal analyses of exposed workers

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Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health or Fire Department of the City or New York.
Overview

• Age Adjustment?
• Development of the NIOSH age tables
• Hearing loss trends in the United States
• Contemporary age adjustment tables
  • Development
  • Comparisons with old NIOSH age tables
  • Comparison with longitudinal results for individuals
Age adjustment

- Permitted, not required
  - Not allowed in some settings (e.g., DoD)
- Intended to account for unavoidable change in hearing sensitivity
  - Genetics
  - Non-occupational
    - \(~ 76 \text{ dB } L_{A,eq,8}\)
- Over-adjustment v. Under-adjustment

- Adjusted change
  - observed change minus expected change

<table>
<thead>
<tr>
<th>Age</th>
<th>Observed</th>
<th>Expected</th>
<th>Adjusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>5</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>25</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>20</td>
<td>3</td>
<td>17</td>
</tr>
</tbody>
</table>

- “Correction” is a misnomer
• Reduced sensitivity to real change
• Perverse outcomes
  • “...the hearing of firefighters deteriorated at a rate that was lower than expected by the presbyacusis estimates...”

Clark & Bohl, 2005
Development of the NIOSH age tables

• NIOSH ONHS study
  • Non-noise: current occupational noise exposure < 80 dBA
  • Cross-sectional trends across 380 men; 206 women
  • Birth years 1905 to 1953
  • 5 age groups. Group n = 76 or 41
  • Age span: 20 to 60 years
  • No demographics
    • Office workers, mostly
    • Tested at any time during the work day
  • 77 % of data were discarded
    • Screening questions
    • Incomplete questionnaire
    • Misunderstanding of test procedure
    • Audiometer failure
Development of the NIOSH age tables

• NIOSH ONHS study
  • Analyses
    • Averaged across left and right ears
    • Regression: \( \log(\text{HL} + k) = \text{age} + e \)
      • \( k \)=frequency-specific adjustment to achieve homogeneous residual variance
    • Regression model smoothed the age trends
  • Outcomes became the NIOSH age tables for the OSHA Hearing Conservation Amendment (29 CFR 1910.95)
Problems with NIOSH age adjustments

• Sampling
  • Small size
  • Convenience sample
    • Conferences
    • USPHS regional offices
    • Company-initiated contact
  • Limited age range
    • Greatest mean age: 55
  • Race/ethnicity unknown
  • Birth-Cohort effects
    • 1905 to 1953

• Principle
  • Cross-sectional trends applied to person-level longitudinal differences
  • Current office work does not rule out significant occupational exposure
    • Prior to last two jobs
    • Military:
      • < 1 year combat
      • < 100 days firearms
      • < 2 years armored vehicle exposure
    • Civilian firearms < 1000 rounds
  • Central tendency does not represent age exclusively
Hearing loss trends in the United States

- General decline among working age
  - Birth cohort:
    - 1890s – 1930s (1959 – 1962)
    - 1940s – 1990s (2011 – 2012)
Hearing loss trends in the United States

- Substantial decline among youth
  - Birth:
Hearing loss trends in the United States

Risk factors from multivariable analyses

- Cigarette smoking
- Very low birth weight
- Ear infections / Otitis Media
- Pressure equalization tubes
- Fair/poor general health
- Firearm use
- Educational level
- Occupational noise exposure
- Occupational + non-occupational noise exposure

Modifiable over decades

- Age
- Race/Ethnicity
- Sex
- Genetics

Modifiable only if proxies for exposures measured poorly or not at all

Hoffman et al, 2016; Hoffman et al., 2018
Contemporary age adjustment tables

- **Source data**
  - NHANES 2005-2012
  - Unweighted N: 9937
  - Ages 12 – 85+
  - Gender
    - Males
    - females
  - Race/Ethnicity
    - Non-Hispanic Black
    - Other
  - Noise exposure
    - Occupational
      - Yes
      - No

- **Analytic approach**
  - Multivariable quantile regression
    - Follows a percentile of the distribution rather than the mean
  - Complex sample weights, stratification, and sampling units
  - Balanced Repeated Replication (BRR) for variance estimation
    - Special case of balanced half-sample replication
  - Guided model-building

Contemporary age adjustment tables

\[ HL_{25} = b_0 + (b_1 \times \text{age}) + (b_2 \times \text{age}^2) + (b_3 \times \text{age}^3) \\
+ (b_4 \times \text{OccNoise}) + (b_5 \times \text{OccNoise} \times \text{age}) \\
+ (b_6 \times \text{RaceEthnicity}) + (b_7 \times \text{RaceEthnicity} \times \text{age}) \]

- Gender-specific models
- Predictor variables
  - Age, polynomial
  - Occupational noise
    - Main effect and interaction with age
    - (control factor)
  - Race/Ethnicity
    - Main effect and interaction with age
- Excluded for impracticality
  - Smoking status
    - 20 pack-years or more
  - Diabetes
    - Declining effect with age
Current cross-sectional trends - Men

- Men: 0.5 kHz
- Men: 1 kHz
- Men: 2 kHz
- Men: 3 kHz
- Men: 4 kHz
- Men: 6 kHz
- Men: 8 kHz
Current cross-sectional trends - Women
Race/ethnicity versus occupational noise

Men

**2 kHz**
- Unexposed Non-Hispanic White
- Exposed Non-Hispanic White
- Exposed Non-Hispanic Black

**3 kHz**
- Unexposed Non-Hispanic White
- Exposed Non-Hispanic White
- Exposed Non-Hispanic Black

**4 kHz**
- Unexposed Non-Hispanic White
- Exposed Non-Hispanic White
- Exposed Non-Hispanic Black

**6 kHz**
- Unexposed Non-Hispanic White
- Exposed Non-Hispanic White
- Exposed Non-Hispanic Black
Validation using longitudinal data

- Proposed adjustments were applied to occupational database of Fire Department of New York
- Median age-adjusted longitudinal change was within 5 dB of NHANES 25th percentile
  - 0.5 through 8 kHz, both ears
  - Asymmetric distribution, perhaps indicating NIHL among the more susceptible workers
Summary

• Old NIOSH age adjustment tables...
  • Do not represent current cross-sectional trends
  • Do not include known and important race/ethnicity differences
  • Do not cover the necessary age range

• Proposed adjustments (NHANES 25\textsuperscript{th} %ile)
  • Reduce effects of proxy variables
  • Extend through age range of current workers
  • Change less in first years of service
  • Are appropriate for people identifying as non-Hispanic Black
  • Match median longitudinal changes

• Next steps
  • Policy for ascertainment of race/ethnicity
Questions?

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