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Hidden Hearing Loss - Revisiting the Limits of Audiometric Diagnosis

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How to cite this Article:
Udaipurwala IH, Hidden Hearing Loss - Revisiting the Limits of Audiometric Diagnosis. J Bahria Uni Med Dental Coll. 2025;15(3): 167-8 DOI: https://doi.org/10.51985/JBUMDC2025607

Hearing loss has traditionally been identified and managed on the basis of audiometric thresholds, with clinicians relying on pure-tone audiograms as the gold standard.[1] However, a growing research has revealed a perplexing phenomenon where individual reports significant hearing difficulty, particularly in noisy environments, despite having normal audiogram.[2,3,4] This condition, termed 'hidden hearing loss' (HHL), is increasingly recognized as a significant but underdiagnosed auditory disorder.[5] Its concept was first elucidated in animal models, demonstrated that noise exposure can cause permanent damage to the synapses between inner hair cells and auditory nerve fibers without altering hearing thresholds.[6] Since then, this cochlear synaptopathy based model has transformed our understanding of auditory dysfunction, pushing the boundaries of clinical audiology and neuroscience.[7,8] Hidden hearing loss challenges traditional assumptions and calls for a rethinking of hearing diagnostics, especially in populations such as veterans, industrial workers, and recreational noise users. About 10% of the patients visiting ENT clinics with complaint of difficulty in understanding speech in noisy environment remain untreated due to this problem.[9]

The World Health Organization in its 2021 report on hearing, estimates that about half population of the globe is at risk of developing noise induced hearing loss due to unsafe exposure to sound in workplace or social activities.[7] Noise induced hearing loss typically damages outer hair cell in the cochlea and subsequent neuronal degeneration which elevates hearing thresholds and is easily detected via standard audiometry.[10] On the other hand in cochlear synaptopathy, pathology lies in the synapses between the hair cells and spiral ganglion which preserves the hearing threshold sensitivity. As a result, individuals with significant synaptic damage may pass audiometric tests yet struggle to interpret complex auditory scenes, particularly speech-in-noise. Electrophysiological studies have provided strong support for this mechanism as reduced amplitude in auditory brainstem response wave I correlates with synaptic loss, even when audiograms appear normal. Furthermore, advanced tests such as envelope following responses (EFRs) and auditory steady-state responses (ASSRs) suggest impaired temporal dependability in the auditory pathway that is another hallmark of synaptopathy. Although most evidence originates from animal models, postmortem analyses and indirect testing in humans support the idea that noise exposure, aging, and possibly ototoxicity contribute to synapse degeneration. Importantly, these changes may not be linear, suggesting an early vulnerability of low-spontaneous-rate fibers that are essential for hearing in challenging listening conditions.

Noise is perhaps the most well established cause of hidden hearing loss, even moderate but repeated exposure to high-intensity sounds such as those encountered in concerts, nightclubs, or workplaces can result in significant synaptic loss. A recent study has found evidence of hidden hearing loss among young adults with frequent recreational noise exposure, despite their normal hearing thresholds.[8] Another significant contributor in hidden hearing loss is age-related cochlear synaptopathy. While presbycusis is traditionally associated with both threshold shifts and outer hair cell loss with neural degeneration, research now suggests that synapse loss may precede these changes. This makes hidden hearing loss a potential early biomarker for age-related hearing decline. Ototoxic drugs, such as aminoglycosides or certain chemotherapeutic agents, have also been implicated in the etiology of synaptopathy. Additionally, individuals with tinnitus or hyperacusis often exhibit signs consistent with hidden hearing loss, even when standard hearing tests fail to capture their auditory dysfunction.[11] Occupational data further highlight the relevance of HHL as military veterans and workers in industrial environments frequently report auditory problems not explained by audiograms. A study by Tepe et al. (2017) documented such deficits in soldiers, suggesting that current hearing conservation programs may underestimate the true burden of auditory damage.[12]

Clinically, hidden hearing loss presents with a diagnostic enigma. Patients often describe difficulty understanding speech in noisy environments, poor sound clarity, listening fatigue, and tinnitus, yet standard audiograms and tympanometry often yield normal results. This dissonance can lead to underdiagnosis, misdiagnosis, or even dismissal of patients' complaints. Standard audiological evaluations lack the sensitivity to detect HHL. As a result, new diagnostic

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Received: 16-05-2025
Accepted: 15-06-2025

paradigms are being explored like speech-in-noise (SiN) test, electrophysiological markers, such as ABR wave I amplitude and EFR metrics, TEN (threshold equalizing noise) testing and self-report auditory questionnaires, which can contextualize physiological findings. Recent reviews emphasize the need for multi-modal diagnostic batteries that incorporate both objective and subjective assessments. Without such integrative approaches, many cases of HHL will continue to go unrecognized, with adverse effects on patients' communication abilities, mental health, and quality of life.

