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Assessment of Hearing in Medical Students with Exposure to Personal Audio Devices

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ABSTRACT
Background: *The prevalence of noise-induced hearing loss (NIHL) among youth is rising, largely attributed to the growing use of personal audio devices (PADs). Unsafe listening behaviors and inadequate awareness contribute significantly to this public health challenge.*
Objectives: *This study aimed to estimate hearing impairment among medical students exposed to PADs, identify high-risk listening patterns, and evaluate knowledge regarding safe practices.*
Methods: *In a cross-sectional survey in a Tertiary Care Centre at Puducherry, 224 third and fourth year students were recruited. Structured questionnaires assessed demographic data, listening habits, device type, duration, and awareness. Pure tone audiometry (PTA) measured hearing thresholds.*
Results: *Over 90% of students demonstrated at least mild sensorineural hearing loss (bone conduction threshold ≥5 dB), with risk elevated in males, senior students, and those with prolonged, high-volume exposure. Most participants (>58%) exceeded recommended daily use. In-ear earphones predominated, while awareness of safe listening standards was poor.*
Conclusions: *The findings reveal an urgent need for routine screening, curriculum-based education, and policy interventions to limit preventable NIHL among young adults.*
Key words: *Noise-induced hearing loss (NIHL), personal audio devices (PADs), Pure tone audiometry (PTA)*

INTRODUCTION:

Recent decades have seen a dramatic increase in hearing-related disorders among young adults, much of which stems from exposure to recreational noise, especially from personal gadgets. The proliferation of PADs, capable of emitting sound intensities exceeding industrial safety standards, has contributed to an unprecedented rise in NIHL.[1,2] Although occupational exposure to loud environments remains a classical risk factor, sustained recreational exposure is equally perilous. The World Health Organization cautions that listening at volumes above 85 dB for extended periods, or using device settings over 60% of maximum, can cause irreversible hearing damage.[3,4]

Safe auditory practices—such as limiting volume to below 60% of maximum and restricting listening time to under an hour daily—have failed to gain traction among youth, resulting in observable hearing threshold shifts and communication difficulties in this population. Multiple studies from Europe, Asia, and North America have documented the harmful consequences of long-term PAD use, highlighting the silent nature of NIHL, often progressing without overt symptoms until it becomes disabling.

Young adults, including medical students, remain at heightened risk due both to heavy device use for academic and recreational purposes and to under appreciation of associated risks. [5]Audiometric studies reveal early sensorineural changes among regular users, even in the absence of clinical complaints. Moreover, this hearing loss influences academic achievements, cognitive processes, and psychological well-being, extending far beyond auditory perception.[6]

Despite increased public health messaging, there is a persistent gap between knowledge and practice. Awareness campaigns, regulatory interventions, and technology design improvements must become priorities to mitigate the present threat to youth hearing health. This study investigates the extent of hearing loss, associated behaviours, and awareness among medical students, contributing essential data for targeted interventions.

MATERIALS AND METHODS

A cross-sectional study was conducted in a Tertiary Care Centre at Puducherry, involving third and fourth year undergraduate medical students. Recruitment of participants was preceded by obtaining institutional

ethical approval (Ref No: 79/SVMCH/IEC-Cert/july.25). Prior to inclusion, each student gave their signed, informed consent.

Participant Selection

Eligible participants were chosen through convenience sampling to reflect a representative distribution of age, gender, and academic year within the institution. Exclusion criteria included a history of conditions predisposing to hearing loss (chronic ear infections, metabolic or hereditary disorders, ototoxic drug use, major childhood infections impacting hearing, previous ear surgery, or hearing amplification device use), so as to isolate the effect of personal audio device (PAD) use on hearing outcomes.

