

**ORIGINAL RESEARCH**

# The Relationship Between Prolonged Mobile Phone Usage and Auditory Well-being: An Examination of High-Frequency Hearing Sensitivity

<sup>1</sup>Dr. Ankit Kumar Tiwari, <sup>2</sup>Dr. Surendra Singh Moupachi

<sup>1</sup>Senior Resident, <sup>2</sup>Head of Department, Department of ENT, Shyam Shah Medical College, Rewa, MP, India

**Corresponding author**

Dr. Surendra Singh Moupachi

Head of Department, Department of ENT, Shyam Shah Medical College, Rewa, MP, India

Received: 22 June, 2023

Accepted: 25 July, 2023

**ABSTRACT**

This study endeavors to meticulously examine the phenomenon of high-frequency hearing loss, specifically frequencies above 8 kHz, within the demographic of prolonged mobile phone users in a tertiary Referral Center. Potential single blinded study. This is the first study that has used high-frequency audiometry. The extensive utilization of mobile phones has reached such a significant magnitude that our endeavor to identify an adequate number of individuals who do not use mobile phones for comparison purposes, as a control group, has proven to be unfeasible. Therefore we did the comparison between the non-dominant ear & the dominant ear using audiometric measurements. The study was a blinded study where in the audiologist was not aware about the dominant ear. A total of 200 subjects were studied. Of the subjects studied 56% were males and 44% females. Mean age was 22. The left ear was dominant in 65%, 21% were dominant in the right ear and 14% did not have a preference. This study has demonstrated a noteworthy disparity in hearing loss between the ear considered dominant and the ear considered non-dominant ( $P < 0.05$ ). Prolonged mobile phone usage has unveiled instances of high-frequency hearing loss in the ear identified as dominant. (mobile phone used) compared to the non dominant ear.

**Keywords:** Mobile phones, Electromagnetic radiation, High frequency hearing loss, Dominant ear

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-Non Commercial-Share Alike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**INTRODUCTION**

Mobile telephones have been accessible since 1983, and their utilization has proliferated extensively and swiftly. In 2007, it was estimated that there were more than 2.25 billion mobile phone users in the world, with an expected rise of 92% to 8 billion people by 2012.

Mobile phones transmit and receive signals utilizing electromagnetic fields within the radiofrequency band. Presently, the Global System for Mobile Communications (GSM) stands as the preeminent digital mobile phone service, functioning within frequency bands ranging from 900 to 1,800 MHz [1]. Despite the emitted electromagnetic radiation falling within permissible limits, regrettably, there exists an absence of comprehensive data regarding its prolonged impact. The potential for electromagnetic radiation to exert an accumulative influence and thereby contribute to cellular damage is indeed a thought that warrants serious consideration. The ear, particularly the inner ear, not only holds the

closest proximity to the mobile phone but also directly receives the electromagnetic radiation, thereby rendering it the organ most susceptible to potential impact. The fragile hair cells within the organ of Corti lack regenerative capabilities, leading to instances of enduring damage that tends to be irreversible, particularly in more progressed stages. Hair cells are acknowledged to be responsive to chronic exposure to elevated levels of noise.

Consequently, the ear remains susceptible to both the noise emanating from the mobile phone and the electromagnetic radiation waves emitted by the device.

Numerous studies have been undertaken to evaluate the impact of mobile phones on auditory function [2–8]. Additionally, a case report has documented instances of hearing loss subsequent to mobile phone usage [9]. Furthermore, a study has proposed a correlation between mobile phone use and hearing loss, substantiated through assessments encompassing Otoacoustic Emissions (OAE), audiometry, and

Brainstem Evoked Response Audiometry (BERA) [10–12]. A short exposure time to mobile phones has no effect on OAE[12]. Nonetheless, none of these studies have examined the occurrence of hearing loss within the higher frequency range (above 8 kHz), a domain that extends beyond the confines of the standard audiogram assessment. Hence, this pilot study serves as a preliminary investigation aimed at evaluating not only the repercussions of mobile phone usage on frequencies spanning from 8 to 16 kHz within a diverse societal context but also the influence of usage duration, quantified in terms of minutes per day and years of mobile phone engagement.

## METHODS AND MATERIALS

This study was done in a tertiary referral center. Healthy, volunteers, are between the ages of 22 and 45 who have been using mobile phones for at least a year were included in the study. We were unable to find non mobile users as controls thus, as almost all of the subjects were using the mobile phone on only one ear (the dominant ear), we used the dominant ear as the study group compared to and the non dominant ear (not used with mobile phone) as control. The dominant ear has been used by another study [10],[11]. The participants encompassed students, university personnel, and individuals from the general population residing in urban locales. These volunteers were well-educated and possessed a comprehensive understanding of the procedures involved.

