

EAA: Effects of Noise Exposure and Implications for Wellness

Overall daily noise pollution is an issue affecting individuals of all ages from the fetus to the older adult (Chepesiuk, 2005). Rapid urbanization, wind turbines in rural areas, industrial machines, vehicles, entertainment activities, and personal and audio devices are all responsible for the increase in the omnipresence of noise (Gupta et al, 2018). Statistics from Pew Research Center (Faverio, 2022) indicate that 95-96% of U.S. adults ages 18-49 own a personal smartphone, with most users connecting via earbuds or headsets that funnel the sound directly into the ear canal. With this significant use of personal devices, its effect on hearing health must be considered. In addition to noise exposure causing hearing loss, there is growing evidence of the potential harmful effects of noise on general wellness (Eichwald & Scinicariello 2020).

Noise and Noise-Induced Hearing Loss (NIHL)

Excessive noise exposure can result in permanent hearing loss, hidden hearing loss, cochlear and nerve synaptopathies, neural and demyelination, and impaired listening in noise. Schlauch estimated that 6% of children aged 12-19 years have noise-induced hearing loss and found this estimate to be stable (2013). Hearing screenings and the standard audiological evaluation are not sensitive enough to detect early effects of noise exposure/ changes in cochlear function (Lieberman 2015, Cohrman et.al. 2020).

Children are at the greatest risk for developing permanent noise-induced hearing loss since their smaller ear canals result in higher intensity signals transmitted through their peripheral system as compared with adults whose larger ear canals deliver sound at the “intended” intensity (Sinclair et al. 1996, Family Hearing Centers 2022). In other words, children receive sounds more intensely than adults when devices are set at the same volume, so greater care must be taken to limit children’s exposure to noise. Volume-limiting headphones and earbuds marketed toward toddlers and labeled as “safe” by the manufacturer do not always keep the volume below the recommended 85 dBA SPL (Dragan 2023). One study tested 20 so-called “safe” headphones and found that almost half allowed music to be played at an intensity exceeding 85dBA SPL, which unsubstantiated manufacturers’ safety claims (Dragan 2023). This study is a reminder that, although products can claim to have volume restricted “safe listening,” there are no industry standards or governing bodies to verify these claims. As such, consumers should not trust the technology to keep children from unsafe listening levels.

With the increasing prevalence of audio and video systems integrated into the day-to-day lives of younger individuals in both recreational and educational settings, there exists a strong push towards promoting safe listening habits among these young people. Dillard et al. (2022) found approximately 1 billion adolescents were at risk of hearing loss from unsafe recreational listening practices. When compared to older listeners, young individuals listen to their personal listening devices at a significantly higher level, with the majority of them exceeding the recommended daily dose of listening (Filgor et al., 2014). Specifically, the World Health Organization [WHO] (2019) found that 50% of 12-35 year old individuals listen to their personal listening devices at volumes that put their hearing at risk. Additionally, 40% of individuals who attend entertainment venues are at risk for noise-induced hearing loss (WHO, 2019). Eichwald (2020) completed a survey of high school students and found 75% of teenage students report loud noise exposure at school without being provided hearing protection or education on hearing prevention techniques to reduce the risk of permanent hearing loss. Clearly, there is a need to address this increased risk for noise-induced hearing loss with young people.

Noise and Wellness

Noise is associated with communication difficulties as well as health consequences, even if it is not intense enough to cause hearing loss. Long reverberation times increase noise and degrade speech intelligibility contributing to potential learning and behavior problems (Astolfi et. al. 2019a). Noise affects cognitive performance, speech perception, and other non-auditory factors such as decreased focus, sociability, mental health, and increased headaches (Klatte et. al 2013, Walinder et al. 2007). Noise levels are also related with increased perceived listening difficulty, which is directly related to increased listener fatigue (Gustafson et. al. 2021). An association between estimated loudness and noise annoyance at preschool was shown to affect children’s behavior such as distractibility, emotional status, the need to be heard, ignorance of important auditory input, avoidance, withdrawal, and exhaustion (Waye et al, 2019). Poor classroom acoustics have also been shown to reduce student perception of being happy (Astolfi et. al 2019). Importantly, research shows that reducing noise can have positive

effects on wellness for children. For example, after modest sound treatment at a preschool, researchers found measurable reductions in physical symptoms such as stomach aches and improvements in communication outcomes (Waye & Karlburg 2021).

