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Medical students and mobile phones: a cross-sectional study on auditory health

Regin William¹, Valli Rajasekaran^{1*} and Gowtham Kulothungan¹

Abstract

Objective The main aim of our study was to identify the effect of prolonged mobile phone usage on hearing status and to correlate the duration of mobile phone usage with hearing status.

Methodology A total of 140 medical students aged 18–30, who had been using mobile phones for more than 5 years, were included in the study. Participants had no preexisting ear disease, systemic illness, or frequent exposure to loud noise. Basic sociodemographic details were recorded, including the average duration of phone use (screen/call), Specific Absorption Rate (SAR) values, and phone network. Handedness was noted to identify exposed and non-exposed ears, followed by a thorough ENT examination. Hearing status was assessed using Pure Tone Audiometry (PTA) and Brainstem Evoked Response Audiometry (BERA).

Result Among the 140 subjects, 71 were males and 69 were females, with a mean age of 23 years. Most participants (138) were right-handed. The average call duration was 21 min/day. Notably, 28% of the students used mobile phones on calls for more than 30 min/day, and 58% of these students experienced mild hearing loss in the exposed ear (5–10 dB). BERA results were in coherence with the audiometry findings.

Conclusion We conclude that mobile phone usage on call > 30 min/ day was associated with mild hearing loss. In conclusion, students should be educated about safe hearing practices to prevent hearing loss.

Keywords Hearing loss, Smartphone, Mobile phone, Radiofrequency, BERA

Introduction

Hearing is a vital sense, involving a complex process that begins before birth. Embryologically, the human ear is fully formed before birth, enabling the foetus to respond to loud sounds [1]. However, hearing tends to diminish with age and can be further impacted by regular exposure to environmental factors like television noise, traffic, and industrial sounds.

Loud noise is defined as any unwanted or unpleasant sound. Although hearing loss is a natural part of aging, it is increasingly common among younger populations due

to the frequent use of mobile phones and earphones [2]. Mobile phones have become an essential part of modern life. In India, mobile phone usage reached approximately 820 million in 2022, placing the country second worldwide, after China [3, 4].

With advancements in technology, the prevalence of wireless networks with high-speed internet has grown, making mobile phones ubiquitous in airports, schools, and homes. Mobile phones, as low-power radio devices, transmit and receive radiofrequency (RF) radiation. Increased exposure to RF fields through wireless technology can pose various health risks. The radiation spectrum extends to near-infrared and microwaves, with frequencies ranging from 300 MHz to 300 GHz [5, 6].

Mobile phones operate on frequencies between 500 and 2700 MHz and are low-power radio transmitters with peak outputs ranging from 0.1 to 2 watts [7]. These devices emit electromagnetic radiation that can have

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both thermal and non-thermal effects on exposed tissues. The auditory system's outer cochlear cells, which are vulnerable to various chemicals, are particularly susceptible to irreversible damage due to this radiation [8, 9]. Consequently, the ear is often exposed to noise and electromagnetic waves emitted by phones.

Health problems from the thermal effects of electromagnetic radiation include headaches, dizziness, decreased concentration, and hypertension. Excessive mobile phone use has also been linked to cancers such as brain tumours, lymphoma, and acoustic neuroma [10–12]. The International Agency for Research on Cancer has classified mobile phone radiation as potentially harmful to humans [13]. Chronic use of mobile phones may also disrupt sleep, trigger epileptic seizures, and contribute to Alzheimer's disease [14, 15]. The World Health Organization (WHO) is particularly concerned about the health hazards of mobile phone usage in developing countries.

Medical students, who heavily rely on mobile phones for communication and educational purposes, should be aware of these risks and take preventive measures such as moderating volume levels, taking regular breaks, and using hands-free options to mitigate potential hearing damage [16, 17]. This study aims to assess the impact of prolonged mobile phone use on hearing status among medical students.

Methods

This cross-sectional study was conducted over 18 months at a tertiary care centre, focusing on medical students who had been using mobile phones for more than 5 years. The sample size was calculated based on a previous study [3], with the required number determined to be 140 participants, selected using simple random sampling.

Inclusion criteria were medical students aged 18–30 years who had used mobile phones for more than 5 years and were users of 2G, 3G, 4G, or 5G phones. Exclusion criteria included students who did not consent, had pre-existing hearing impairment, were taking ototoxic drugs, had systemic illnesses like diabetes or hypertension, had a family history of hearing loss, were exposed to sudden loud noises or chronic noise, regularly used headphones, or had middle ear disease or pre-existing ear conditions.

