

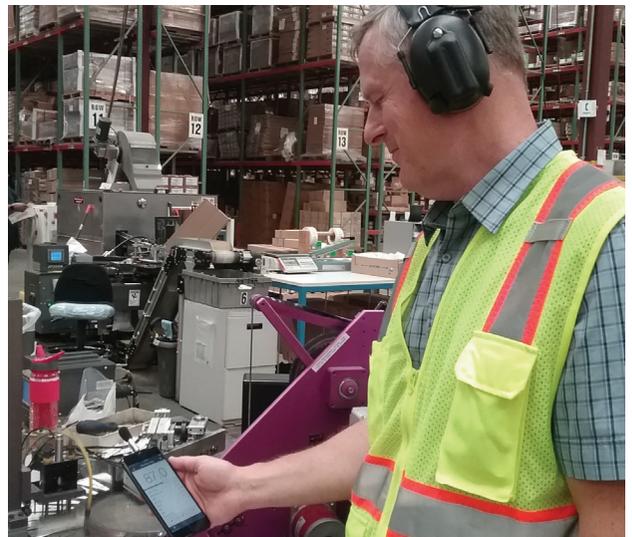
'Internet of Ears' and Hearables for Hearing Loss Prevention

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New technologies are reshaping health interventions across disciplines. This technological surge offers a clear opportunity to expand and improve hearing health, particularly in hearing loss prevention. A person's hearing health trajectory is defined by his or her overall hazardous exposures, environmental factors, and genetic determinates.¹ Among the many factors that can contribute to hearing health (such as overall health, smoking, diet, and ototoxicant exposure), reducing noise exposure—particularly at work—has the greatest potential to significantly decrease the burden of hearing loss and tinnitus.² About 24 percent of hearing impairment cases among U.S. workers is attributable to workplace noise exposures. Because noise-induced hearing loss is preventable, approximately one-fourth of hearing impairment cases in this population may be avoided by adopting preventive measures.³ While progress has been made toward the prevention of work-related hearing loss, it remains among the most common occupational illnesses. Overall, nearly one in four U.S. adults has audiometric evidence of noise-induced hearing loss—and most do not realize it.⁴ People continue to focus on the use of hearing protection to reduce noise exposure, even though only limited evidence is available on the effectiveness of this approach.⁵ However, new technologies to measure and control noise and test hearing hold the promise of expedited progress.

RISE OF MOBILE APPS, WEARABLES

In 2018, nearly 40 percent of the world's population owned a smartphone, with smartphone penetration exceeding 70 percent in many countries, including the developing world.⁶ Hundreds of mobile applications (apps) related to noise and hearing loss are available, with new and improved apps appearing nearly every month. These apps can empower individuals to become more proactive in protecting their hearing health. In the past, a person needed expensive instrumentation and professional expertise to learn about their noise exposure. Nowadays, smartphone apps can accurately estimate noise exposure and make recommendations for appropriate protection.^{7,8} These tools, in conjunction with online information (e.g., NIOSH Sound Level Meter and Know Your Noise), provide mechanisms for individuals to manage their risk and protect their hearing. Other apps are now available to



Using the NIOSH sound level meter app to measure noise at a metal manufacturing plant.

conduct hearing tests, measure daily sound allowance from music listening devices, and use crowdsourcing to provide information about environmental noise and quiet entertainment and dining venues (e.g., NoiseCapture, NoiseAdapt, NoiseScore, iHEARu, SoundPrint, etc.). Given the limitations of pure-tone audiometry for the early identification of ear damage, several groups have been looking into testing alternatives. Research has shown that audiometric thresholds obtained in untreated open rooms through mobile, wireless automated hearing test systems exhibit within subject test–retest reliability comparable to thresholds obtained using conventional computer-automated audiometry conducted in a single-walled, sound-treated booth in a mobile trailer.⁹ The development of portable, easily operated, economical, and reliable alternatives can facilitate hearing testing in typical worksite locations. Additional research is needed to make sure that such tools are accurate and can meet international sound and hearing measurement standards, but work is underway to establish compliance with pertinent standards.¹⁰

Wearable technologies are attracting attention in other health fields and could be useful in hearing loss prevention as



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HEARING TECHNOLOGY



Intensity levels of common sounds. Repeated exposure to sounds 85 dBA and higher can cause hearing loss.

well. Fitness trackers collect large amounts of data that data could be delivered directly to patient medical records, creating a mobile health (mHealth) system that gives health care professionals access to a patient's real-time data to aid in diagnosis and monitoring. At present, the primary limitation is sensor technology.¹¹ As sensor technology improves, one could imagine monitoring noise exposure levels from a smart wristwatch and providing them directly to a hearing health or workplace safety professional—providing insight into hearing risk and enabling targeted prevention strategies.