They underwent a questionnaire including the average duration of their daily use of mobile phone and their dominant ear and gave informed consent prior to being included into the study after approval was obtained from the Medical Ethics Committee. Exclusion criteria encompassed a history of chronic ear disease, recent occurrence of upper respiratory infection, significant exposure to high-intensity noise, ongoing use of chronic medications, and a record of previous illnesses.

Individuals utilizing Bluetooth devices, portable music players, and hands-free devices were likewise excluded from the study. All subjects in this study used GSM 2G mobile phones.

Otoscopic examination was performed by ENT surgeon, following which high frequency hearing test was performed by an experienced audiologist at frequencies of 500, 1000, 2,000, 4,000, 6,000, 8,000, 10,000, 12,000, 14,000 and 16,000 Hz. Participants were categorized as having normal hearing if their Pure Tone audiometry demonstrated no hearing loss surpassing 20 dB across the frequency range of 500 to 16,000 Hz. On the other hand, individuals were classified as having hearing loss if any of their hearing thresholds exceeded 20 dB within the 500 to 16,000 Hz range.

The study was a blinded study, with the audiologist unaware of the participants' dominant ear. Audiograms were meticulously analyzed, and the magnitude of the notch (measured in decibels) as well

as the corresponding frequency (in Hertz) were meticulously recorded. Individuals with bilateral hearing loss were excluded from participation in the study.

## STATISTICAL ANALYSIS

The analysis was executed utilizing SPSS version 11.0. A significance level of  $P < 0.05$  was established. Our analytical approach incorporated Chi-square tests and Pearson's correlation coefficient for the examination of relationships and associations

## RESULTS

Two hundred volunteers fulfilled our criteria and thus were included in the study. Among the 200 subjects, 56% were males and 44% were females. The age of the volunteers was between 22 and 45 years with mean age of 22 years. The subjects were then divided into two groups: those with hearing loss and those without hearing loss. Out of the total volunteers, sixty-four percent (64%) exhibited no evidence of hearing loss, while thirty-six percent (36%) displayed hearing impairment exceeding 20 dB across frequencies spanning from 500 to 16,000 Hz. Among the 38 volunteers with hearing loss, the higher threshold of hearing (above 20 dB) were at 10,000 Hz and above.

Comparisons were made between these two groups, those without hearing loss and those with hearing loss. There was a statistically significant difference in age between the no hearing loss group ( $28.4 \pm 4.4$  years) and the hearing loss present group ( $34.0 \pm 4.2$  years). Duration of usage of mobile phones ranged from 15 to 200 min per day. There was a statistically significant difference in usage time between the no hearing loss group ( $15.4 \pm 10.8$  min/day) and hearing loss present group ( $44.6 \pm 28.2$  min/day). The duration of mobile phone usage was also subjected to comparison in terms of the number of years of usage. Once more, a statistically significant disparity between these two groups was observed (refer to Table 1). The data suggests that prolonged daily usage of mobile phones and a lengthier span of years using mobile phones might elevate the susceptibility to hearing loss.

Within the study cohort, Malays constituted 46%, Chinese accounted for 10%, Indians represented 36%, and the remaining 8% encompassed individuals from other ethnic backgrounds such as Sudanese and Iranians. Statistical analysis did not reveal any significant variations among the major racial groups or between genders. Furthermore, no discernible correlation emerged between the dominant ear and the dominant hand. Among our subjects 60% were dominant on the right ear, 18% left ear and 22% had no preference.

There was statistically significant hearing loss present in the dominant ear compared to the non-dominant ear, as well as those with no ear preference (Table 2). This was statistically significant value of  $P < 0.05$  under Chi-square tests. This indicates that the usage of

mobile (as most of the standards permit GSM900 mobile phones to transmit at a pulsed power of 2W with an average output of 0.25W) respondents use it on their dominant ear) predisposes to high frequency hearing loss Table3. [12]. Mobile phones have been seen to generate electro-magnetic radiation well

below the guidelines of the Inter-national Commission on Non Ionizing Radiation Protection(ICNIRP)[13]. Radio frequency emitted from mobile phones are not enough energetic to weaken electron configuration within DNA molecules. Thus there is no direct link

