Simulations of Control Strategies to Reduce Sound Exposures for Music Instructors

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Background

Music instructors are at risk for auditory damage due to frequent exposure to loud sound during musical instruction and performance.

There is inherent variability in music instructors' sound exposures due to differences in required job tasks and musical repertoire.

In our previous study, evaluating the effectiveness of different hearing protection devices (HPD) for musicians, participants preferred wearing a custom uniform attenuation earplug (UAE) for musical activities, but due to issues with sound distortion and insertion difficulty, did not wear them for all activities.

Monte Carlo simulations offer a way to examine the variability in music instructors' exposures and understand the impact wearing hearing protection devices (HPD) may have on reducing those exposures.

Objectives

1) To use Monte Carlo simulations to estimate long-term risk of hearing loss in brass instructors by understanding if equivalent weekly sound exposures were likely to exceed the recommended limit of 85 dBA
2) To incorporate potential control strategies into estimation models to predict the effects that wearing HPD may have on reducing exposure

Methods

Personal sound exposure measurements were collected from brass faculty and graduate teaching assistants employed at the University of Iowa School of Music using Casella dBadge2 Pro dosimeters.

Three participants wore dosimeters for a total of 36 days workdays and completed activity logs recording work-related tasks throughout the day.

For more on the exposure study, check out our 2018 study here.

Time-stamped, one-minute sound levels from the dosimeters were:

- Coded according to the activities listed in the logs
- Used to calculate 30-minute sound equivalent levels ($L_{eq,\ 30\text{-}min}$)

Logs were examined to determine the duration and frequency of seven main activities by day and by week.

In a separate study, real-ear attenuation at threshold (REAT) testing was performed on 24 music instructors to measure:

- Unoccluded baseline hearing thresholds
- Thresholds while wearing custom UAE marketed towards musicians (Westone Style 49 Concert Earplugs with Etymotic ER-15 filters)

For more on the HPD evaluation, check out our 2019 study here.

Personal attenuation ratings (PAR) for each participant were calculated according to a method described by Michael and Associates[1] .

PAR data were examined to identify the distribution of values achieved by participants (minimum, 5th, 50th, 95th percentiles).

[1]**Michael, K. (1998).** Measurement of Insert-type Hearing Protector Attenuation on the End-user: A Practical Alternative to Relying on the NRR. *Spectrum* 16: 13-17.

Simulations

Monte Carlo simulations, of 5000 trials each, were performed using Oracle Crystal Ball (Redwood Shores, CA).

Distributions of $L_{eq,\ 30\text{-}min}$ for each activity were entered as assumptions.

Table 1. Summary of sound levels for each 30-minute activity block including distribution descriptions for simulation assumptions

Activity	N	Distribution	Parameters, dBA
Class	57	Normal	Mean=71, SD=6
Group Rehearsal	76	Normal	Mean=92, SD=4
Individual Lesson	87	Triangle	Min=70, Likeliest=88, Max=94
Meeting	9	Triangle	Min=63, Likeliest=70, Max=92
Office	79	Triangle	Min=50, Likeliest=70, Max=97
Personal Practice	61	Triangle	Min=76, Likeliest=94, Max=97
Performance	16	Normal	Mean=87, SD=7

Each activity was assigned a sequential two-digit range of values that corresponded to the mean proportion of time spent in that activity.

The simulation randomly selected a value, corresponding to an activity, and assigned that activity to a "block".

16 blocks= one 8-hour day
80 blocks= one 40-hour week

A $L_{eq,\ 30\text{-}min}$ sound level from the activity distribution was randomly selected for each corresponding block.

Data were used to estimate daily ($L_{EX,8hr}$) and weekly equivalent exposure levels ($L_{EX,w}$).

To evaluate effects of wearing HPD, additional simulations subtracted the median PAR from the $L_{eq,\ 30\text{-}min}$ for **25%, 50%, 75%, and 95%** of **group rehearsals, individual lessons, personal practices, and performances**.

