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The Honorable Edward J. Markey
United States House of Representatives
2108 Rayburn House Office Building
Washington, D.C. 20515-2107

Dear Mr. Markey:

I am writing in response to your January 26, 2006 letter regarding the status of research in portable music players and their impact on hearing loss. I share your concerns about the increased use of personal music devices and the potential that these popular devices, if used improperly, can cause noise-induced hearing loss (NIHL). The National Institute on Deafness and Other Communication Disorders (NIDCD) is supporting an extensive research portfolio on noise-induced hearing loss but has not supported much research on personal music devices and its relationship to hearing loss. We conducted a review of available literature that has been published in research journals on the topic of NIHL and music.

Young people live in a loud and noisy world. In this age of the escalating use of personal stereo systems, hands-free cell phones, and portable movie/game systems, youth worldwide are exposed to harmful levels of noise every day. Scientists generally agree that, over time, this can lead to permanent noise induced hearing loss (NIHL) by damaging and/or destroying the inner ear's sensory hair cells. Scientists once believed that NIHL damaged the hair cells by the pure force of the loud sound vibrations. In that case, the only means of prevention was to reduce the sound exposure and/or use ear protectors. Recent studies, however, have found that noise exposure triggers the formation of molecules (free radicals) known to cause hair cell death. Based on data from the National Health and Nutrition Examination Survey (NHANES), it is estimated that approximately 10 percent (or 22 million) of American adults between 20-69 years old may have suffered permanent damage to their hearing from exposure to loud sounds or noise at work or in leisure time activities, including portable music devices.

Research on the impact on NIHL caused by loud music from portable music devices emerged in the early 1980's following the introduction of the portable radio/cassette player in 1979. Since then, scientists and doctors began cautioning individuals who listened to loud music about hearing loss that could potentially result from use of their portable cassette or compact disc (CD) players, including headphone use. A steady, but modest, flow of research was conducted throughout the 1980's and into the early 1990's. In 1990, the NIDCD, together with the National Institutes of Health's Office of Medical Applications of Research, convened a Consensus Development Conference on Noise and Hearing Loss, which concluded that sounds of sufficient

intensity and duration could damage the ear and result in temporary or permanent hearing loss at any age. The amount of research on the effects on NIHL by loud music from portable devices decreased slightly in the late 1990's with a resurgence in the past few years following the introduction of the portable MP3 player. All of these devices have maximum sound output levels that range from 115 to 130 decibels (dB), which is comparable to the sound level of a jet engine.

The following is a brief summary of the scientific literature from the past two years on NIHL and the impact of loud music from portable devices. Recent research has not only investigated the impact of the loudness output levels from portable music devices, but also tested the various styles of headphones or earphones (earbuds) that come with the devices. In developing the response, NIDCD conducted a review of research literature that was published in peer-reviewed journals within the past few years.

A 2004 study examined both output levels and a variety of headphones. According to Filgor and Cox (2004), users should hold the volume of a music player no higher than 60 percent of the maximum, and use it for no more than one hour a day. They also found that, on average, the smaller the headphones or earbuds, the higher their output levels at any given volume control setting. Earbuds allow more external sounds into the ear canal. Thus, this encourages users to increase the volume on their music devices.

According to Voss and Hermann (2005), sound pressure level (SPL in dB) generated by headphones that surround the external ear, sit on the ear), or insert directly into the ear canal depends on the dimensions of the ear canal and on the type of headphone used. This study suggested that the earphones inserted into the ear canal generated increased SPLs in smaller ears compared to larger ears.

Despite all the data on exposure to loud music over time and NIHL, a 2005 study by Chung et al. reported that of the nearly 10,000 individuals who responded to a survey posted on the MTV™ web site, only 8 percent considered hearing loss "a very big problem." Even though 61 percent said they had experienced ringing in their ears or other hearing problems after attending rock concerts, only 14 percent said they had used ear protection.

