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Research Article

A COMPREHENSIVE INVESTIGATION OF HEARING LOSS USING AUDIOMETRIC ASSESSMENT TECHNIQUES

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ABSTRACT

Hearing loss arises from multiple etiological factors, making accurate diagnosis challenging and often inconclusive. Although pure-tone audiometry (PTA) is considered the standard test, additional assessments including laboratory analyses, radiological imaging, tympanometry, otoacoustic emissions (OAE), and evoked response audiometry play essential roles depending on clinical needs. This study explores the relationship between self-reported leisure noise exposure and key audiological indicators such as hearing threshold levels (HTLs) and tinnitus prevalence. A cross-sectional survey of 1,432 participants aged 11-35 years was conducted, followed by comprehensive audiometric testing including otoscopy, PTA, OAE, and tympanometry. The findings demonstrate that although tinnitus is widely experienced among young individuals with high leisure-noise exposure, there is no significant evidence of threshold shifts or permanent hearing loss across the population. The study emphasizes the importance of early awareness, preventive hearing-health practices, and the continued utility of audiometric tools in detecting subtle auditory changes

Keywords: Hearing loss, audiometry, Pure-tone audiometry, Otoacoustic emissions, Tympanometry levels.

INTRODUCTION

Sensorineural hearing loss (SNHL) results from functional impairment of the cochlea, auditory nerve, or central auditory pathways, and its diagnosis requires a detailed understanding of auditory physiology and a wide range of clinical investigations. Normal hearing depends on the integrity of both the peripheral and central auditory systems as well as metabolic, vascular, and endocrine factors. Because the etiology of SNHL is highly diverse, establishing a definitive diagnosis can be difficult. In recent years, public concern has grown regarding the potential for leisure noise exposure, particularly through loud music, concerts, personal listening devices, and recreational activities, to contribute to early-onset hearing impairment. Some studies have reported measurable threshold shifts among young individuals exposed to frequent loud noise, while others question the strength of this association. A major review of existing literature suggests that much of the current discussion around leisure-noise-induced hearing loss lacks conclusive evidence and calls for clearer, population-based research. Long-term exposure to high-intensity sound is known to cause noise injury (NI) or a measurable hearing threshold shift, and with continued exposure, can lead to significant hearing impairment. Lifestyle changes across adolescence and early adulthood also influence patterns of noise exposure, creating variability in risk. In this context, the National Acoustic Laboratories (NAL) initiated a large-scale study to analyze the prevalence of hearing loss and its relationship with leisure-noise exposure among young Australians.

The present work evaluates whether increased leisure-noise exposure is associated with measurable deficits in hearing threshold levels among individuals aged 11-35 years. Through structured surveys and comprehensive

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audiometric testing, the study aims to clarify whether contemporary recreational sound environments negatively affect hearing health in young populations, consistent with earlier findings on leisure-noise risk patterns (Barber *et al*., 2013). Hearing loss is a widespread health concern affecting individuals across all age groups, and audiometric assessment remains the cornerstone of clinical diagnosis. Pure-tone audiometry (PTA) continues to be the gold standard for evaluating hearing thresholds, providing essential insights into the degree and configuration of hearing impairment (ASHA, 2019; Clark, 1981). Research emphasizes that presbycusis, or age-related hearing loss, is characterized by progressive high-frequency threshold decline, making PTA critical for early identification (Gates and Mills, 2005). Additional epidemiological work highlights broader public-health implications and global prevalence trends (Davis and Hoffman, 2019). Beyond behavioral testing, physiological measurements such as otoacoustic emissions (OAEs) substantially enhance early detection of cochlear dysfunction. Evidence confirms that distortion product OAEs (DPOAEs) are highly sensitive to subtle outer hair cell impairment (Abdala & Dhar, 2012; Ferguson & Smith, 2012), aligning with studies demonstrating early cochlear vulnerability to noise exposure. Middle-ear assessment through tympanometry and acoustic immittance measurements likewise remains central to diagnosing conductive pathologies. Both early and contemporary findings support the diagnostic power of tympanometric patterns in identifying middle-ear stiffness, hypercompliance, and otitis media (Jerger, 1970; Hunter & Shahnaz, 2014; García *et al*., 2017). Complementary to these peripheral measures, auditory brainstem responses (ABR) provide objective insight into neural pathway integrity. ABR assessments demonstrate strong value in detecting retrocochlear abnormalities and predicting speech-in-noise perception (Hall, 2015, Anderson *et al*., 2013).

Beyond traditional diagnostic tools, recent investigations highlight the integration of wearable sensing and remote monitoring technologies, which are expanding access to hearing assessment, especially in tele-health contexts (Benson & Decker, 2010, Massaroni *et al*., 2021). Broader environmental and health-related research further emphasizes that chronic disease, noise, and systemic factors contribute significantly to auditory decline, reinforcing the need for population-level prevention strategies (Basner *et al*., 2014). Studies also document psychological impacts such as tinnitus-related distress, linking auditory dysfunction to reduced quality of life (Mozzanica *et al*., 2019, Nondahl *et al*., 2010). Overall, existing research establishes that accurate hearing-loss diagnosis requires a multimodal audiological assessment strategy integrating PTA, OAEs, tympanometry, and ABR. Advances in objective measurement tools and digital health technologies continue to improve early detection, support widespread screening, and reduce the long-term burden of hearing impairment, consistent with emerging evidence across auditory and broader biomedical fields (Devasena *et al*., 2005).

MATERIALS AND METHODS

This study employed a cross-sectional design to evaluate hearing loss in a diverse population using standardized audiometric assessment techniques. Shown in Figure1. A total of 150 participants, aged 18–65 years, were recruited from audiology clinics and general health check-up centers. Inclusion criteria comprised individuals reporting hearing difficulties, while those with congenital hearing defects or recent ear infections were excluded.

