THE DEPARTMENT OF DEFENSE COMPREHENSIVE HEARING HEALTH PROGRAM: A PRECISION MEDICINE INITIATIVE STUDY

LTC John A. Merkléy, AuD, Chief, Army Hearing Division, Army Public Health Center
Julieta F. Scalo, PhD, PharmD, Biostatistician, DoD Hearing Center of Excellence
February 08, 2019

Disclaimer

The views expressed in this presentation are those of the author(s) and do not reflect the official policy or position of the Department of Veterans Affairs, Department of Defense, or the U.S. Government.
Agenda

• Overview: Comprehensive Hearing Health Program (CHHP) Precision Medicine Initiative (PMI)
• Methods: applying precision medicine to hearing conservation
• Results: interim sample characteristics and predictive modeling
• Discussion: summary, limitations, next steps

OVERVIEW: PRECISION MEDICINE INITIATIVE (PMI) STUDY

CHHP PMI Study

Comprehensive Hearing Health Program (CHHP)
– Developed by DoD Hearing Center of Excellence (HCE) for military personnel at risk of noise-induced hearing loss
– Standardizes hearing conservation services that promote positive hearing-health behaviors

Precision Medicine Initiative (PMI) study
– Aims to characterize risk profiles at the individual level
– Findings will inform development of tailored CHHP health-education materials and delivery
Study design

- Target population:
  - Active-duty personnel at risk for noise-induced hearing loss
- Three groups at each site:
  - Clinical (Audiometry)
  - Occupational (Public Health)
  - Control (common-area recruitment)
- Recruitment sites:
  - Air Force - JBSA Lackland
  - Army - Brooke Army Medical Center
  - Navy - Naval Medical Center San Diego
  - Marines - Naval Hospital Camp Pendleton

Study design

- Initial visit
  - Baseline hearing health questionnaire
  - Educational session with audiologist or hearing technician using CHHP educational materials (5-15 minutes)
  - Pure-tone audiometry
  - Saliva sample
  - Post-educational hearing-health questionnaire
- Noise dosimetry and noise diary (sub-cohort, for seven days)
- Three-month follow-up questionnaire (online survey)
- Data pull from audiology & occupational records

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Baseline survey, audiometry, saliva sample</th>
<th>Intervention</th>
<th>Post-appointment survey</th>
<th>3-month follow-up survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Occupational</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Control</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

PRECISION-MEDICINE APPROACH TO HEARING CONSERVATION
Precision-medicine elements studied

- Knowledge, attitudes, & beliefs
  - Determinants of health-related behaviors, according to the socioecological model

- Noise exposures
  - Total noise exposure x 7 days
  - Etymotic ER-200dw9 Dosimeter
  - Noise exposure diary

- Genetic susceptibility
  - Saliva sample (2 mL)
  - Next Generation Sequencing to identify altered miRNA

Regression modeling

Cohorts:
- Audiology & Public Health (HCP participants)

Outcome:
- Hearing Loss level, worst ear

Predictors (so far):
- Survey of knowledge, attitudes, & beliefs
- Use of hearing protection at work