After receiving clearance from the institutional ethics committee, students who met the inclusion and exclusion criteria and gave informed consent were included in the study. The students were first screened with questions on basic sociodemographic details, audiological and non-audiological symptoms if any, followed by a thorough clinical examination. Impedance audiometry confirmed normal middle ear status.

Basic sociodemographic details and the average duration of mobile phone use were recorded. Students were asked which ear they used for phone calls, identifying the exposed and unexposed ears. A cutoff of 2 h/day of mobile phone usage was used to compare hearing thresholds between exposed and non-exposed ears.

Hearing was assessed using a 512 Hz tuning fork test and Pure Tone Audiometry, which measured hearing thresholds for air and bone conduction from 250 to 8000 Hz. A pure tone average was calculated at 500, 1000, and 2000 Hz. BERA was performed to evaluate hearing thresholds and diagnose retro-cochlear lesions.

Data and statistical analysis

The hearing thresholds was identified across all frequencies for both air conduction and bone conduction. The hearing threshold between the exposed and non-exposed ears was compared. The hearing threshold was compared based on the duration of mobile phone use.

The collected data was analysed using SPSS (Statistical Package for Social Sciences). The latency for waves I, III, and V and the interaural latency in BERA were compared. The mean hearing threshold in both ears for air conduction and bone conduction were identified for various frequencies.

The hearing threshold was compared based on the duration of mobile phone usage. The hearing threshold was compared between the exposed and the non-exposed ear. Statistical significance was taken at a 95% confidence interval and $P < 0.05$ was taken as significant.

Result

Out of 140 subjects in our study, 71 were males & 69 were females. The mean age was 23 years. There were 138 right-handed & 2 left-handed subjects. The average duration in minutes on call was 21 min/day. The average hearing threshold for the right ear: is 17 dB & left ear is 16 dB.

We observed that 30% of the students used mobile phones for over 30 min per day on calls for 5 years, with 58% among the 30% experiencing mild hearing loss in exposed ears (Fig. 1). BERA results were in coherence with the audiometry findings.

Additionally, comparison of the Pure Tone Average (Global real digital audiometer was used to check PTA) between the right and left sides with the duration of mobile phone use among the medical student participants revealed a statistically significant change on the right side (Table 1).

All Participants using mobile phones for more than 30 min daily on calls for over 5 years showed Statistically significant hearing threshold differences at 4 kHz (10–15 dB loss) in pure tone audiometry for both air and bone

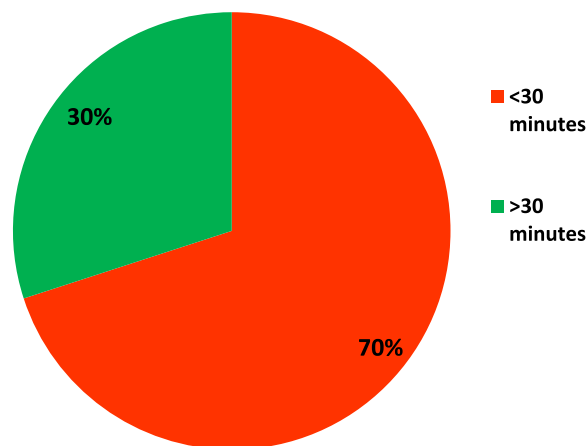


Fig. 1 Frequency distribution of duration of mobile phone per day on call usage among the medical student participants

Table 1 Comparison of Pure tone Average right and left side and duration of mobile used among the medical student participants

Pure tone audiometry	< 30 min N (%) N=98	> 30 min N (%) N=42	Total N (%) N=140	X ² - Value	p - value
Right side					
Normal	97 (99.0)	24 (57.1)	121 (86.4)	43.871	0.000***
Mild	01 (05.3)	18 (42.9)	19 (13.6)		
Left Side					
Normal	97 (99.0)	40 (95.2)	137 (97.9)	1.963	0.161 (ns)
Mild	01 (05.3)	02 (04.8)	03 (02.1)		

Table 2 Comparison of air conduction by Pure tone audiometry between right and left ear among the study participants

Air conduction different decibel	Right ear Mean $\pm$ SD N=140	Left ear Mean $\pm$ SD N=140	t value	p value
250 K	21.58 $\pm$ 8.87	20.68 $\pm$ 8.95	0.845	0.399 (ns)
500 K	14.20 $\pm$ 6.35	14.35 $\pm$ 5.87	0.364	0.952 (ns)
1000 K	15.20 $\pm$ 6.76	14.99 $\pm$ 3.43	0.999	0.105 (ns)
2000 K	18.63 $\pm$ 14.07	18.99 $\pm$ 13.50	0.652	0.112 (ns)
4000 K	20.63 $\pm$ 6.24	24.15 $\pm$ 7.10	-4.038	0.000***
8000 K	18.55 $\pm$ 6.424	18.1 $\pm$ 7.80	-6.939	0.152 (ns)
Pure tone Average	17.37 $\pm$ 5.67	16.40 $\pm$ 4.66	1.564	0.119 (ns)

conduction (Tables 2 and 3). Comparison was done using student t test.