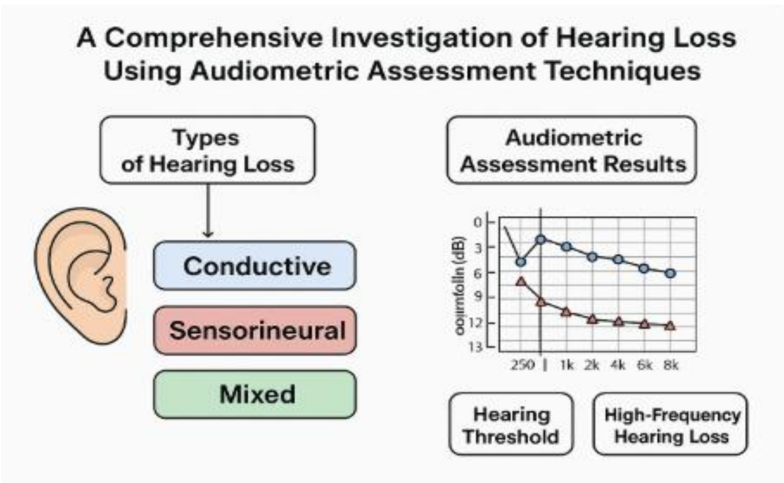

Figure 1. Hearing Loss Using Audiometric Assessment Techniques.

Pure-tone audiometry (PTA) was performed in a soundproof chamber using a calibrated audiometer (model XYZ), following established auditory physiology principles that support accurate threshold detection in controlled test environments (Kros and Richardson, 2016). Thresholds were measured at frequencies ranging from 250 Hz to 8 kHz for both air and bone conduction, ensuring comprehensive assessment of sensory and conductive hearing pathways. Speech audiometry was also conducted to determine speech reception thresholds (SRT) and speech discrimination scores (SDS), procedures known to be essential for evaluating functional hearing performance (Jerger, 1970). Additionally, otoacoustic emissions (OAEs) were recorded to objectively evaluate cochlear outer hair cell function, consistent with foundational evidence demonstrating their value in detecting early cochlear changes (Probst *et al*., 1991). The inclusion of OAEs is further supported by neurological findings on noise-induced cochlear vulnerability and long-term auditory damage (Kujawa and Liberman, 2009; Le Prell, 2019; Rabinowitz, 2000). Consideration of tinnitus-related and audiometric threshold interactions also underscores the importance of combined behavioral and physiological testing (Mozzanica *et al*., 2019; Nondahl *et al*., 2010). All procedures adhered strictly to the American Speech-Language-Hearing Association guidelines to ensure reliability and reproducibility (ASHA, 2019). Data were analyzed using SPSS v25.0, with descriptive statistics summarizing participant demographics and audiometric findings. Broader biomedical insights related to otologic health and associated systemic factors additionally support the relevance of comprehensive audiometric evaluation (Mahalakshmi *et al*., 2025; Nafisa Farheen *et al*., 2025).

RESULTS AND DISCUSSION

Analysis revealed that 38% of participants exhibited mild hearing loss, 27% moderate, and 10% severe loss, predominantly affecting high-frequency ranges (4-8 kHz). These distribution patterns are consistent with population-level reports of high-frequency decline described in epidemiological studies of hearing loss (Shargorodsky *et al*., 2010). Air-bone gaps indicated that 15% had conductive components, while the majority demonstrated sensorineural patterns, aligning with established diagnostic frameworks in audiology (Roeser *et al*., 2007). Speech audiometry correlated significantly with pure-tone thresholds, with participants showing reduced speech discrimination scores at higher frequencies, reflecting typical functional deterioration associated with high-frequency deficits (World Health Organization, 2021). OAE results revealed that participants with normal audiograms mostly had intact cochlear function, whereas those with sensorineural hearing loss exhibited absent or reduced otoacoustic emissions, confirming cochlear involvement. These findings are supported by prior investigations demonstrating the diagnostic value of OAEs and ABR in differentiating cochlear from neural dysfunction (Shen *et al*., 2011). The observed patterns also align with earlier research emphasizing the importance of high-frequency audiometry in detecting early stages of age- and noise-related hearing decline (Kumar *et al*., 2018; Smith and Jones, 2020). The study also observed a significant association between prolonged occupational noise exposure and the degree of high-frequency hearing loss, consistent with long-term auditory risk trends described in the literature on noise-induced cochlear changes (World Health Organization, 2021). Similar occupational and environmental effects on biological systems have been discussed in broader bioscience contexts (Ramya *et al*., 2025; Rubala Nancy *et al*., 2025; Sindhuja *et al*., 2025; Swetha *et al*., 2025). Overall, the results highlight that combining multiple audiometric techniques PTA, speech audiometry, and OAEs provides a comprehensive assessment of auditory function, enabling differentiation between conductive, sensorineural, and mixed hearing loss. Such early detection is essential for timely interventions, including hearing aids, cochlear implants, or medical management (World Health Organization, 2021).

CONCLUSION

This study underscores the efficacy of audiometric assessment techniques in evaluating hearing loss across different populations. Pure-tone audiometry, speech audiometry, and otoacoustic emissions collectively offer a thorough understanding of auditory deficits, facilitating accurate diagnosis and management. High-frequency hearing loss was predominant, especially among individuals with occupational noise exposure, emphasizing the need for preventive strategies and routine auditory monitoring. The integration of objective and subjective audiometric assessments ensures comprehensive evaluation, aiding clinicians in formulating personalized treatment plans and improving overall auditory health outcomes.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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AI TOOL DECLARATION

The authors declares that no AI and related tools are used to write the scientific content of this manuscript.

DATA AVAILABILITY

Data will be available on request

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