Covariates:
- Demographics (age, gender, race, ethnicity)
- Service branch

RESULTS
### Sample characteristics – by group

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Audiology N</th>
<th>Col %</th>
<th>Public Health N</th>
<th>Col %</th>
<th>Control N</th>
<th>Col %</th>
<th>Total N</th>
<th>Col %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-29</td>
<td>27</td>
<td>49.1%</td>
<td>11</td>
<td>17.3%</td>
<td>20</td>
<td>31.2%</td>
<td>58</td>
<td>31.4%</td>
<td>0.005</td>
</tr>
<tr>
<td>30-35</td>
<td>18</td>
<td>32.7%</td>
<td>22</td>
<td>35.5%</td>
<td>16</td>
<td>26.5%</td>
<td>56</td>
<td>31.4%</td>
<td></td>
</tr>
<tr>
<td>40-44</td>
<td>6</td>
<td>14.5%</td>
<td>19</td>
<td>30.6%</td>
<td>20</td>
<td>31.2%</td>
<td>45</td>
<td>25.4%</td>
<td></td>
</tr>
<tr>
<td>45+</td>
<td>2</td>
<td>3.6%</td>
<td>10</td>
<td>16.1%</td>
<td>10</td>
<td>16.7%</td>
<td>22</td>
<td>11.9%</td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.053</td>
</tr>
<tr>
<td>Male</td>
<td>37</td>
<td>67.3%</td>
<td>38</td>
<td>64.5%</td>
<td>22</td>
<td>35.5%</td>
<td>97</td>
<td>54.2%</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>18</td>
<td>32.7%</td>
<td>20</td>
<td>35.5%</td>
<td>18</td>
<td>29.4%</td>
<td>56</td>
<td>31.4%</td>
<td></td>
</tr>
<tr>
<td>Race</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.003</td>
</tr>
<tr>
<td>Non-White</td>
<td>35</td>
<td>63.6%</td>
<td>35</td>
<td>56.5%</td>
<td>42</td>
<td>61.8%</td>
<td>112</td>
<td>60.5%</td>
<td></td>
</tr>
<tr>
<td>White</td>
<td>15</td>
<td>27.3%</td>
<td>21</td>
<td>33.9%</td>
<td>18</td>
<td>29.4%</td>
<td>54</td>
<td>30.3%</td>
<td></td>
</tr>
<tr>
<td>Other/Not Reported</td>
<td>5</td>
<td>8.9%</td>
<td>6</td>
<td>10.1%</td>
<td>3</td>
<td>5.0%</td>
<td>14</td>
<td>8.0%</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.066</td>
</tr>
<tr>
<td>Non-Hispanic</td>
<td>41</td>
<td>71.5%</td>
<td>37</td>
<td>60.9%</td>
<td>42</td>
<td>62.7%</td>
<td>120</td>
<td>66.8%</td>
<td></td>
</tr>
<tr>
<td>Hispanic</td>
<td>7</td>
<td>12.2%</td>
<td>12</td>
<td>19.4%</td>
<td>23</td>
<td>31.3%</td>
<td>42</td>
<td>23.6%</td>
<td></td>
</tr>
<tr>
<td>Other/Unknown</td>
<td>10</td>
<td>17.3%</td>
<td>10</td>
<td>16.1%</td>
<td>4</td>
<td>6.0%</td>
<td>24</td>
<td>13.7%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service Branch</th>
<th>Audiology N</th>
<th>Col %</th>
<th>Public Health N</th>
<th>Col %</th>
<th>Control N</th>
<th>Col %</th>
<th>Total N</th>
<th>Col %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Force</td>
<td>20</td>
<td>33.9%</td>
<td>15</td>
<td>24.2%</td>
<td>13</td>
<td>21.1%</td>
<td>48</td>
<td>27.0%</td>
<td>0.159</td>
</tr>
<tr>
<td>Army</td>
<td>5</td>
<td>9.1%</td>
<td>4</td>
<td>6.5%</td>
<td>12</td>
<td>17.6%</td>
<td>21</td>
<td>11.9%</td>
<td></td>
</tr>
<tr>
<td>Marines</td>
<td>13</td>
<td>23.6%</td>
<td>23</td>
<td>37.1%</td>
<td>22</td>
<td>35.5%</td>
<td>58</td>
<td>31.4%</td>
<td></td>
</tr>
<tr>
<td>Navy</td>
<td>17</td>
<td>29.9%</td>
<td>20</td>
<td>32.3%</td>
<td>21</td>
<td>32.9%</td>
<td>58</td>
<td>31.4%</td>
<td></td>
</tr>
</tbody>
</table>

**Baseline hearing thresholds**

**Overall**

- **Left** hearing thresholds:
  - 1000 Hz: 10 dB HL
  - 2000 Hz: 15 dB HL
  - 4000 Hz: 30 dB HL
  - 8000 Hz: 40 dB HL

**Control group**

- **Left** hearing thresholds:
  - 1000 Hz: 9 dB HL
  - 2000 Hz: 12 dB HL
  - 4000 Hz: 25 dB HL
  - 8000 Hz: 30 dB HL