BERA (labat-etic plus) at 40 decibels, there was a significant delay and reduction in amplitude of wave I and alteration in interpeak latency from I to III waves in the right ear for students using mobile phones for more

Table 3 Comparison of bone conduction by Pure tone audiometry between right and left ear in the study population

Bone conduction different decibel	Right ear Mean $\pm$ SD N=140	Left ear Mean $\pm$ SD N=140	t value	p value
250 K	19.64 $\pm$ 6.73	17.83 $\pm$ 8.41	1.983	0.048*
500 K	19.64 $\pm$ 5.83	18.96 $\pm$ 6.47	0.921	0.358 (ns)
1000 K	19.35 $\pm$ 5.74	18.53 $\pm$ 6.50	1.120	0.264 (ns)
2000 K	18.96 $\pm$ 5.73	18.28 $\pm$ 6.22	0.948	0.344 (ns)
4000 K	19.88 $\pm$ 5.53	22.26 $\pm$ 8.35	-2.808	0.005***
8000 K	25.19 $\pm$ 13.50	23.55 $\pm$ 9.15	1.177	0.240 (ns)
Pure tone Average	19.53 $\pm$ 6.05	18.60 $\pm$ 6.29	1.257	0.210 (ns)
Air Bone Gap	7.23 $\pm$ 4.30	7.64 $\pm$ 2.45	-9.72	0.332 (ns)

Table 4 Comparison of BERA value at 40 decibels between the 2 groups based on the duration of mobile phone usage

BERA (40 decibel)	< 30 min Mean $\pm$ SD N=98	> 30 min Mean $\pm$ SD N=42	t- Value	p - value
Right side (Inter peak latency)				
I – III	1.96 $\pm$ 0.310	2.27 $\pm$ 0.38	- 4.919	0.000***
III – V	2.06 $\pm$ 2.22	2.06 $\pm$ 0.23	-	1.000 (ns)
I – V	3.99 $\pm$ 0.32	4.01 $\pm$ 0.24	-0.418	0.677 (ns)
Left side (Inter peak latency)				
I – III	1.87 $\pm$ 0.30	1.93 $\pm$ 0.38	-1.126	0.262 (ns)
III – V	2.08 $\pm$ 0.26	2.04 $\pm$ 0.26	0.820	0.413 (ns)
I – V	4.07 $\pm$ 0.31	4.06 $\pm$ 0.24	0.195	0.846 (ns)
Inter Aural Latency VWave Peak				
Right	5.30 $\pm$ 0.17	5.32 $\pm$ 0.155	-0.587	0.557 (ns)
Left	5.25 $\pm$ 0.17	5.25 $\pm$ 0.165	0.065	0.948 (ns)
Right – Left difference	0.14 $\pm$ 0.08	0.171 $\pm$ 0.96	-1.419	0.158 (ns)

than 30 min per day compared to those with lesser usage (Table 4). Comparison was made using Student t test.

Discussion

Age and gender distribution of mobile phone users

In our study, 84.3% of medical students were under the age of 25, while 15.7% were between 26 and 30 years old. Mobile phone usage was slightly more common among males (50.7%) than females (49.3%). Prajapati et al. [18] reported a mean age of 26.17 ± 2.65 years among their subjects, compared to 26 ± 3.93 years in their control group. Hegde et al. [19] found that their participants ranged from 18 to 30 years old, with a mean age of 26 years. Velayutham et al. [20] conducted a study with 100 subjects where 53% were males and

47% were females, with a mean age of 27 years. Shayani Nasab et al. [21] did a study on 200 subjects, including 100 mobile phone users (80% male, 20% female) and 100 non-mobile users (70% male, 30% female), with a mean age of 28 ± 5.5 years.

Preferred ear for mobile usage

Our study found that 98.6% of medical students preferred using their right ear for mobile phone calls, while only 1.4% used their left ear. Velayutham et al. [20] observed that 63% of subjects preferred their right ear, and 22% used their left ear more frequently. Karthikeyan et al. [3] noted that 80% of participants used their right ear, while 8% preferred their left ear.