Data Collection Tools

A systematic and validated questionnaire that was based on national and international recommendations was used to collect data. It was reviewed by experts and pilot tested for clarity.. The survey included:

- Demographic details (age, sex, year of study, background)
- PAD usage history (total duration in months/years, frequency per week, average daily listening hours, preferred device type, listening context, usual volume settings)
- Auditory symptoms (tinnitus, muffled hearing, ear fullness)
- Awareness of sound safety guidelines and preventive practices

Audiometric Assessment

Objective hearing evaluation was carried out by pure tone audiometry (PTA) under standardized conditions. Measurements included:

- **Bone Conduction (BC):** Thresholds at 500–4000 Hz, categorized as normal (<5 dB) and abnormal (>10 dB), with >10 dB considered as sensorineural hearing loss.
- **Air Conduction (AC):** Thresholds at 250–8000 Hz, graded as normal (<15 dB), mild loss (15–20 dB), and moderate or higher loss (>20 dB).

STATISTICAL ANALYSIS

Data were compiled and processed using IBM SPSS version 26. Descriptive statistics were used to summarize categorical and continuous variables. Associations between PAD usage characteristics (duration, frequency, daily exposure, device type) and the presence/severity of hearing loss were tested by chi-square analysis, with a significance threshold of $p<0.05$. Statistical analyses were performed to identify relationships across gender, year of study, device preferences, exposure patterns, and awareness level.

RESULTS

The present study included 224 undergraduate medical students with a predominance of young adults aged 20–22 years (67.4%), followed by participants less than 20 years old (18.8%), and a minority in the 23–25 years (12.9%) and above 25 years (0.9%) age categories. The cohort consisted of more females (58.0%) than males (42.0%), with a majority enrolled in the third year of study (65.2%) compared to 34.8% in the fourth year. (Table 1)

Table 1: Socio-demographic Characteristics of Study Participants

Socio-Demographic Characteristics		Frequency (n)	Percentage (%)
Age Category	<20 years	42	18.8
	20-22 years	151	67.4
	23-25 years	29	12.9
	>25 years	2	0.9
Sex	Male	94	42.0
	Female	130	58.0
Year of Study	3rd Year	146	65.2
	4th year	78	34.8
Total		**224**	**100.0**

Personal Audio Device Usage Patterns

Exposure to personal audio devices (PADs) was notable, with 34.8% reporting more than two years of use and another 24.6% having one to two years' history. Additionally, 21.4% of students used devices for six to twelve months and 19.2% for less than six months. In terms of weekly frequency, daily users formed the largest group (37.5%), followed by those listening for one to two days (25%), three to four days (19.6%) and five to six days (17.9%) each week. More than half the students (58.9%) listened for more than two hours daily, while only 41.1% limited their exposure to two hours or less. Nearly three-quarters preferred in-ear earphones over other device types. (Table 2)

Table 2: Personal Audio Device Usage Patterns

Duration of usage of PAD Use		**Frequency**	**Percentage**
In years	<6 months	43	19.2
	6–12 months	48	21.4
	1–2 years	55	24.6
	>2 years	78	34.8
Days per week	1–2	56	25.0
	3–4	44	19.6
	5–6	40	17.9
	Everyday	84	37.5
Hours in day	≤ 2 hrs	92	41.1
	> 2 hrs	132	58.9
Total		**224**	**100.0**

Hearing Loss Grading Based on Audiometry

Pure tone audiometry was used for audiometric examination; the results were alarming. Only 4.5% of right and 7.6% of left ears had bone conduction threshold scores below 5 dB, which is considered normal hearing, whereas 95.5% of right and 92.4% of left ears had scores at or above 5 dB, indicating the existence of sensorineural hearing loss. (Table 3)

Table 3: Distribution of Hearing Loss by Bone Conduction Thresholds

Hearing Loss	**Right Ear (BC) n (%)**	**Left Ear (BC) n (%)**
<5 dB	10 (4.5%)	17 (7.6%)
5-10 dB	210 (93.7 %)	205 (91.5 %)
>10 dB	4 (1.8 %)	2 (0.9 %)
Total	**224(100 %)**	**224(100 %)**

Air conduction thresholds showed 38.8% of right ears and 58.0% of left ears within the normal range (<15 dB), whereas mild hearing loss (15–20 dB) was recorded in 58.9% of right and 39.7% of left ears. Moderate or higher hearing loss (>20 dB) was infrequent, identified in just 2.2% of both right and left

ears. No significant conductive losses or middle ear pathology were detected, hence the alteration in thresholds primarily indicated sensorineural, noise-induced changes. (Table 4)