The implications of HHL extend far beyond hearing difficulties. Social withdrawal, cognitive fatigue, and depression are commonly reported in individuals with undiagnosed auditory impairments. From a society standpoint, untreated HHL contributes to productivity loss, educational challenges, and increased healthcare utilization. The issue is especially critical in high-demand auditory environments, such as classrooms, military operations, emergency services, and busy workplaces. Children with undiagnosed HHL may be mislabeled as inattentive or underperforming, while adults may suffer in job performance or safety-sensitive tasks. Moreover, the potential for progression from HHL to overt hearing loss remains a matter of concern. While the natural course of cochlear synaptopathy is still under investigation, early synaptic damage may predispose individuals to accelerated hearing decline if left unaddressed.

Given the limitations of current treatment options, prevention remains the cornerstone of HHL management. Public health strategies should include:

- Educational campaigns about safe listening practices, particularly among youth.
- Stricter enforcement of occupational noise regulations and enhanced protective equipment.
- Routine auditory screenings that go beyond audiograms, particularly for at-risk populations.

On the research front, the development of non-invasive, cost-effective diagnostic tools is urgently needed. Technologies such as portable ABR and machine learning-assisted SiN analysis may help bridge the gap between research and clinical practice. Furthermore, therapeutic innovation is on the horizon. Experimental models suggest that neurotrophic factors can promote synapse regeneration. Gene therapy and nanoparticle-mediated drug delivery are also being explored, though translation to human application remains pending. Longitudinal studies are essential to understand the trajectory of HHL, identify early predictors of progression, and evaluate the impact of targeted interventions. Multidisciplinary collaboration encompassing audiology, neurology, otolaryngology, and behavioral science will be key to advancing the field. By recognizing HHL as a genuine and pressing auditory disorder, we can offer better support, develop novel therapies, and, most importantly, validate the lived experiences of those who hear but cannot truly listen.

Authors Contribution:
Iqbal Hussain Udaipurwala: Conception, writing, literature search, proof reading

REFERENCES

1. Walker JJ, Cleveland LM, Davis JL, Seales JS. Audiometry screening and interpretation. Am Fam Physician. 2013; 87(1): 41-7.
2. Bajin MD, Dahm V, Lin VYW. Hidden hearing loss: current concepts. Curr Opin Otolaryngol Head Neck Surg. 2022; 30(5): 321-325. doi: 10.1097/MOO.0000000000000824.
3. Bharadwaj HM, Masud S, Mehraei G, Verhulst S, Shinn-Cunningham BG. Individual differences reveal correlates of hidden hearing deficits. J Neurosci. 2015; 35(5): 2161-72. doi: 10.1523/JNEUROSCI.3915-14.2015.
4. Shenoy S, Bhatt K, Yazdani Y, Rahimian H, Djalilian HR, Abouzari M. A Systematic Review: State of the Science on Diagnostics of Hidden Hearing Loss. Diagnostics. 2025; 15(6):742. doi: https://doi.org/10.3390/diagnostics15060742
5. Liu J, Stohl J, Overath T. Hidden hearing loss: Fifteen years at a glance. Hear Res. 2024; 443: 108967. doi: 10.1016/j.heares .2024.108967.
6. Kujawa SG, Liberman MC. Adding insult to injury: cochlear nerve degeneration after "temporary" noise-induced hearing loss. J Neurosci. 2009; 29(45): 14077-85. doi: 10.1523/ JNEUROSCI.2845-09.2009.
7. Valderrama JT, de la Torre A, McAlpine D. The hunt for hidden hearing loss in humans: From preclinical studies to effective interventions. Front Neurosci. 2022; 16: 1000304. doi: 10.3389/fnins.2022.1000304
8. Liberman MC, Epstein MJ, Cleveland SS, Wang H, Maison SF. Toward a Differential Diagnosis of Hidden Hearing Loss in Humans. PLoS One. 2016; 11(9): e0162726. doi: 10.1371/journal.pone.0162726
9. Parthasarathy A, Hancock KE, Bennett K, DeGruttola V, Polley DB. Bottom-up and top-down neural signatures of disordered multi-talker speech perception in adults with normal hearing. Elife. 2020; 9: e51419. doi: 10.7554/eLife.51419.
10. Udaipurwala, I. H. Noise-Induced Hearing Loss and Tinnitus in the Digital Era: An Alarming Rise in the Younger Generation. Journal of Bahria University Medical and Dental College. 2025; 15(01), 01–02. https://doi.org/10.51985/ JBUMDC 2024451
11. Kara E, Aydýn K, Akbulut AA, Karakol SN, Durmaz S, Yener HM, Gözen ED, Kara H. Assessment of Hidden Hearing Loss in Normal Hearing Individuals with and Without Tinnitus. J Int Adv Otol. 2020; 16(1): 87-92. doi: 10.5152/iao.2020.7062
12. Tepe V, Smalt C, Nelson J, Quatieri T, Pitts K. Hidden Hearing Injury: The Emerging Science and Military Relevance of Cochlear Synaptopathy, Military Medicine. 2017; 182(9): e1785–e1795. doi: https://doi.org/10.7205/MILMED-D-17-00025