Mobile phone exposure

In our study, the average duration in minutes on call was 21/day. We found that 28% of the students had been using their phones for calls for more than 30 min a day for the previous five years and that 58% of them had mild hearing loss in pure tone average (5-10 dB) in their exposed ears. Shayani Nasab et al. [21] conducted a similar study where they found out the duration in using the mobile sets was from one year to five years with daily use from 10 to 50 min on a call. Velayutham et al. [20] conducted which showed the Duration of usage of mobile phones ranged from 5 to 80 min per day. Panda [22] conducted a retrospective, cross-sectional, randomized, case-control study where the mean average usage of mobile phone was 35 min. In a study conducted by Patel [23] the mean usage of mobile phones for the study group was 106.0 ± 40.73 min and for the control group was 9.33 ± 3.65 min.

The duration of mobile phone use was highly variable in various studies probably due to the inclusion of different groups of people as study populations.

Type of mobile phone and network used

Our study, we noted that the 42.9% of the medical students used Samsung model type mobile phones, 37.9% used iPhone model, 15.7% used one plus model, 2.1% used pixel model, 0.7% of the students used vivo and Poco model mobile phones. 75% of our participants used 5G network, 24.3% used 4G network and 0.7% used 3G network.

The comparison of type of Mobile used and specific absorption rate value of the devices among the medical student participants in our study showed that for iPhone SAR was 1.1280 ± 0.14 W/kg, for Samsung was 1.239 ± 0.161 W/kg, one plus was 1.271 ± 0.163 W/kg and others was 1.220 ± 0.286 W/kg.

In our study, we found that the specific absorption rate (SAR) values of the mobile phones used by the subjects

were within the normal limits set by international safety guidelines. This indicates that while the SAR values were within acceptable limits, prolonged usage still posed a risk to hearing health, as evidenced by the mild hearing loss identified in medical students using their phones for extended periods. Therefore, adherence to safety standards for SAR values does not fully mitigate the potential auditory risks associated with prolonged mobile phone usage.

Mobile usage and hearing loss

In our study, we compared Pure tone average of the right and left side and the duration of mobile used among the medical student participants.

The pure tone average on the right ear was 17 dB and the left ear was 16 dB. We also found that on the right side, there was an increased threshold of hearing by 5–10 dB for those students who used mobile phone on call for more than 30 min compared to students who used mobile phone for less than 30 min. The comparison of Air conduction and bone conduction hearing thresholds determined by Pure tone audiometry between right and left ear for (250 k, 500 k, 1 k, 2 k, 4 k and 8 k) in the study participants showed statistical significance at 4 k (15 dB) for those who used mobile phone for more than 30 min per day on call.

Similarly, comparison of BERA value at 40 decibels on both sides and duration of mobile used showed a reduction in amplitude and delay for wave I for students with hearing loss compared with other students. The comparison was statistically significant than for other waveforms.

Shayani Nasab et al. [21] conducted a study where Pure tone threshold of all subjects were in the normal range but there was a significant difference between mean pure tone threshold of users and non-users, $+0.12 \pm 5.93$ dB and -3 ± 4.73 dB, respectively. Duration of use was also related to threshold changes. This study revealed showed that usage of mobile may cause increase of the pure tone threshold. According to study by Prajapati et al. [18], mean hearing loss at high frequencies (4 k, 8 k) was 8.47 ± 4.15 dB, whereas the control groups was 0.33 ± 1.826 dB. This difference was statistically significant.

Velayutham et al. conducted a study [20] and discovered a statistically significant mild hearing loss in high frequency (10-15 dB in 4 k and 8 k).

Hegde et al. [19] conducted a study found that in those using phones for 2–3 h daily, had hearing loss of 5 dB in 10%, 10 dB in 3.3%, and 15 dB in 1.6% were noted. Also hearing loss of 5 dB in 6.6% and 10 dB in 3.3% were noted in those using 3–4 h daily. Sensorineural hearing loss was seen in 26.6% of the subjects in study group and 3.3% in control group.

Callejo and Santamaria [24] did a study comparing hearing threshold at the beginning of the use and after 3 years of usage. The audiometric curve was similar in cases and controls at the beginning of the study. After this follow-up, cases showed an increase in hearing threshold between 1-5 dB HL after 3 years of usage ($p < 0.001$).

Oktaý and Dasdg [25] conducted a study with three groups: 20 men who used a cell phone for about 2 h per day for four years, 20 men who used it for 10–20 min daily for the same period, and 20 men who never used a cell phone (control group). They found that those using the phone for 2 h daily had higher detection thresholds compared to moderate users and controls. Significant differences were noted at 4000 Hz for both bone and air conduction in the right ear, and at 500 Hz and 4000 Hz for the left ear. This indicates a higher degree of hearing loss associated with long-term exposure to electromagnetic fields from cell phones.