**Table 1: The frequency specific hearing loss among the 36 volunteers with hearing loss**

Frequency	No of volunteers with hearing loss
12kHz	8
12and14kHz	18
12,14,16kHz	3
12,14,16,18kHz	36

**Table 2: Summary of duration of using mobile phones daily and years of usage**

	Hearing status	N	Mean	SD	Std error mean
Usage (min/day)	No hearing loss	64	17.35	16.612	4.729
	Hearing loss	36	40.84	28.219	6.929
Years using mobile phones	No hearing loss	64	6.21	3.840	0.692
	Hearing loss present	36	12.32	24.086	6.258

**Table 3: Summary of the occurrence of hearing loss among the volunteers, sorted by ear preference**

	Dominant ear		No preference	Total
	Right	Left		
No hearing loss	50(50%)	2(2%)	12(12%)	64(64%)
Hearing loss present	10(10%)	16(16%)	10(10%)	36(36%)

**DISCUSSION**

Rising apprehension surrounds the potential health repercussions stemming from extended mobile phone usage. The foremost concern lies in the impact on the inner ear, which stands as the primary recipient of electromagnetic radiation due to its close proximity to the device. The fragile nature of the inner ear's hair cells makes them potentially more susceptible to harm than other bodily structures. Numerous studies have been undertaken to investigate the effects on hearing, keeping this consideration in mind.

A comparison of pure tone thresholds was conducted between individuals who use mobile phones and those who do not. Notably, a discernible difference emerged despite the thresholds remaining within the bounds of normalcy [5]. An investigation into the impact of mobile phone usage on auditory function encompassed frequencies spanning 500 to 6,000 Hz. The findings indicated a correlation between extended exposure to mobile phone-generated electromagnetic fields and hearing impairment [6]. Conversely, a brief 10-minute exposure to electromagnetic fields emitted by a mobile phone exhibited no discernible influence on hearing capabilities [7].

It's important to reiterate that our focus is primarily on prolonged or chronic exposure and the resultant effects, rather than on brief, short-term exposure.

Research has also been conducted to investigate the impact of electromagnetic fields emitted by mobile phones on human sleep[8,13].

*Other health effects*[13]: There are emmense number of arguments regarding brain tumors linked with

mobile phone with users, for and against [14], [15], [16], [17]. Mobile phones produce electromagnetic radiation through two primary mechanisms. Firstly, from the antennae distributed throughout our urban areas, and secondly, from the phones themselves. The current global consensus revolves around investigating the relationship between radiofrequency exposure and potential genotoxic outcomes, such as DNA mutations.[13].

Extensive research has been conducted regarding the electromagnetic radiation emitted by mobile phones and its implications for public health [2], [3–9]. Nonetheless, due to the limited prevalence of mobile phones before the 1990s, the body of studies addressing the effects of long-term usage on a substantial population remains relatively scarce.

As of now, there have been no studies conducted on children, despite their growing prevalence as heavy users of mobile phones. It's worth noting that these children might accumulate a greater overall exposure to electromagnetic radiation compared to adults of the same age. While the electromagnetic radiation emitted by mobile phones falls within established safety limits, the lingering uncertainty lies in whether prolonged use could potentially harm the delicate hair cells.

In terms of anatomy, the mobile phone is typically held near the ear, with an approximate distance of around 3 cm from the inner ear. Sensorineural hearing loss is the prevalent cause of deafness, often attributed to the deterioration of hair cells within the inner ear as we grow older.

The initial impact is observed in higher frequencies. This is due to the cochlea's mechanism, where the base conveys high frequencies and the apex carries low frequencies. Scientific evidence confirms that repeated exposure to loud noises can indeed damage the hair cells, leading to a decline in hearing ability. Regrettably, researchers have encountered challenges in accessing and studying hair cells effectively. It's worth noting that consonants are characterized by higher frequencies in contrast to vowels. Hearing impairment specifically within the higher frequency range can substantially impact speech comprehension. In cases where hearing loss becomes notable, the primary recourse often involves the utilization of hearing aid devices.

The highest electromagnetic absorption occurs on the side where the phone is held, gradually decreasing to about one-tenth of that intensity on the opposite side of the head. [13]. Consequently, the ear predominantly used with the mobile phone encounters the highest exposure to electromagnetic radiation. In this study, respondents identified this ear as their dominant ear. Our findings from the study indicated a noteworthy hearing impairment in the dominant ear when compared to the non-dominant ear. Additionally, we observed a correlation: the greater the duration of mobile phone usage—both in terms of daily frequency and years of use—the more pronounced the hearing loss became

Several limitations were present within the scope of this study. To gain a more comprehensive understanding, a larger population-based study is essential. An important aspect that requires attention is the absence of non-mobile phone users for comparison, which highlights the swift proliferation of mobile phone users. It is imperative to track and document the hearing thresholds of these subjects over time to account for continued usage effects. Additionally, the study did not delve into laboratory correlations. An ideal avenue for future research would involve examining the impact of electromagnetic radiation on hair cells directly.