Resources for Increasing Awareness of NIHL

Lack of public awareness, ineffective dissemination of information, materials, and curriculum, and not wanting to appear different than peers seem to be the greatest reasons that our children have not embraced healthy listening habits to avoid noise exposure and its harmful effects (National Center for Environmental Health, 2022; Folmer, 2002). Programs such as “Dangerous Decibels” (www.dangerousdecibels.org), “Noisy Planet” (<https://www.noisyplanet.nidcd.nih.gov>), and “Crank It Down” (www.hearingconservation.org) provide basic information on hearing loss prevention and suggested activities for use with students. Even when educated about the harmful effects of noise exposure, students still largely do not choose to use ear protection reportedly due to lack of use by their friends (Johnson et. al., 2016).

Several measures are recommended to prevent NIHL. The WHO (2019) recommends that personal audio device users activate volume limiting, a feature that limits the volume output. If available, WHO recommends users activate automatic volume reduction at 60% (WHO, 2022). Ear protection should be worn when in excessively intense noise such as when at concert venues, car auto racing venues, and stadiums.

Role of Educational Audiologists for Addressing Noise

Based on training and scope of practice of audiologists as defined by the American Academy of Audiology (2004), American Speech-Language-Hearing Association (2018), and the Individuals with Disabilities Education Act (IDEA) [34CFR300.34(c)(1)(iv)], educational audiologists have the primary responsibility to provide noise education and hearing loss prevention education. The educational audiologist is best suited to assist the general education teacher in integrating this critical information into health, science, and/or vocational education courses. Designing a hearing loss prevention program requires consideration of the below components to increase efficacy and retention of concepts (Dillmuth-Miller & Bulger 2021, Meinke et al. 2008).

1. Determining the contents and making the curriculum relevant for the various age groups.
2. Using interactive instruction.
3. Adding repetition within the program.
4. Implementing skills-based learning.
5. Identifying existing courses where noise education may be infused.
6. Identifying the role of the educational audiologist and other responsible parties in the management and delivery of the program.

When these concepts were implemented in fourth and seventh graders via the Dangerous Decibels curriculum, knowledge and attitudes about NIHL significantly increased when assessed immediately after the presentation. When reassessed three months after the program, students in both grades retained their knowledge, but only the fourth graders retained their improved attitudes toward NIHL prevention (Griest et al, 2007). This finding suggests that education needs to start in elementary school and should be repeated in order to change behavior much like other health initiatives such as smoking cessation (Dillmuth-Miller & Bulger, 2021; Griest et. al., 2007).

Noise education is vital to protect our youth’s hearing and to promote wellness. These services can best be planned and coordinated by audiologists working in the schools as part of the education team.

References:

American Academy of Audiology. (2004). Audiology: Scope of practice [PDF]. <https://www.audiology.org/wp-content/uploads/2022/10/2004-Scope-of-Practice.pdf>

American Speech and Hearing Association. (2018). Scope of practice in audiology. <https://www.asha.org/policy/sp2018-00353/>

