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Adverse Effects of Mobile Phone Usage on Auditory Thresholds in Healthy Individuals in Dominant Ear v/s Non-Dominant Ear: An Observational Cross-Sectional Study

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Abstract:

- ***Background***

The ubiquitous use of mobile phones and personal listening devices (PLDs) has raised concerns regarding potential long-term risks to auditory health due to combined acoustic and radiofrequency electromagnetic field (RF-EMF) exposure.

- ***Objective***

To evaluate and compare the pure-tone audiometric (PTA) thresholds between the dominant ear (used for mobile phone calls) and the non-dominant ear in healthy, asymptomatic individuals.

- ***Materials and Methods***

An 18-month observational cross-section study was conducted on 600 healthy volunteers aged 20–45 years. Detailed mobile exposure profiles (years of use, daily duration) were recorded. Standard pure-tone audiometry (PTA) was performed across frequencies from 250 Hz to 8000 Hz. The dominant ear served as the exposure group, while the non-dominant ear served as the internal control. Data were analyzed using the Wilcoxon signed-rank test and Spearman's rank correlation.

- ***Results***

The mean age of the cohort was 31.4 +/- 6.2 years. Audiometric thresholds were significantly higher in the dominant ear compared to the non-dominant ear across all tested frequencies ($p < 0.001$). The most pronounced variations were observed at

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higher frequencies: at 4000 Hz (dominant: 22 dB HL vs. non-dominant: 18 dB HL) and 8000 Hz (dominant: 28 dB HL vs. non-dominant: 22 dB HL). Subclinical hearing loss (>20 dB HL) at 8000 Hz was observed in 39.0% of dominant ears compared to 20.2% of non-dominant ears. A significant positive correlation was identified between cumulative years of mobile phone use and high-frequency threshold shifts (rho = 0.322 at 4 kHz, rho = 0.367 at 8 kHz; p < 0.001).

- ***Conclusion***

Prolonged mobile phone usage is strongly associated with an asymmetric, subclinical increase in high-frequency auditory thresholds in the dominant ear. The findings suggest a dose-response relationship, indicating early auditory fatigue and emphasizing the need for preventive public health strategies.

Keywords: *Mobile Phones, Pure-Tone Audiometry, High-Frequency Hearing Loss, Radiofrequency Electromagnetic Fields, Cochlear Basal Turn.*

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I. INTRODUCTION

The global rise in the use of mobile phones and personal listening devices (PLDs) has revolutionized communication and their prolonged and unregulated use has emerged as a significant environmental and public health concern.

The human auditory apparatus is uniquely exposed during mobile phone usage. The ear is subjected not only to direct, localized acoustic sound pressure via earphones or speakers but also to near-field radiofrequency electromagnetic fields (RF-EMFs) emitted by the device hardware. Chronic exposure to these combined stressors has been hypothesized to impact the delicate microscopic structures of the inner ear, particularly the outer hair cells of the cochlea.

Most conventional studies evaluate generalized hearing loss, often missing the subtle asymmetric changes induced by lateralized device habits. Because individuals typically prefer one specific ear for telephonic conversations, an internal comparative model can be established. This study aims to investigate the adverse effects of mobile phone use on hearing by performing a rigorous frequency-by-frequency audiometric comparison between the dominant (exposed) and non-dominant (unexposed/less exposed) ears in healthy, asymptomatic adults.

II. MATERIALS AND METHODS

- Study Design and Setting- This was a hospital-based, prospective observational cross-sectional study conducted over a period of 18 months at the Department of Otorhinolaryngology, Index Medical College, Hospital & Research Centre under Malwanchal University, Indore, Madhya Pradesh, India.

- Participant Selection- A total of 600 healthy volunteers were recruited using a purposive sampling strategy.
  - Inclusion Criteria: Asymptomatic individuals aged 20 to 45 years with a history of regular mobile phone, headphone or earphone usage.
  - Exclusion Criteria: Individuals presenting with a history of ear discharge, active middle/inner ear pathology, recent upper respiratory tract infections (URTI), history of acoustic trauma, occupational noise exposure, systemic metabolic diseases (e.g., diabetes mellitus), or prior administration of ototoxic medications.

- Data Collection and Handedness/Laterality Assessment- Demographic profiles, clinical history, and detailed mobile usage habits—including the total duration of device ownership (years) and average daily use (hours)—were systematically documented. The "dominant ear" was strictly defined as the side exclusively or preferentially used by the participant to hold a mobile phone during active voice calls.

- Audiometric Evaluation- All participants underwent a comprehensive otoscopic examination to rule out impacted cerumen, tympanic membrane abnormalities, or structural pathology. Standard pure-tone audiometry (PTA) was performed in a soundproof, acoustically treated audiology booth. Air conduction and bone conduction thresholds were measured across standard frequencies: 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, and 8000 Hz. Subclinical hearing loss was defined as an auditory threshold exceeding 20 dB HL in an otherwise asymptomatic individual.