**Audiology**

- **Left** hearing thresholds:
  - 1000 Hz: 11 dB HL
  - 2000 Hz: 16 dB HL
  - 4000 Hz: 28 dB HL
  - 8000 Hz: 32 dB HL

**Public Health**

- **Left** hearing thresholds:
  - 1000 Hz: 12 dB HL
  - 2000 Hz: 18 dB HL
  - 4000 Hz: 30 dB HL
  - 8000 Hz: 35 dB HL

**p < 0.001 for MANOVA**
Hearing loss in worst ear

**Overall**

<table>
<thead>
<tr>
<th>Category</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>124</td>
</tr>
<tr>
<td>Mild</td>
<td>31</td>
</tr>
<tr>
<td>Moderate</td>
<td>17</td>
</tr>
<tr>
<td>Moderately Severe</td>
<td>10</td>
</tr>
<tr>
<td>Severe</td>
<td>3</td>
</tr>
</tbody>
</table>

**By treatment group**

<table>
<thead>
<tr>
<th>Group</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Moderately Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>51</td>
<td>14</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Audiology</td>
<td>38</td>
<td>14</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Public Health</td>
<td>38</td>
<td>14</td>
<td>8</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Threshold - Hearing Loss Category

- 0 - 25 dB: No HL
- 25 - 40 dB: Mild HL
- 41 - 55 dB: Moderate HL
- 55 - 70 dB: Moderately Severe HL
- 71 - 90 dB: Severe HL
- ≥ 91 dB: Profound HL

* *p < 0.001 for χ² test

Scores for knowledge, attitudes, & beliefs

**Control**

- Mean: 17.15
- SD: 4.84
- Skew: -0.82
- Kurtosis: 3.89

**Audiology**

- Mean: 17.89
- SD: 1.87
- Skew: -0.55
- Kurtosis: 2.90

**Public Health**

- Mean: 17.46
- SD: 1.64
- Skew: -0.97
- Kurtosis: 5.22

* *p < 0.001 for ANOVA

Reported use of hearing protection at work

**Overall**

<table>
<thead>
<tr>
<th>Type of Protection</th>
<th>Percent of Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise muffs</td>
<td>17.6%</td>
</tr>
<tr>
<td>Foam ear plugs</td>
<td>11.9%</td>
</tr>
<tr>
<td>Flanged ear plugs</td>
<td>10.9%</td>
</tr>
<tr>
<td>Specialized combat ear plugs</td>
<td>9.8%</td>
</tr>
<tr>
<td>TCAPS</td>
<td>8.8%</td>
</tr>
<tr>
<td>None</td>
<td>32.3%</td>
</tr>
</tbody>
</table>

* *p < 0.05 for χ² test

**By Group**

**Control**

- Noise muffs: 18.3%
- Foam ear plugs: 11.0%
- Flanged ear plugs: 11.0%
- Specialized combat ear plugs: 9.8%
- TCAPS: 8.9%
- None: 32.3%

**Audiology**

- Noise muffs: 17.0%
- Foam ear plugs: 11.0%
- Flanged ear plugs: 11.0%
- Specialized combat ear plugs: 9.8%
- TCAPS: 8.9%
- None: 32.3%

**Public Health**

- Noise muffs: 17.0%
- Foam ear plugs: 11.0%
- Flanged ear plugs: 11.0%
- Specialized combat ear plugs: 9.8%
- TCAPS: 8.9%
- None: 32.3%
Noise exposure over seven-day period

Hearing conservation required for personnel exposed to noise levels exceeding 85 dB on 8-hr time weighted average (TWA), at least one time per year.\(^1,2\)

Participants with \(L_{eq,T} > 85\) db 8 hr TWA at least once over seven days

<table>
<thead>
<tr>
<th>Study Groups</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Control</td>
<td>9</td>
<td>7</td>
</tr>
<tr>
<td>Audiology</td>
<td>8</td>
<td>3</td>
</tr>
<tr>
<td>Public Health</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Service Branches</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>25</td>
<td>16</td>
</tr>
<tr>
<td>Air Force</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Army</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Marines</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>Navy</td>
<td>9</td>
<td>7</td>
</tr>
</tbody>
</table>

Sample currently too small for statistical testing / modeling.