Table 4: Distribution of Hearing Loss by Air Conduction Thresholds

Hearing Loss	Right Ear (AC) n (%)	Left Ear (AC) n (%)
<15 dB	87 (38.8%)	130 (58.0%)
15-20 dB	132 (58.9%)	89 (39.7%)
> 20 dB	5 (2.2%)	5 (2.2%)
Total	224(100 %)	224(100 %)

Listening Behaviours and Symptoms

Analysis of device-related behaviours revealed that a large majority of students favoured in-ear earphones, accounting for nearly three-quarters of preferred listening devices. The study population predominantly used personal audio devices in academic, recreational, and commuting contexts, selecting settings and environments that often-required increased volume for clarity and immersion. Notably, 26.4% of students reported habitually listening at high average volumes, compounding the risk of threshold shifts due to prolonged and excessive exposure. The listening context, including noisy environments and extended use for study or leisure, further contributed to increased volume settings and potential auditory harm. Despite these widespread practices, the prevalence of self-reported auditory symptoms such as tinnitus, muffled hearing, or ear fullness was relatively low and not found to be a reliable predictor of audiometric hearing loss. Overall, these findings underscore the silent and incremental progression of noise-induced hearing damage in this population, driven by device type, volume habits, and extended use in diverse contexts. (Figure 1-5)