- Astolfi A, Puglisi GE, Murgia S, Minelli G, Pellerey F, Prato A, Sacco T (2019a). Influence of Classroom Acoustics on Noise Disturbance and Well-Being for First Graders. *Front Psychol.*, 10:2736. doi: 10.3389/fpsyg.2019.02736.
- Astolfi A, Puglisi G, Prato A, Murgio S, Menelli G, Sacco T (2019b) Well-being and noise annoyance outcomes from first graders and relationships with classroom acoustics. In *Proceedings of the 23rd International Congress on Acoustics : integrating 4th EAA Euroregio 2019 : 9-13 September 2019 in Aachen, Germany / proceedings editors: Martin Ochmann, Michael Vorländer, Janina Fels, Seiten/Artikel-Nr: 5910-5917*
- Chepesiuk, R. (2005). Decibel hell: The effects of living in a noisy world. *Environmental Health Perspectives*, 113(1), A34-A41. doi.org/10.1289/ehp.113-a34
- C Kahrman D, Wan G, Cassinotti L, Corfas G. (2020) Hidden Hearing Loss: A Disorder with Multiple Etiologies and Mechanisms. *Cold Spring Harb Perspect Med.* 2020 Jan 2;10(1):a035493. doi: 10.1101/cshperspect.a035493.
- Dillard, L. K., Arunda, M. O., Lopez-Perez, L., Martinez, R. X., Jiménez, L., & Chadha, S. (2022). Prevalence and global estimates of unsafe listening practices in adolescents and young adults: A systematic review and meta-analysis. *BMJ Global Health*, 7(11).
- Dillmuth-Miller S. & Bulger MK (2021) Knowledge and attitudes of excessive noise exposure in college and middle school students. (Educational Audiology Conference 2021).
- Dragan, L. (2023, July 10). The Best Kids Headphones. *Wirecutter*. <https://www.nytimes.com/wirecutter/reviews/best-kids-headphones/#how-we-tested-the-unabridged-edition>
- Eichwald, J., & Scinicariello, F. (2020). Survey of Teen Noise Exposure and Efforts to Protect Hearing at School - United States, 2020. *Morbidity and mortality weekly report*, 69(48), 1822–1826.
- Family Hearing Centers. (2022, August 9). Are children's ears more sensitive to loud noises? <https://familyhearingcenters.com/are-childrens-ears-more-sensitive-loud-noises#:~:text=Children's%20ears%20are%20at%20the,noise%20at%20a%20higher%20rate>.
- Faverio, M. (2022, January 13). Share of those 65 and older who are tech users has grown in the past decade. *Pew Research Center*. <https://www.pewresearch.org/short-reads/2022/01/13/share-of-those-65-and-older-who-are-tech-users-has-grown-in-the-past-decade/>
- Fligor, B. J., Levey, S., & Levey, T. (2014). Cultural and demographic factors influencing noise exposure estimates from use of portable listening devices in an urban environment. *Journal of Speech, Language, and Hearing Research*, 57(4), 1535–1547. https://doi.org/10.1044/2014_JSLHR-H-12-0420.
- Folmer, R. L. (2002). Why Aren't Hearing Conservation Practices Taught in Schools?. *Audiology Online*. <https://www.audiologyonline.com/articles/why-aren-t-hearing-conservation-1170>.
- Griest, S., Folmer, R. & Martin, W. (2008). Effectiveness of "Dangerous Decibels," a School-Based Hearing Loss Prevention Program. *American Journal of Audiology*. 16. S165-81. 10.1044/1059-0889(2007/021)
- Gupta A., Gupta A., Jain K., & Gupta S. (2018). Noise pollution and the impact on children's health. *The Indian Journal of Pediatrics*. 85(4):300–306 <https://doi.org/10.1007/s12098-017-2579-7>
- Gustafson S., Camarata S., Hornsby B., and Bess F. (2021). Perceived Listening Difficulty in the Classroom, Not Measured Noise Levels, Is Associated With Fatigue in Children With and Without Hearing Loss. *American Journal of Audiology*, 9 December 2021, doi.org/10.1044/2021_AJA-21-00065, https://pubs.asha.org/doi/full/10.1044/2021_AJA-21-00065
- Johnson T, Lovett B, & Dillmuth-Miller S (2016) Attitudes towards noise exposure: CSD vs. Non CSD students. (Poster presentation). 2016 American Speech-Language-Hearing Association (ASHA) Convention, Philadelphia, PA
- Klatte M, Bergström K, Lachmann T. (2013) Does noise affect learning? A short review on noise effects on cognitive performance in children. *Front Psychol*. doi: 10.3389/fpsyg.2013.00578. PMID: 24009598; PMCID: PMC3757288.
- Liberman MC. (2015). Hidden Hearing Loss. *Scientific American* Aug;313(2):48-53. doi: 10.1038/scientificamerican0815-48. PMID: 26349143.
- Meinke, D., Martin, W., Griest, S., Howarth, L., Sobel, J., & Scarlotta, T. (2008). Dangerous Decibels® I: Noise induced hearing loss and tinnitus prevention in children. Noise exposures, epidemiology, detection, interventions and resources. [Paper presentation]. Hearing loss: 9th International Congress on Noise as a Public Health Problem (ICBEN), Foxwoods, CT. https://www.researchgate.net/publication/228443408_Dangerous_DecibelsR_I_Noise_induced_hearing_loss_and_tinnitus_prevention_in_children_Noise_exposures_epidemiology_detection_interventions_and_resources
- National Center for Environmental Health. (2022). Loud noise can cause hearing loss. Centers for Disease Control and Prevention. www.cdc.gov/healthyyouth/noise/index.htm.