To help address this growing problem, the NIDCD continues to conduct NIHL-related research and increase awareness of NIHL by public education activities. By focusing on children and teens and addressing key topics such as the use of personal stereo systems, the NIDCD hopes to teach young children and teens how to protect their hearing while still enjoying their music, movies, and video games. In 2002, NIDCD-supported scientists reviewed the current hearing conservation programs for children. They used a NIH-supported Science Education Partnership Award (SEPA) to develop a hands-on and web-based curriculum to increase knowledge, change attitudes, and promote behaviors consistent with hearing loss prevention. The NIDCD is also sponsoring a Small Business Innovation Research (SBIR) award to develop a miniature, low cost, user-friendly personal sound level dosimeter to allow individuals to measure and monitor their exposure to sound levels and identify those levels that might cause hearing loss.

In addition to an overview of research in personal music devices and hearing loss, I am providing responses to specific questions that you had stated in your letter.

1) Do portable music players contribute to premature hearing loss? If so, to what extent?
There are three factors that contribute to noise-induced hearing loss: the loudness of the sound, the duration of exposure to the sound, and the distance from the sound source. Portable music players can contribute to hearing loss if the volume is set too high, the listener uses the device for a long period of time, and if the sound source is situated too close to the ears.

2) Short of giving up their personal music devices, what can consumers do to protect their hearing?
Consumers can set the volume of their music devices to a safe level. If you cannot hear people speaking near you while listening to your music, then the volume on your device is too high. In addition, consumers should limit the amount of time they listen to their devices. As mentioned above, researchers have suggested users set the volume of their music player no higher than 60 percent of the maximum, and use it for no more than one hour a day.

3) What research is currently available with regard to safe volume limits and exposure time for recreational listening?
Most research regarding NIHL has been done in the context of occupational (not recreational) exposures over an occupational lifetime (40 years). Although there are not similar standards for recreational noise exposures, it is reasonable to assume that the exposure limits for occupational noise are applicable to recreational noise. These standards are set by the U.S. Department of Labor's Occupational Safety and Health Administration (OSHA). You can learn more from the OSHA website at http://www.osha.gov/SLTC/noisehearingconservation/. However, the extrapolation from occupational to recreational exposures is not straightforward. For example, because recreational exposures vary (snow blower, snow mobile, hunting, concerts, loud headsets) so too will the damage limits. In addition, the combination of occupational and recreational exposures is a factor for some and not for others, which requires more consideration for some individuals. NIHL occurs slowly and over time as a cumulative process. Environmental noise exposures vary dramatically among individuals making it difficult to characterize real world exposure for recreational noise. Because of these complexities, there is not a wide literature base on volume limits and exposure time for various types of recreational noise.

4) According to the Washington Post, Apple has declined to provide information on the maximum output level for its iPod devices. What information is readily available to consumers regarding the maximum output level for various portable music devices?
Although manufacturers do provide technical specifications for each device and the included earphones/headphones, the actual maximum audio output (in dB) is probably not readily available to consumers from the manufacturer.

5) According to the American Speech-Language-Hearing Association (ASHA), "Loud noise above 85 decibels can cause permanent hearing loss." How can consumers determine whether they are listening to music at levels that put them at risk for hearing loss? Consumers need to be aware that listening to loud music puts them at risk for NIHL. Since the majority of consumers do not have access to sound level dosimeters, it is imperative to continue the following efforts to increase public awareness for NIHL:

NIDCD's WISE EARS!® national campaign efforts focus especially on the prevention of noise-induced hearing loss in children and workers in noisy environments. For more than 5 years, NIDCD has built a coalition network with nearly 100 organizations nationwide to promote awareness about protecting our hearing for a lifetime. For elementary school teachers and students we have developed the "I Love What I Hear" classroom activity and video for grades 3 through 6, along with a web-based interactive sound ruler and a "How Loud Is Too Loud" bookmark. Recently, this educational outreach video aired on a news program that reaches 8 million students in 12,000 schools. NIDCD also developed a middle school curriculum supplement, "How Your Brain Understands What Your Ear Hears." Students in grades 7 and 8 learn to develop healthy hearing habits and to avoid excessive exposure to loud noise that can lead to hearing loss. These materials are available on the NIDCD Web site, along with a Kids and Teachers Web page that has become a major resource for information about NIHL prevention. Students, teachers, and parents have access to interactive quizzes, learning tools, and videos that are available in English and Spanish. Print materials also are available for teachers without Web resources. Later in 2006, NIDCD is planning to participate in a national conference on Noise-Induced Hearing Loss in Children and Youth at Work and Play and explore new partnerships to expand the WISE EARS!® campaign objectives to reach younger audiences. Information on WISE EARS!® can be found on http://www.nidcd.nih.gov/health/wise/.