Figure 1: Distribution of Personal Audio Device Types Used by Medical Students

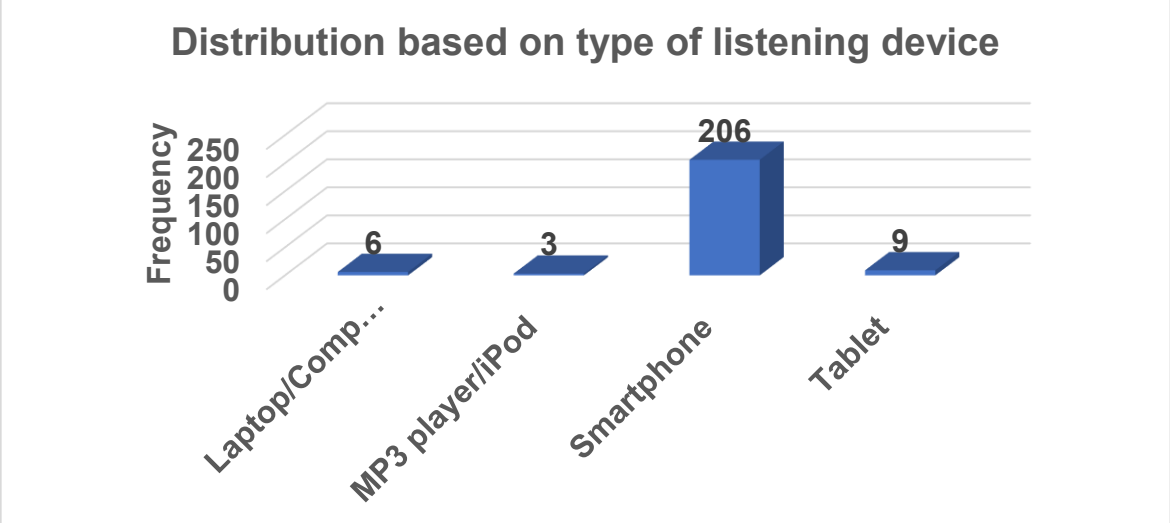

Figure 2: Distribution of study participants based on the type of ear phone

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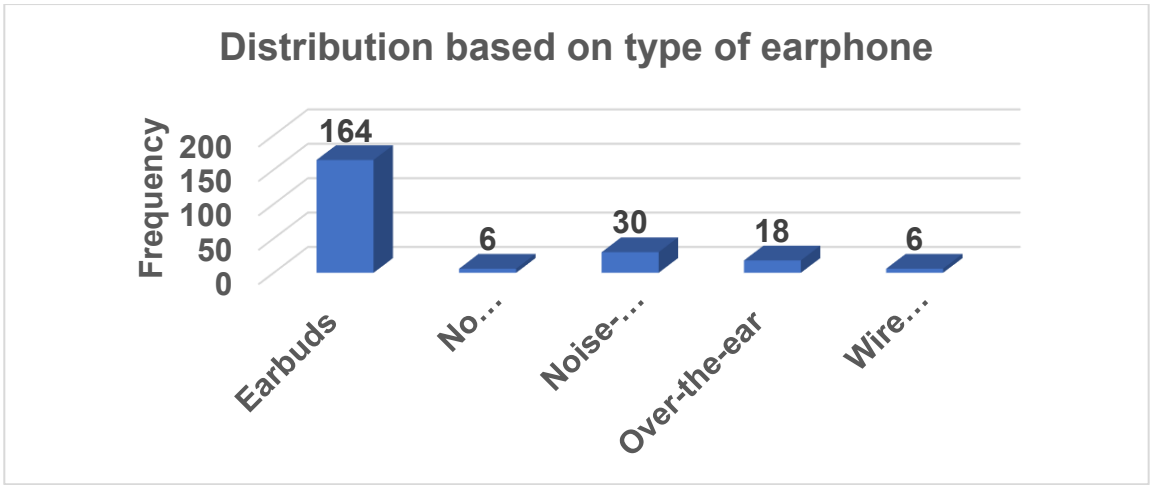