- Schlauch, R. S. (2013). Noise-Induced Hearing Loss in Teen-agers. *Acoustics Today*, 9(4), 14. <https://doi.org/10.1121/1.4826997>
- Sinclair ST, Beauchaine KL, Moodie KS, Feigin JA, et al. (1996) Repeatability of a real-ear-to-coupler difference measurement as a function of age. *AJA* 1996;5(3):52–56.
- Tomblin, J. B., Harrison, M., Ambrose, S. E., Walker, E. A., Oleson, J. J., & Moeller, M. P. (2015). Language Outcomes in Young Children with Mild to Severe Hearing Loss. *Ear and Hearing*, 36 Supplemental 1(01), 76S–91S. <https://doi.org/10.1097/AUD.0000000000000219>
- Walker, E. A., Sapp, C., Dallapiazza, M., Spratford, M., McCreery, R. W., & Oleson, J. J. (2020). Language and reading outcomes in fourth-grade children with mild hearing loss compared to age-matched hearing peers. *Language, Speech, and Hearing Services in Schools*, 51(1), 17–28. https://doi.org/10.1044/2019_lshss-ochl-19-0015
- Wålinder R, Gunnarsson K, Runeson R, Smedje G. (2007) Physiological and psychological stress reactions in relation to classroom noise. *Scand J Work Environ Health*. doi: 10.5271/sjweh.1141. PMID: 17717617.
- Waye K, Fredriksson S, Hussain-Alkhateeb L, Gustafsson J, van Kamp I (2019). Preschool teachers' perspective on how high noise levels at preschool affect children's behavior. *PLoS ONE* 14(3): e0214464. <https://doi.org/10.1371/journal.pone.0214464>
- Waye K & Karlberg J (2021). Sound Quality Characteristics of Importance for Preschool Children's Perception and Wellbeing after an Acoustic Intervention. *Frontiers Built Environ.* (7). <https://www.frontiersin.org/articles/10.3389/fbuil.2021.688836/full>
- World Health Organization (2019). New WHO-ITU standard aims to prevent hearing loss among 1.1 billion young people. <https://www.who.int/news/item/12-02-2019-new-who-itu-standard-aims-to-prevent-hearing-loss-among-1.1-billion-young-people>
- World Health Organization. (2022, February 23). Deafness and hearing loss: Safe listening. <https://www.who.int/news-room/questions-and-answers/item/deafness-and-hearing-loss-safe-listening#:~:text=Keep%20the%20volume%20down.,raise%20volume%20in%20noisy%20situations.>
- World Health Organization. (2019). Guidelines on physical activity, sedentary behavior, and sleep for children under 5 years of age. <https://www.who.int/publications/i/item/9789241550536>