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Forward

Making sound waves: selected papers from the 2016 annual conference of the National Hearing Conservation Association

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In 2016, the National Hearing Conservation Association (NHCA) (http://www.hearingconservation.org), held its annual meeting in San Diego, California, with the theme of the meeting ''Making Sound Waves''. Several papers presented at that meeting were invited to be developed as contributions to this special supplemental edition of the International Journal of Audiology (IJA). The articles included here were specifically selected to highlight the diversity of research activities that are successfully generating new data that inform Best Practices and improve the success of Hearing Loss Prevention Programmes in achieving the goal of preventing the onset and progression of noise-induced hearing loss (NIHL). In many cases, these articles created widespread waves across the membership, with active discussions propagating well beyond session's end.

This is the seventh year of the partnership between the NHCA and the IJA to produce a meeting-related supplemental issue. As in previous supplemental issues, these papers address the three strategies that can effectively prevent hearing loss when implemented consistently and correctly, which include engineering controls (reduction of sound level at the sound source), administrative controls (reducing the amount of time an individual is in the vicinity of the sound source), and the use of personal protective equipment (PPE) in the form of hearing protection devices (HPDs) such as ear plugs and ear muffs.

There can be little argument that decreasing sound at its source will provide the most consistent protection across workers in that area. The contribution by Roberts et al examines noise exposure data from the US mining industry and provides some insights on how the 1999 Mine Safety and Health Administration revised noise regulations affected exposures among miners. Although the noise levels in US mines have generally decreased, the changes are not consistent across all parts of the industry. This article describes how to better predict noise exposures and subsequent NIHL across workers in the mining industry.

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Unfortunately, there is frequently a significant reliance on HPDs to attenuate sound exposure at the individual level, either in lieu of or perhaps despite significant efforts to attenuate sound levels at their source. The effective use of HPDs was therefore a major topic at conference, and is a major topic within the supplement. For example, factors influencing HPD performance are discussed in detail in the contributions from Fackler et al, Lee and Casali, and Sheffield et al The development of novel technologies for audiometric monitoring is of course also of interest. In this issue, the contribution by Meinke et al describes a novel device that has the potential to be used for testing worker hearing at their job site via sound-attenuating ear muffs and tablet-based audiometry. In addition, the extent to which additional monitoring might be appropriate is always of interest. In this supplement, Flamme et al present data on the acoustic reflex from a nationally representative sample. This topic is relevant indeed, given the recently promulgated Department of Defence MIL-STD 1474E Design Criteria Standard [for] Noise Limits, which includes a middle ear muscle contraction (MEMC) as part of the cochlear model used to assess the response of the cochlea to high level impulse noise. Flamme et al describe the prevalence of the MEMC from a population perspective; variability in the MEMC across workers might explain some of the known variation in vulnerability, which is a topic of interest in the contributions by Johnson et al, and Dobie and Humes. In the following comments, we offer a brief introduction to each of these timely and interesting contributions.

The contribution from Fackler et al characterises the performance of several HPDs (a foam earplug, a level-dependent earplug, and an electronic sound-restoration earmuff) in attenuation of impulses generated by an acoustic shock tube, and an AR-15 rifle. They analyzed both impulse peak insertion loss and impulse spectral insertion loss, and compared the obtained values to the measured insertion loss obtained with steady-state noise and the real-ear attenuation at threshold methodology. Technical challenges associated with short duration signals are highlighted, in that signals with a short A-duration, such as the discharge from an AR-15 rifle, do not meet the requirements of the current ANSI/ASA S12.42-2010.

We have observed a trend in recent years to look more closely at functional tests such as hearing protector fit-testing and speech intelligibility. The contribution from Lee and Casali thus focuses on the attenuation of sound by HPDs, but from a different approach and using a very different methodology that emphasises the ability to detect, understand, and localise a signal, and communicate. John Casali, PhD, has led the development of an auditory situation awareness (ASA) test battery that was designed to objectively measure specific auditory task performance of a user wearing an HPD relative to a user with an open (i.e. unprotected) ear as a control condition. In this study, they describe changes in performance that occur with a tactical communication and protective system (TCAPS), or an advanced HPD. The ''DRILCOM'' test battery includes four tests, assessing **D**etection, **R**ecognition/**I**dentification, **L**ocalisation, and **COM**munication. Their article describes the results of the detection test – the first and most fundamental task that has to be accomplished before any further cognitive processing of the signal can be accomplished. They observed significant interactions between HPD, signal, and signal location.

The impact of HPD use on a soldier's survival (mortality) and performance (lethality) in a field setting are critical issues, and this is the specific topic of inquiry in the study by Sheffield et al Active HPDs and TCAPS have been met with enthusiasm given that they preserve situation awareness relative to passive hearing protection; the current data highlight the urgent need to understand both strengths and potential weaknesses of both active and passive HPDs. Their research demonstrates that hearing impairment adversely affects performance in a tactical simulation.