Figure 3: Average Listening Volume Categories among PAD Users

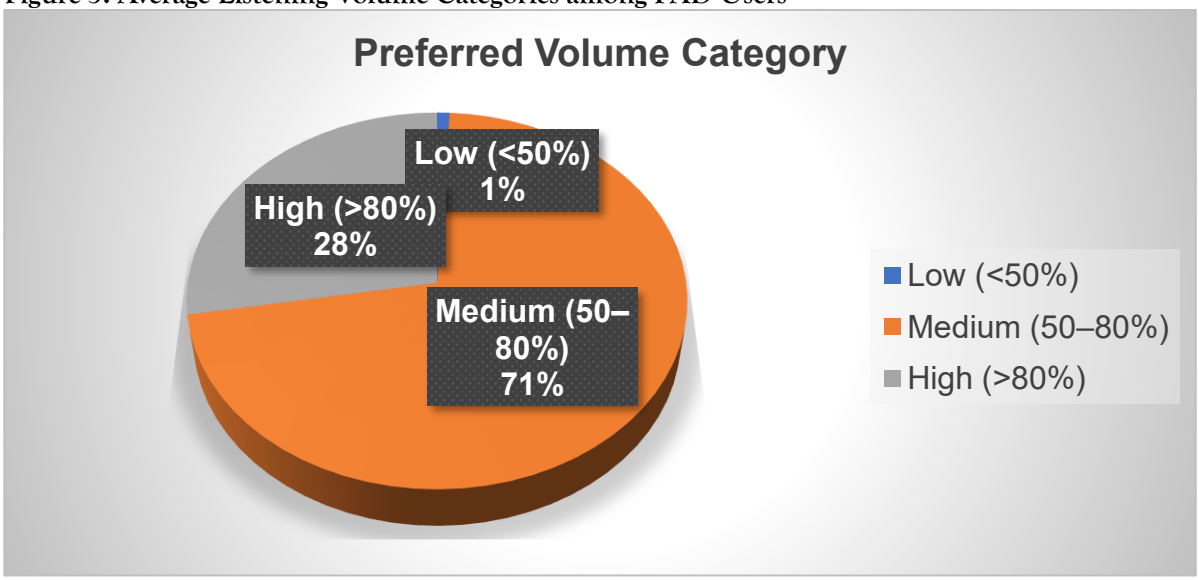


Figure 4: Listening Contexts for Personal Audio Device Use

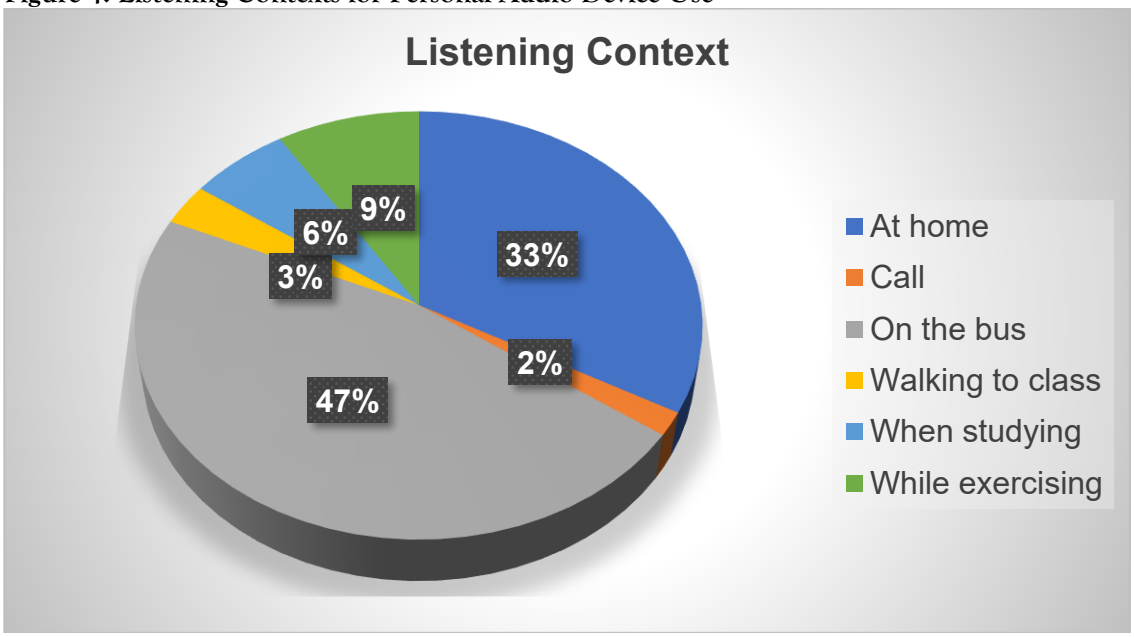
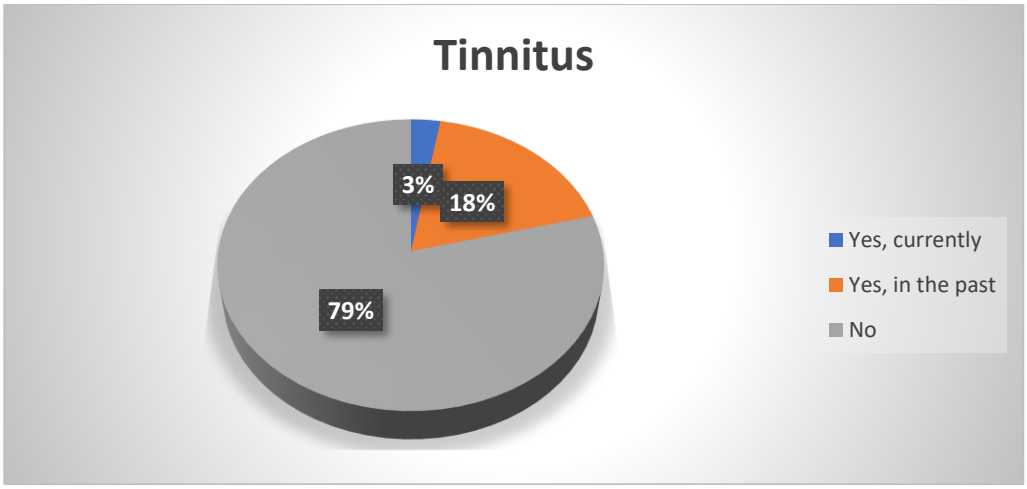