NIDCD and the NIH's National Center for Research Resources (NCRR) are supporting a Science Education Partnership Award (SEPA) to the Oregon Hearing Research Center at the Oregon Health & Science University (OHSU) and the Oregon Museum of Science and Industry (OMSI), in affiliation with the Portland VA National Center for Rehabilitative Auditory Research, and the American Tinnitus Association, on a public health campaign called "Dangerous Decibels." This project is a designed to reduce the incidence and prevalence of NIHL and tinnitus (ringing in the ear) by changing knowledge, attitudes, and behaviors of school-aged children. The campaign can be found at http://www.dangerousdecibels.org

The Center for Disease Control and Prevention (CDC)/National Institute of Occupational Safety and Health (NIOSH) has an informative website at http://www.cdc.gov/niosh/topics/noise/abouthlp/noisemeter_flash/soundMeter_flash.html, which provides a sound meter of everyday noises and a scale illustrating the safe limits of exposure to certain sound levels.

In addition, the House Ear Institute recently announced a campaign aimed at teens and young adults about the potential dangers to hearing from listening to loud sounds. Information on this campaign and their public service announcement on NIHL, which appeared on MTV™, can be found on http://www.earbud.org/.

6) Do earbuds increase the risk of hearing loss more than traditional earmuff style headphones?

A factor that contributes to NIHL is the proximity of the source of sound to the ears. Earbud headphones are situated snugly on the bowl of the ear and they project sound directly into the canal. In contrast, traditional earmuff style headphones are placed outside the ears and this allows the sound to diffuse. Any type of headphone has the potential to cause NIHL if used improperly in terms of absolute level of the sounds, the length of exposure time to sound, and the fit of the earphone or headphone (Voss and Herrmann, 2005). Therefore, more research is required to determine if a particular type increases the risk of NIHL.

7) Are sound-minimizing headsets (either "noise-canceling" or "sound-isolating" headphones) better for your hearing than traditional headphones or earbuds? In your opinion, what are the most promising areas of deafness research today, and what does the future hold for those impacted by deafness and hearing loss?

Noise-canceling headphones may filter outside noise and enable the listener to hear music at a lower volume but it is also important for the listener to be able to hear sounds in the environment, such as an approaching vehicle or speech. Noise-canceling headphones may reduce background noise, changing the overall level and frequency components of the sound you are hearing, however, the absolute level of the sound at the ear and the length of exposure time are important factors in considering risk to NIHL.

There has been much progress made in biomedical research in the last decade and the NIDCD has been at the forefront of research in deafness and other disorders of human communication. Some promising areas of hearing research include:

- **Newborn Hearing Screening and Early Intervention**

In the U.S., approximately 2-3 out of 1,000 children are born each day who are deaf or who have a hearing loss significant enough to potentially affect their speech, language, and cognitive development. Some of these children are not identified until they are two-years old or more, in spite of advances in the technology of early detection of hearing loss. Results from NIDCD-supported research show that if children are identified with a hearing impairment by 6 months of age and then receive appropriate intervention, they have significantly better language development than children whose impairment was identified after 6 months of age. This is important because later identification results in significant delays in spoken language and literacy. Data have shown that deaf or hearing-impaired students are disproportionately disadvantaged. For example, the average reading level for individuals who are deaf, at age 18 years, is estimated at the fourth grade. Without appropriate and timely identification and intervention, early childhood hearing impairment interferes with the development of oral/aural communication, impedes academic performance, and results in negative long-term vocational consequences. The NIDCD supports a research portfolio on early identification strategies (including hearing screening systems for measuring auditory brainstem responses (ABR) and otoacoustic emissions (OAE) and interventions as well as research in language acquisition, both spoken and signed, the development of cochlear implants, hearing aids, and other assistive devices. The NIDCD

encourages research that will assist clinicians as they characterize auditory performance in a newborn who fails hearing screening, as well as research that designs intervention strategies to optimize communication success.