The development of novel technologies for audiometric monitoring is of interest, given that a major component of any Hearing Loss Prevention Programme is the annual testing requirement. Hearing testing is at the heart of the NHCA. A significant barrier to hearing loss prevention can be finding a suitable location to conduct testing – namely, ''Is it sufficiently quiet?'' In this issue, the contribution by Meinke et al describes a novel device that has the potential to be used for testing worker hearing at their job site via sound attenuating ear muffs and tablet-based audiometry. Here, threshold data collected using this device are directly compared to threshold data collected using ''gold standard'' best practices including a mobile van service and a clinical audiometer. When disruptive technologies come along, we should embrace them and make certain that they meet high standards. ''Going wireless and booth-less for hearing testing in industry'' describes the performance of a new approach to audiometry where the testing equipment can be carried by the hearing conservation professional to the location(s) where testing is to be conducted.

In this supplement, Flamme et al present data on the acoustic reflex from a nationally representative sample. When the National Health and Nutrition Examination Survey (NHANES) was being planned, the screening of the acoustic reflex was included but to date these data have not been analyzed. Flamme et al examined more than 60,000 reflex traces collected from more than 15,000 participants from 1999 to 2012. One may ask, ''How does this make waves?'' The recently promulgated Department of Defence MIL-STD 1474E Design Criteria Standard [for] Noise Limits includes a cochlear model to assess the response of the cochlea to high level impulse noise. This model includes a MEMC. The MEMC is assumed to be pervasive in the military population. The prevalence rates for bilateral acoustic reflex were found to be less than 90% for persons with normal hearing status. These results can have broad implications in the assessment of high-level impulse noise exposure and the associated risk of producing NIHL.

In the introductory comments above, we pointed to the variability in hearing loss across workers. To understand the effects of environmental factors, Johnson et al assessed changes in hearing in male twins with different noise and solvent exposures. Two important outcomes from this study were the finding that those with existing hearing loss were at increased risk for progressive occupational NIHL in this longitudinal study, and that those with workplace exposure below 85 dBA were at increased risk for hearing impairment, perhaps suggesting inconsistent or incorrect use of HPDs for those in relatively lower noise environments (i.e. relative to those working in environments where sound levels were 85 dBA or greater).

If one were to stick with the wave analogy, many would surely agree that the hypothesis that a temporary change in hearing (i.e. a temporary threshold shift, TTS) can result in a ''hidden hearing loss'' has sent profound waves through the hearing loss prevention community. Seminal work from Kujawa and Liberman has clearly established that noise exposures that result in TTS in a mouse model, with no lasting permanent threshold shift at the time of the exposure, can result in disruption of the synaptic connections of the inner hair cells to the auditory nerve, and the long-term degeneration of the auditory nerve fibres themselves. The loss of synaptic integrity, and subsequent neural degeneration, result in decreased amplitude of wave I of the sound-evoked auditory brainstem response (ABR) in mice and other rodents. There is significant speculation that such damage might be expected to result in difficulties understanding speech in noise, which can be a commonly reported challenge not only within workers exposed to occupational noise, but also for other adults who have never worked in a noisy environment, despite the presence of otherwise normal detection thresholds. However, in other work coming from the laboratories of Kujawa and Liberman, noise exposure that has resulted in a smaller TTS has not resulted in a consistent pattern of pathology, raising questions about where hazard ''begins'' and what the dose-relationship is both in rodents and potentially in humans as well. In their article, Dobie and Humes compare the robust TTS associated with neural injury in mice to the ''pathological TTS'' described in early human investigations by Ward (in the 1960s) and Mills (in the 1970s), and they contrast these large pathological TTS changes with the smaller but much more frequent TTS changes that would be typical of workers or those that attend loud recreational events. More research is urgently needed in this area. While it would be premature to conclude that noise exposures below the OSHA permissible exposure limit (PEL) result in neural injury in humans, it would be equally premature to conclude that noise exposures that result in small but repeated TTS changes do not have the potential to result in either a neural injury, or a functional deficit, which might include difficulties understanding speech in noise. This topic will be revisited at the 2017 meeting of the NHCA, when Sharon Kujawa, PhD, leads a workshop on the topic of noise-induced neural injury. We hope that the broader discussion of these questions will lead to new functional test batteries to more completely characterise the potential for noise-induced functional deficits on the performance of supra-threshold identification and localisation tasks.

We hope that the articles selected for this special issue will provide readers with new ideas and new tools to consider within their own Hearing Loss Prevention efforts. We are grateful to the sponsors who provided financial support that makes this supplemental issue possible, including the National Hearing Conservation Association, the National Institute for Occupational Safety and Health (NIOSH), the Council for Accreditation in Occupational Hearing Conservation (CAOHC), and the Safe-in-Sound Excellence in Hearing Loss Prevention Award.

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