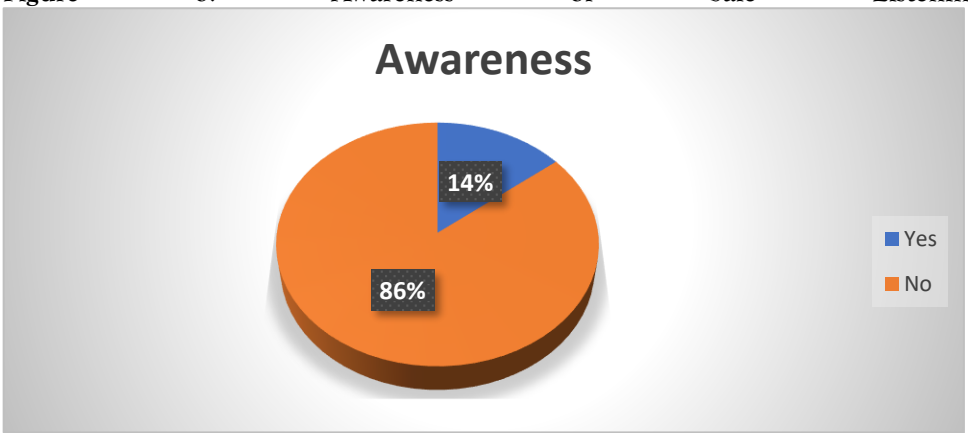
Figure 5: Prevalence of Auditory Symptoms (e.g., Tinnitus) Among Participants



Awareness of Safe Listening Practices

Knowledge regarding safe listening practices was found to be lacking among the study population. Only a small proportion of students were aware of recommended volume or duration guidelines, and few acknowledged protective behaviors such as the use of noise-limiting earphones, volume caps, or regular hearing screening. Such results mirror global literature, emphasizing the urgent need for increased education and advocacy regarding hearing conservation strategies, especially in high-risk youth groups. (Figure 6)

Figure 6: Awareness of Safe Listening Practices



Correlation of Hearing Loss with Exposure and Demographics

Statistical analysis underscored a significant association between increased duration of PAD exposure and greater degree of hearing loss. Bone conduction thresholds at or above 5 dB were significantly more common in students who listened for more than two hours per day, with a corresponding chi-square value showing robust significance ($p<0.05$). Additionally, the advancing academic year and male gender were found to be independent risk factors for higher hearing thresholds. The prevalence of risky listening behaviours, such as high average listening volumes and frequent usage of insert-style earphones, supported previous findings from worldwide studies. On the other hand, the degree of audiometric impairment did not consistently correlate with the existence of symptoms like tinnitus and ear fullness, underscoring the quiet course of noise-induced hearing loss. (Table 5)

Table 5: Association between Right Ear Bone Conduction & Sex, Duration of usage (Hours/Day)

Duration of Usage (Hours/Day)	Bone Conduction ≥5dB	Bone Conduction <5dB	Total	Chi-Square Statistic and p-value
≤2 hrs	72	20	92	8.0089 , 0.0047

>2 hrs	121	11	132	
Total	**193**	**31**	**224**	
Sex	**Bone Conduction <5dB**	**Bone Conduction ≥5dB**	**Total**	**Chi-Square Statistic and p-value**
Female	130	0	130	8.5261 , 0.0035
Male	88	6	100	
Total	**218**	**6**	**224**	

DISCUSSION

The current findings are consistent with studies from around the world regarding recreational noise exposure and NIHL in young people, with medical students showing a notably elevated risk profile. This population is constantly at risk for auditory deterioration since they use devices frequently for commuting, studying, leisure, and lectures. The predominant pattern is sensorineural, with audiometric losses often low to moderate but, crucially, likely to get worse if nothing is done.

The insidious nature of NIHL is reaffirmed: symptoms such as tinnitus and ear fullness are not always accurate markers of true threshold alterations, and students rarely notice hearing impairment until late-stage deficits arise. Interestingly, a number of studies report neurocognitive aftereffects of long-term exposure, with afflicted patients exhibiting deficiencies in social interaction, working memory, speech processing, and even higher neuropsychological function.