AI-POWERED HEARABLES

Companies like Apple, Google, and Amazon along with established hearing aid companies are moving fast to introduce artificial intelligence into earphones and earpieces called hearables. This marketplace will not only deliver higher sound fidelity to the ear by cancelling unwanted background noise, but will also learn the user's environment and listening habits to deliver a better listening experience. In addition, hearables can be constantly connected and deliver information straight to the user's ears. Communicating in the opposite direction, the "Internet of Ears" is expanding the realm of voice-activated devices and may soon make it possible to control a myriad of household devices—including noise sources such as televisions and music players—by voice command. As these technologies become more commonplace, research into the total sound energy delivered daily to the ear needs to be studied, and recommendations from regulatory bodies need to be established to protect people from unsafe exposure to sound in recreational and work settings.

ADDRESSING NOISE AT WORK

The hierarchy of controls emphasizes protecting workers from the harmful effects of noise through elimination and reduction of hazards whenever possible, and emerging technologies are improving our ability to do so.¹² For instance, nanomaterials offer the potential to effectively reduce noise across the frequency spectrum—including very low frequencies, where traditional sound absorption materials perform poorly.¹³ Cutting-edge technologies should not, however, cause us to lose sight of more basic solutions that may be very appropriate in some instances. For example, winners of the annual Safe-In-Sound Awards™ have implemented simple changes that have helped reduce noise levels such as large displays providing continuous noise

monitoring results and changing from metal to rubber cart wheels. The CDC's Buy Quiet is another key strategy for long-term noise reduction that relies on the purchase of new, quieter equipment.¹⁴

Hearing protection falls lower on the hierarchy of controls for noise exposure; however, many workplace hearing loss prevention programs still focus primarily on hearing protectors. One serious limitation of this approach is the inability to know exactly how much hearing protection a worker receives from the device. Fit-testing technology has changed that. Multiple systems are available that allow employers and other hearing care professionals to quickly evaluate how much sound reduction an individual is receiving from a particular device. Such information is invaluable to ensure

that noise-exposed individuals are sufficiently protected and it can dramatically improve training, re-fitting, and the identification of appropriate alternatives as necessary.¹⁵ NIOSH has a web-based fit-test "screening" that can be used if a full fit-test system is unavailable.¹⁶

Innovative and imaginative entrepreneurs are taking advantage of the opportunities afforded by these new technologies, bringing products to market that many hearing care professionals may never have imagined. In 2016, several U.S. federal occupational safety and health agencies launched the Hear and Now Noise Safety Challenge, inviting individuals to compete for funding to develop creative ideas for reducing the occupational hearing loss problem.¹⁷ More than 30 entries were received, with winning ideas that included wearable sensors to monitor personal safety and information platforms that integrate health and safety data from different devices into a single, real-time database.

Although new technologies offer many new prospects for hearing loss prevention, cutting-edge technology isn't always essential to make an intervention successful. Several Hear and Now challenge winners proposed simple ideas that could promote hearing loss prevention, such as adding logos to create fashionable hearing protection devices and using a simple, disposable device to insert foam earplugs properly and hygienically.

Every hearing health professional—regardless of discipline, employment setting, or population served—has a role to play in ensuring that these emerging technologies help prevent hearing loss. Government agencies, standard-setting bodies, and professional organizations need to provide guidelines for developers to ensure that new technologies meet professional standards. Clinicians and safety professionals should implement emerging technologies however they can in their practices and provide feedback to developers on ways to improve or expand their utility. New technologies should help people make informed decisions about their noise exposure and take an active role in protecting their hearing, increase the effectiveness of hearing loss prevention and intervention programs, and reduce the burden of hearing disorders on society.

Disclaimer: The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the NIOSH, CDC.

References for this article can be found online at <http://www.thehearingjournal.com>.