## CONCLUSION

Our study reveals a proclivity for mobile phone usage to be associated with an increased susceptibility to hearing loss in the dominant ear (the ear frequently employed during mobile phone use). The presence of unilateral hearing loss exclusively in the dominant ear suggests a plausible link between the usage of mobile phones and the observed hearing impairment. This aspect frequently goes unnoticed, given that the majority of audiograms typically evaluate frequencies only up to 8 kHz. Hearing loss and other health hazards resulting from chronic use of mobile phones are important factors that need further research.

## REFERENCES

1. Mostafapour SP, Lahargoue K (1998) Noise induced hearing

lossinyoungadults.Laryngoscope108(12):1832–1839

2. Garcia Callejo FJ, Garcia Callejo F, Pena Santamaria J, AlonsoCastaneira I, Sebastian Gil E, Marco Algarra J (2005) Hearinglevel, intensive use of mobile phones. ActaOtorrinolaringolEsp56(5):187–191

3. Kerekkhanjanarong V, Supiyaphun P, Naratricoan J, Laungpi-tackchumpon P (2005) The effect of mobile phone to audiologysystem.JMedAssoThai88:S231–S234

4. Monnery PM, Srouji EI, Bartlett J (2004) Is cochlea outer haircell function affected by mobile telephone radiation? Clin Oto-laryngolAlliedSci29(6):747–749

5. Shayani-NasabM,SafaviNaiianniSA,FatholAlolomiMR,Makaremi A (2006) Effects of mobile telephones on hearing.ActaMedicaIran44:46–48

6. Oktay MF, Dasdag S (2006) Effects of intensive and moderatecellular phone use on hearing function. ElectromagnBiol Med25:13–21

7. Ozturan O, Erdem T, Miman MC, Kalcioğlu MT, Oncel S (2002)Effects of mobile telephone's electromagnetic field on hearing.ActaOtolaryngol122(3):289–293

8. Parazzini M, Brazzale AR, Paglialonga A, Tognola G, Collet L,Moulin A et al (2007) Effects of GSM cellular phones on humanhearing:theEuropeanproject“GUARD”.Radiat Res168:608–613

9. Al-Dousary SH (2007) Mobile phone induced hearing loss. SaudiMedJ28(80):1283–1286

10. Panda NK, Modi R, Munjal S, Virk RS (2011) Auditory changesinmobilephoneusers:isevidenceforthcoming? OtolaryngolHeadNeckSurg144(4):581–585

11. Panda NK, Jain R, Bakshi J, Munjal S (2010) Audiologic dis-turbances in long term mobile phone users. J Otolaryngol HeadNeckSurg39(1):5–11

12. Loughran SP, Wood AW, Barton JM, Croft RJ, Thompson B,Stough C (2005) The effects of electromagnetic fields emitted bymobilephonesonhumansleep.Neuroreport16(17):1973–1976

13. Ahlbom A, Green A, Kheifets L, Savitz D, Swerdlow A, Inter-nationalCommissionforNon-IonizingRadiationProtectionStanding Committee on Epidemiology (2004) Epidemiology ofhealth effects of radiofrequency exposure. Environ Health Perspect112(17):1741–1754

14. Klæboe L, Blaasaaas KG, Tynes T (2007) Use of mobile phonesin Norway and risk of intracranial tumours. Eur J Cancer Prev16:158–164

15. HardellL,CarlbergM,SoderqvistF,MildKH,MorganL L(2007)Longtermcellularphoneusageandbraintumors :increased risk with the use for 10 years. Occup Environ Med64:626–632

16. DubeyRB,HanmandluM,GuptaSK(2010)Riskofbrain tumorsfromwirelessphoneuse.JComputAssistTomogr 34(6):799–807

17. AydinD,FeychtingM,SchüzJ,TynesT,AndersenTV,Shmidt LS,PoulsenAH,JohansenC,ProchazkaM,LanneringB, Klæboe L, Eggen T, Jenni D, Grotzer M, Von der Weid N,KuehniCE,RöösliM(2011)Mobilephoneuseandbraintumors in children and adolescence: a multi centric study. J Natl CancerInst103:1264–1276