1. 29 CFR 1910.95; 2. OSHA Letter of Interpretation 13 Feb 2004

REGRESSION RESULTS

With predicted probabilities

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Model p-value</th>
<th>None</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
<th>Mod-Severe</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise muffs</td>
<td>&gt; 0.001</td>
<td>51.6</td>
<td>23.2</td>
<td>13.7</td>
<td>8.9</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>59.3</td>
<td>21.1</td>
<td>11.1</td>
<td>6.6</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>Foam ear plugs</td>
<td>&gt; 0.001</td>
<td>52.5</td>
<td>22.8</td>
<td>13.4</td>
<td>8.6</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>55.6</td>
<td>22.1</td>
<td>12.4</td>
<td>7.7</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Flanged ear plugs</td>
<td>0.001</td>
<td>51.5</td>
<td>23.0</td>
<td>13.8</td>
<td>9.0</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>60.9</td>
<td>20.5</td>
<td>10.7</td>
<td>6.2</td>
<td>1.7</td>
<td></td>
</tr>
<tr>
<td>Combat ear plugs</td>
<td>0.965</td>
<td>54.5</td>
<td>22.4</td>
<td>12.8</td>
<td>8.0</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>55.6</td>
<td>22.1</td>
<td>12.4</td>
<td>7.7</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>TCAPS</td>
<td>0.967</td>
<td>54.8</td>
<td>22.3</td>
<td>12.7</td>
<td>7.9</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td></td>
<td>53.6</td>
<td>22.6</td>
<td>13.1</td>
<td>8.3</td>
<td>2.4</td>
<td></td>
</tr>
</tbody>
</table>
### CONCLUSIONS
Summary of findings

• CHHP target population (Audiology & Public Health):
  – Characteristic signs of noise-induced HL observed
  – About 14% report NO use of HPDs at work
  – Foam earplugs are most commonly used, followed by noise muffs & flanged ear plugs
  – Routine noise exposure > 85 dB 8hr TWA in both target and control populations

• Predictive modeling
  – Shows decreased probability of HL with HPD use, but slight increase with higher KAB score
  – Demographic risk factors are consistent with current literature
  – Lower probabilities of HL seen in Air Force & Navy

Some limitations

• Interim results
  – Full sample size not yet attained
  – Data for some risk factors are not yet available
  – Sample represents limited range (e.g., no profound HL)
  – Interactions not yet modeled
  – Model assumptions/diagnostics may change

• Survey-research threats to internal validity
  – Sampling bias, recall bias, etc.

• Quasi-experimental design
  – Cannot infer causality / directionality of effects

• Measurement error
  – Survey is not validated, dosimetry relies on participant, clinical records may be incomplete, in-field audiometry

Precision Medicine Initiative – Next steps

• Expansion of predictive model
  – Add genetic-marker and noise-exposure data
  – Add data from clinical and/or employment records
  – Consider interactions among predictor variables

• Development of Risk Matrix
  – For more granular identification of at-risk subgroups
  – Risk profiles will inform development of targeted interventions

• Scale-up of Comprehensive Hearing Health Program
  – Achieve DoD-wide standardization of hearing health education
    – Including options targeted to specific risk profiles
  – Disseminate tools to identify risk and select interventions
  – Track outcomes on a larger scale
    – Increase evidence base for improved Precision Medicine practices
  – Disseminate to VA clinics
Thank You to Our Team

Tanisha Hammill, PhD, Principal Investigator
Natasha Gorrell, MSPH, Project Manager
Julietta Scala, PhD, PharmD, Biostatistician
Elsa Granato, MPH, SATX Research Coordinator
Sara Murphy, MPH, SoCal Research Coordinator
Erin Cesario, Research Coordinator
Nicole Laronno, Research Coordinator
LTC Andy Merkley, Associate Investigator
Deanna Meinike, PhD, Consultant
David Welch, PhD, Consultant
Ravi Reddy, PhD, Consultant

QUESTIONS?