Our study also revealed significant differences in pure tone audiometry results between the right and left ears at 4000 Hz, suggesting that high-frequency hearing loss is more pronounced. This finding aligns with Kumar et al. [26] who observed greater hearing loss at higher frequencies in individuals with mild hearing impairment. Similarly, Sullivan et al. [27] and Zhao et al. [28] found that high-frequency hearing loss is a sensitive indicator of early impairment.

Long-term mobile phone use (over 5 years) can lead to mild hearing loss. Studies indicate that prolonged exposure to mobile phone radiation can damage cochlear hair cells, gradually reducing hearing sensitivity. A 2019 study published in the *International Journal of Epidemiology* found that adults using mobile phones for over 5 years had a higher risk of hearing loss, especially in the high-frequency range (2000–8000 Hz). However, a large-scale prospective cohort study by Auvinen et al. [29] found no significant association between mobile phone usage and hearing loss. The absence of hearing loss in their study could be attributed to the use of operator recorded call data at a single time point rather than continuous monitoring over years. Moreover, they relied on self reported hearing loss instead of objective audiometric assessments like Pure Tone Audiometry or BERA, possibly underestimating subtle auditory damage. The cohort also included a broad adult population with varying mobile phone usage patterns, unlike our focused group of medical students with consistent and prolonged daily use over several years.

Comparing our findings with previous research, we conclude that extended exposure to electromagnetic fields from cell phones is linked to greater hearing loss. However, results vary across studies. While some have shown a clear association between prolonged mobile

phone use and hearing impairment, others report minimal impact. This discrepancy suggests that individual susceptibility, phone usage patterns, and study methodologies might influence outcomes, highlighting the complexity of establishing a definitive link.

Our study faced several limitations. Self-reporting bias might have affected the accuracy of mobile phone usage and hearing issue data, as participants could have underreported or overreported their usage and symptoms. The absence of a control group made it challenging to directly attribute hearing issues to mobile phone use, as comparisons with less frequent users were not made. Variability in phone use, such as differences in volume levels and types of earphones or headphones, was not controlled, potentially introducing variability. Additionally, exposure to other noise sources, like social environments and other electronic devices, could have influenced hearing, complicating the isolation of mobile phone effects. Cross-sectional data provided a snapshot in time but did not track changes in hearing over time.

Future research should explore the risks associated with mobile phone use and establish user guidelines. Longitudinal studies could offer insights into the long-term impacts by tracking hearing health over several years. Investigating how age-related hearing changes interact with mobile phone usage would also be valuable. Larger and more diverse sample sizes, including multi-centre studies, could enhance the applicability of results across different geographic and cultural contexts.

Conclusion

Our study, conducted among 140 medical students using mobile phones for more than 5 years, revealed several key findings. The mean age of participants was 23 years, with a gender distribution of 51% males and 49% females. The average duration of mobile phone use for calls was 21 min, with the most commonly used model being a Samsung type with 5G. Notably, iPhones were found to have higher specific absorption rate (SAR) values, though the SAR values of the devices were within normal safety limits.

Among the 140 students, 42 used their mobile phones for calls exceeding 30 min daily, with 58% of these individuals experiencing mild hearing loss (5-10 dB) in the exposed ears. There was a significant increase in hearing threshold in pure tone audiometry at 4 k Hz for participants using mobile phones for more than 30 min daily over 5 years.

Additionally, BERA results showed a significant delay in wave I for students who used mobile phones for more than 30 min with mild hearing loss and alterations in interpeak latency from waves I to III. These findings underscore the importance of educating medical

students about safe hearing practices to mitigate the risk of hearing loss.

Abbreviations

BERA	Brainstem Evoked Response Audiometry
HL	Hearing Loss
PTA	Pure tone audiometry
RF	Radiofrequency
SPSS	Statistical Package for Social Sciences
WHO	The World Health Organization

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Authors' contributions

Dr. Regin William Author designed the study, conducted the data collection, performed statistical analysis, and drafted the manuscript. He is responsible for the primary research, data interpretation, and initial manuscript writing. Dr. Valli Rajasekaran- corresponding author conceived the idea, refined the study design, supervised the research process, provided critical revisions to the manuscript, and guided the interpretation of results. As the corresponding author, she ensured the accuracy and integrity of the work, as well as managed the manuscript submission process. Dr. K. Gowtham- Co-author Contributed to the study design, provided guidance on statistical analysis, and critically revised the manuscript for important intellectual content. He also contributed to the overall conceptualization of the research.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study has been done after obtaining approval from the Institutional ethical committee. (IEC NO:2022/738). Informed written consent was obtained from all the participants.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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