A final set of simulations subtracted the median PAR from the $L_{eq,\ 30\text{-}min}$ for any of those four activities where sound levels exceeded **90 dBA**.

The sensitivity of the PAR value was tested by using the minimum, 5th percentile, and 95th percentile for simulations instead of the median PAR.

Results

Estimated weekly exposures for instructors exceeded recommended limits.

- Mean = 91 dBA, SD = 1 dBA
- 95th percentile = 92 dBA

Estimates for mean and 95th percentile remained > 85 dBA unless:

- HPD were worn for 95 % of musical activities
- HPD were worn any time a 30-minute block > 90 dBA

Percentages of 30-min blocks that exceeded 90 dBA:

- Group Rehearsal: 71%
- Individual Lesson: 29%
- Personal Practice: 75%
- Performance: 44%

Scan the QR code to see a short video presentation.

Results, continued

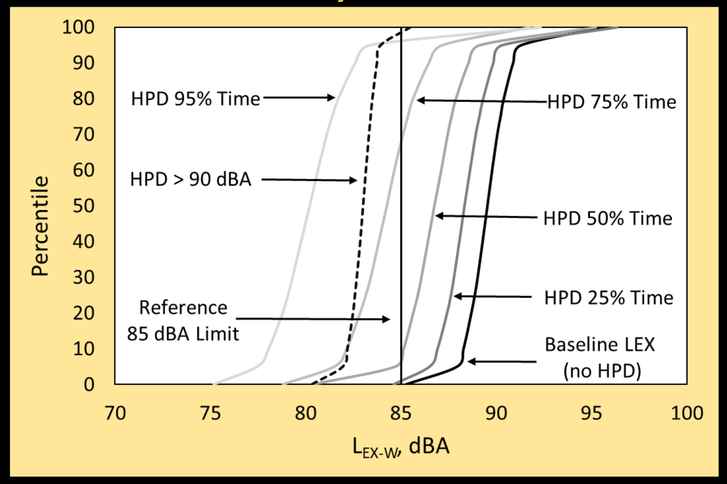

Figure 1. Effects of wearing HPD on weekly exposure ($L_{EX,w}$) estimates

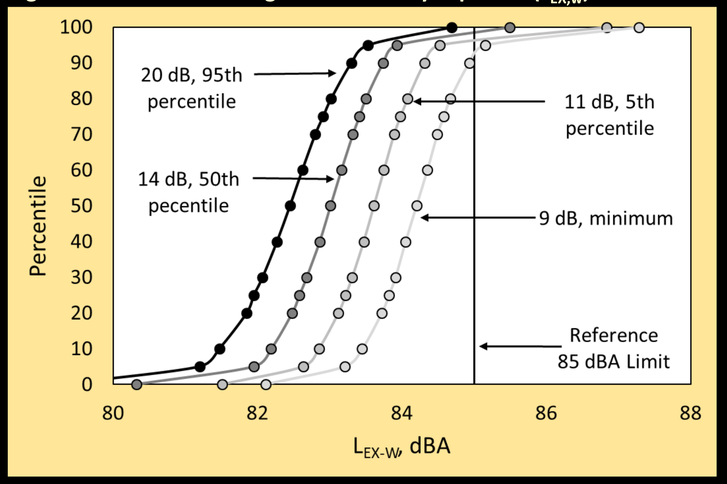

Figure 2. Comparison of effect of PAR on weekly exposure ($L_{EX,w}$) estimates when HPD are worn when sound levels exceed 90 dBA during music activities

Conclusions and Future Work

Effective interventions should focus on increasing the adoption rate of HPD during musical activities, specifically personal practice, group rehearsals, individual lessons and performances.

Wearing HPD for 95% of activities may be unnecessary if activities only exceed 90 dBA between 29% and 75% of the time. If worn when sounds >90 dBA, even minimal attenuation may be effective in reducing exposures.

A system to inform musical instructors when sound levels >90 dBA are occurring is needed to prompt the wearing of UAE to optimize hearing conservation.

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