- **Identifying Gene Mutations that Cause Hereditary Hearing Impairment**

Of the estimated 12,000 American babies born each year that have a severe hearing impairment, in almost two-thirds of the cases the etiology is genetic. Many genes that cause hereditary hearing impairment have been located, and mutations in many of these genes cause hearing impairment in the absence of other clinical findings (non-syndromic hereditary hearing impairment). Remarkable progress has been made within the last few years by NIDCD-supported scientists in identifying these genes and their loci. Empowered by the progress made from the Human Genome Project, these scientists are now determining the precise identity of these genes and the nature of mutations in these genes that cause hereditary hearing impairment. This genetic information will ultimately aid in the precise and timely diagnosis of hearing impairment in infants, thereby helping parents plan for the educational and habilitation needs of their children at the earliest possible opportunity. Effective habilitation programs will ensure the acquisition of spoken or signed language and consequently improve the quality of life for these children over a lifetime.

- **Cochlear Implants Restore Communication Capacity**

The cochlear implant is the only sensory neural prosthesis in widespread clinical use. As of May 2005, the Food and Drug Administration reported that approximately 96,000 individuals have received cochlear implants worldwide, including an estimated 37,000 Americans, with about one-half of the recipients being children. This device converts sound into electrical impulses on an array of electrodes that is surgically inserted into the inner ear, bypassing the inner ear hair cells and stimulating the auditory nerve directly, restoring the perception of sound to persons who are totally, or almost totally deaf. Longitudinal clinical studies show that deaf children who receive the implant during the period when language skills are developing can acquire good speech and auditory/aural communication skills. NIDCD-supported scientists are discovering improvements in the electrode array and sound processing algorithms, making the cochlear implant a useful device for an ever-expanding group of individuals with severe hearing impairment who receive marginal benefit from using hearing aids. Additional research has shown that performing implant surgery before two years of age in a child with congenital deafness results in better long-term language skills than when surgery is performed later in childhood.

- **Treatment for Otitis Media**

Otitis media (middle ear infection) is the most common reason for a young child to be taken to a physician, and is one of the most frequent reasons that doctors prescribe antibiotic therapy for children. The estimated total cost of otitis media in the U.S. is $5 billion per year. Repeated bouts of otitis media can lead to hearing loss, underscoring the need for a vaccine to prevent this costly and destructive disease. With the emergence of antibiotic-resistant strains of bacteria that cause otitis media, NIDCD intramural scientists have developed a candidate vaccine to prevent otitis media caused by a common bacterial pathogen, nontypeable *Haemophilus influenzae*, and have completed Phase I testing of this vaccine in clinical trials.

Results of this trial suggest that this investigational vaccine may be useful in preventing otitis media in children. NIDCD intramural scientists are also developing a candidate vaccine for *Moraxella catarrhalis*, another major bacterial pathogen that causes otitis media. In a prospective study involving twins and triplets, NIDCD-supported scientists have determined that a strong genetic link is associated with a high rate of occurrence of otitis media in children. Studies of the genetic mechanisms responsible for the increased risk and frequency of this disease could lead to additional approaches for intervention and treatment. Research is also being conducted on the genes of *H. influenzae* and *M. catarrhalis* to help scientists determine the virulence factors of these bacteria and under which circumstances these bacteria cause otitis media.

I hope this information responds to your questions. Please contact me if I can be of further assistance.

Sincerely,

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Director, National Institute on Deafness
and Other Communication Disorders

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