III. STATISTICAL ANALYSIS

Data was tabulated and analyzed using standard statistical software. Continuous variables were expressed as Mean Standard Deviation (SD). Because auditory thresholds often present a non-parametric distribution, the Wilcoxon signed-rank test was utilized to compare the paired thresholds between the dominant and non-dominant ears of the same participant. Spearman's rank correlation coefficient (rho) was computed to

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assess the relationship between device exposure metrics (years of use) and threshold shifts. Statistical significance was established at $p < 0.05$.

IV. RESULTS

Demographic and Exposure Profiles- The study evaluated 600 healthy volunteers. The mean age of the study cohort was 31.4 +/- 6.2 years, spanning a distribution from 20 to 45 years. Lateral preference for telephonic calls was heavily skewed to the right side, with 470 participants (78.3%) identifying as right-ear dominant and 130 participants (21.7%) as left-ear dominant. The cohort exhibited a mean duration of mobile device usage of 6.3 +/- 1 years, with an average daily conversation/listening time of 2.8 +/- 0.9 hours.

Comparison of Audiometric Thresholds- A frequency-by-frequency comparative analysis of mean pure-tone thresholds revealed a consistent, statistically significant elevation in the thresholds of the dominant ear compared to the non-dominant ear ($p < 0.001$). While low-to-mid frequency thresholds remained well within the standard physiological limits, noticeable changes were detected starting at 1000 Hz, widening significantly into the higher frequencies.

Table 1 Mean Pure-Tone Audiometric Thresholds Between Dominant and Non-Dominant Ears (N=600)

Frequency (Hz)	Dominant Ear Mean Threshold (dB HL)	Non-Dominant Ear Mean Threshold (dB HL)	Wilcoxon Test Significance (p-value)
250 Hz	12	10	<0.001
500 Hz	12	10	<0.001
1000 Hz	15	12	<0.001
2000 Hz	18	15	<0.001
4000 Hz	22	18	<0.001 (Z = -8.534)
8000 Hz	28	22	<0.001 (Z = -9.173)

Correlation with Duration of Exposure- Spearman's rank correlation analysis established a clear dose-response relationship. The total duration of mobile phone usage (years) shared a significant positive correlation with the elevation of high-frequency thresholds in the dominant ear:

- At 4000 Hz: rho = 0.322, $p < 0.001$
- At 8000 Hz: rho = 0.367, $p < 0.001$

V. DISCUSSION

The findings of this cross-sectional study demonstrate that chronic, lateralized exposure to mobile phones is associated with a statistically significant, subclinical increase in pure-tone auditory thresholds. The unique design of this study, utilizing each patient's non-dominant ear as an internal control, minimizes confounding genetic, metabolic, and socioeconomic factors, highlighting mobile phone exposure as a primary variable.

The data reveal that high frequencies (4000 Hz and 8000 Hz) are selectively vulnerable to device-related injury. From an anatomical and physiological perspective, this pattern aligns with the tonotopic organization of the cochlea. High-frequency sounds are processed at the basal turn of the cochlea, a region uniquely susceptible to environmental, acoustic, and metabolic trauma.

Two primary pathophysiological mechanisms are proposed to explain this localized damage:

- Acoustic Overstimulation: The direct delivery of acoustic energy into the external auditory canal via earphones or phone speakers over extended periods induces continuous mechanical stress on the organ of Corti. This continuous stimulation can result in microvascular ischemia and chronic outer hair cell exhaustion.
- Radiofrequency Electromagnetic Field (RF-EMF) Toxicity: Mobile devices emit near-field RF-EMF radiation that is readily absorbed by nearby tissues, including the temporal bone and inner ear structures. Literature suggests that RF-EMFs can induce non-thermal oxidative stress, prompting the overproduction of reactive oxygen species (ROS) within the cochlear fluid, leading to accelerated cellular apoptosis of the outer hair cells.

The significant correlation (rho) between years of mobile usage and threshold shifts further confirms a cumulative dose-response relationship. While most participants remain clinically "asymptomatic" and within functional communication ranges,

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these shifts represent early auditory fatigue. Left unmanaged, this progressive subclinical degradation may cross the threshold into permanent, clinically symptomatic sensorineural hearing loss (SNHL).

VI. CONCLUSION

This study demonstrates a clear association between long-term mobile phone usage and elevated auditory thresholds in healthy individuals. The significant degradation observed at 4000 Hz and 8000 Hz in the dominant ear points to early, localized damage within the basal turn of the cochlea, directly correlating with the duration and intensity of device use.

RECOMMENDATIONS

Based on these findings, we recommend the following measures to preserve public auditory health:

- Clinical Integration: Otolaryngologists should routinely incorporate detailed mobile devices and headphone history into standard clinical protocols. Annual pure-tone audiometry screenings should be recommended for heavy users (individuals exceeding 2 hours of daily use) to catch early subclinical shifts.
- Preventive User Habits: Public education should emphasize preventive strategies, such as adopting the 60:60 rule (limiting listening to 60 minutes at less than 60% of maximum volume), utilizing hand-free speaker modes, and alternating ears during extended voice calls.
- Public Health Frameworks: Policymakers should introduce occupational and public health guidelines to raise awareness about safe listening habits and the potential long-term risks of unregulated personal audio devices.

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