According to recent systematic reviews, between 0.67 and 1.35 billion youth globally may be at risk for hearing loss as a result of voluntary, risky recreational listening practices, most frequently brought on by frequenting noisy entertainment venues and using personal listening devices (PLDs). Unsafe listening practices are very common among teenagers and young adults, according to a major meta-analysis by Dillard et al. This highlights the urgent need for regulatory legislation and public health action to address this new issue.[6–9]

The high-risk behaviours seen in our group are supported by a number of research. Similar to our findings, Gajendran et al. discovered that 33% of medical students who used personalized listening devices had high-frequency hearing loss, with a higher prevalence in males and those who had been exposed for longer periods of time and at higher volumes.[10] Additionally, Asghar et al. found that about one-third of medical students had mild sensorineural hearing loss, which was closely associated with long-term use and a preference for insert-style earbuds.[11] Similarly, a study conducted in South India by Rekha et al. revealed that there was a low understanding of NIHL preventative techniques in addition to the high incidence of risky listening behavior.[12]

Extended high-frequency audiometry and hearing threshold analyses have revealed that adverse effects may initially be present at higher frequencies in young PLD users—even those without subjective complaints—indicating subclinical cochlear injury. These subtle early changes can easily progress to noticeable hearing loss with continued exposure.[13]

Both in the current study and in prior research on college students, where mean knowledge scores are low even if attitudes are typically positive toward hearing protection, awareness of the risks of NIHL and best listening techniques is still remarkably low. For example, Kashyap et al. discovered that Indian medical students had high rates of frequent PLD use and dangerous behaviors, with varying patterns of threshold alterations but often lacking commensurate knowledge or preventative measures. The disparity is further highlighted by a poll of college students, which shows that although young adults may support the concept of prevention, few regularly follow safe behaviours. This emphasizes the urgent need for frequent, structured education programs and the inclusion of hearing health in academic curricula.[14,15]

The relationship between volume, duration, and device type with hearing loss is well established. Exposure to sound levels above safe thresholds for extended periods, especially with in-ear or insertable devices, has been shown to produce both temporary and permanent threshold shifts.[1,16] Not all high-risk behaviours consistently result in measurable changes, as highlighted by Kashyap et al., but the overall pattern remains: longer duration, higher volume, and lack of breaks are key predictors of harm.[15]
Tinnitus, muffled hearing, and other symptoms are variably reported—often in only a minority of affected students. Many individuals who fail audiometric screening report no symptoms, further illustrating the insidious and subclinical progression of NIHL in this population, as reinforced by recent reviews.[17]
WHO and CDC policy recommendations supporting routine hearing screening in at-risk populations, daily exposure below 60 minutes, and device volume less than 60% of capacity support this synthesis. Innovative approaches like volume capping, integrated noise-level monitoring, and noise-cancelling technology are desperately required interventions everywhere.[5]
A single-institution sample, reliance on self-reported exposure histories, and the incapacity to assess cumulative environmental risk, genetic vulnerability, or external noise exposure are some of the study's limitations. However, the findings of this study are consistent with multicentric, cross-national research, which validates their validity and emphasizes the urgent need for a multimodal strategy to avoid NIHL.
Future efforts must integrate behavioral interventions, curriculum reform, technology design (e.g., volume cap defaults, duration limits), policy change to mandate institutional screening programs, and broadening awareness efforts aimed not just at students but also at educators and parents.

CONCLUSION

This investigation establishes the alarming prevalence of noise-induced hearing loss in medical students exposed to personal audio devices. Longer duration and higher daily usage, male gender, and increased academic seniority each independently predict higher severity of hearing impairment. A deficit in knowledge regarding safe listening practices and preventive measures underlies this health challenge, demanding urgent and comprehensive intervention.
Proposed solutions encompass routine audiometric screening, embedded health education, device engineering for automatic volume regulation, and the propagation of safe listening campaigns. Institutional and policy-level actions must complement individual behavioral change to stem the rising tide of NIHL among young adults.

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