International Journal of Community Medicine and Public Health
*Sahni D et al. Int J Community Med Public Health. 2023 Dec;10(12):4849-4853*
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20233789

**Original Research Article**

# Hearing assessment in mobile phone users

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**Received:** 02 October 2023
**Revised:** 15 November 2023
**Accepted:** 16 November 2023

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## ABSTRACT

**Background:** Mobile phones have become an indispensable part of today's modern world. But with various day-to-day benefits, mobile phones also bring detrimental effects on the health of users. Ear being the closest organ in contact with phones, faces maximum effect of electromagnetic waves generated by them. Chronic exposure to these waves and sounds can result in permanent hearing loss. Hence, the present study was done to assess the association between hearing loss and duration of mobile usage.
**Methods:** This cross-sectional study was conducted on mobile phone users between the age group of 20 and 40 years in the Department of ENT, Rajindra Hospital, Patiala over 6 months (1 August 2022 to 31 January 2023). 600 volunteers were involved and divided into three groups based on the duration of mobile phone usage. Pure tone audiometry and DPOAE were used to assess the hearing loss in these subjects.
**Results:** A variable degree of hearing loss was observed on PTA and DPOAE in all three groups with a significant association between hearing loss and the duration of mobile phone usage. A higher proportion of sensorineural hearing loss was observed in the group with mobile phone usage of more than 1 hour per day for a minimum of 4 years as compared to those who used them for <1 hour per day for a minimum of 4 years and control group (p=0.001) which was significant statistically.
**Conclusions:** People using mobile phones for long hours are at higher risk of developing hearing loss, especially in the dominant ear.

**Keywords:** DPOAE, Electromagnetic waves, Mobile phones, PTA, Sensorineural hearing loss

## INTRODUCTION

Mobile phones are one of the most important tools for staying informed and connected to the outside world. Calls are made and received via them, and the calls themselves both receive and release electromagnetic radiation.[1] Beginning in the early 1980s, the use of mobile phones has grown rapidly ever since.[2] There are approximately 750 million smartphone users in India at the end of 2022, which is the second largest smartphone market.[3] The electromagnetic field that mobile devices create is pulsed at high frequency and has the potential to enter the skull and scalp.[4] According to research, the user's head absorbs between 40% and 50% of the radiation generated from mobile phones.[5]

Exposure to microwave radiation from mobile phones poses a threat to people's health leading to both thermal

and non-thermal effects. Non-thermal effects include altered sleep patterns, elevated blood pressure, impairments to cognitive function, burning, and tingling, and are primarily brought on by placing the device near the body. Thermal effects include a feeling of burning sensation in the ear and skin of the face, headache, and remodelling of the blood-brain barrier.[6] Mobile phone radiation was categorized in 2011 by the International Agency for Research on Cancer (IARC) as Group 28, probably Carcinogenic.[7] Due to its proximity to the body, the inner ear is likely the first organ to fully experience the effects of electromagnetic radiation.[8]

Electromagnetic radiations generated by mobile phones are absorbed by all components of the auditory system from the skin to the inner ear and cochlear nerve. Various endogenous and exogenous chemicals also affect outer hair cells as these hair cells are highly sensitive to them.[9] Capacity of regeneration is deficient in these delicate hair cells. So, whatever damage occurs to these cells is often irreversible with limited chances of recovery in later stages.[10] These EMFs are known to cause structural and functional changes in the cell membrane leading to abnormal cell response. In addition to this, electromagnetic waves have a direct effect on nerve conductivity. They reduce the neuronal reactivity and increase the neural conductivity resulting in the prolongation of the refractory period of nerve cells.[11] Thus, the whole auditory system including the cochlea and auditory nerve is particularly at risk. The present study was done to assess the effect of electromagnetic waves from mobile phones on the hearing status of patients.

### *Aim and objectives*

Aim and objectives of current study were to study the effects of mobile phone use on hearing and to evaluate the relationship between the hearing loss and duration of mobile phone usage.

## METHODS

The present cross-sectional study was conducted on 600 mobile phone users and occasional users between 20 and 40 years of age in the Department of ENT, Rajindra Hospital, Patiala, over 6 months from 1 August 2022 to 31 January 2023.

### *Sample size*

Sample size has been calculated by using the formula:

$$n = (Z)2\ pq/(e)\ 2$$

Where; n=Sample size; Z = 1.96 for 95% CI; p=0.84; e=0.03 & q=1-p, Z2=3.8416, e2=0.0009, q=0.16, pq=0.1344. Thus minimum (573.6789) 574 sample are required for the study.

### *Inclusion criteria*

Subjects of age between 20 to 40 years without any other known ear pathology causing hearing loss will be included in the study.

### *Exclusion criteria*

Subjects with any other ear pathology causing hearing loss such as otitis media, otosclerosis, perforation of the tympanic membrane, sudden or repeated exposure to noise without adequate protection, ototoxicity, head and neck trauma, high or low blood pressure and psychological problems were excluded.

### *Procedure*

After taking informed written consent, all 600 subjects were explained in detail about the aim and nature of the study. A detailed history regarding pattern (type of exposure - office calls, zoom calls, games, listening to music, etc) and duration of mobile phone usage was taken from all the participants. A pre-formed questionnaire was used to collect the relevant data. 600 healthy volunteers were further divided into three groups; Group A: consisted of 200 subjects with mobile phone usage of >1 hour per day for a minimum of 4 years and was further subdivided according to the duration of mobile phone usage; group a - 1 to 2 hours per day, group b - 2 to 4 hours per day and group C - more than 4 hours per day. Group B: consisted of 200 subjects with mobile phone usage of <1 hour per day for a minimum of 4 years Group C: consisted of 200 occasional mobile users (<1 hour per week). Pure tone audiometry (using ALPS-AD 2100 system from 0.25 to 8 kHz separately in both the ears) and Distortion product otoacoustic emissions (DPOAE) (using MAICO ERO-SCAN scan) both were done for hearing assessment.

### *Statistical analysis*

Collected data was entered in a Microsoft Excel spreadsheet. Analysis was done using the statistical package for Social Sciences (SPSS-IBM) software version 22. Mean, standard deviation, and proportions were calculated. The Chi-square test was used to find the difference in proportions. p-value <0.05 was considered statistically significant.

## RESULTS

The majority of subjects in our study are between the age group of 20- 30 years with a mean age in groups A, B, and C of 27.63±4.15, 27.63±4.39, and 28.99±4.65 respectively. Out of these 600 participants, 345 (57.5%) were males and 255 (42.5%) were females. In our study, the majority of participants were using mobile phones from 6 to 10 years with mean years of mobile usage of 8.87±3.20 in group A, 9.96±4.41 in group B, and 7.70±3.01 in group C. In group A, the majority of

participants were students (25%) followed by housewives (21%), private jobs (10%), laborers (9%), shopkeepers (9%), teachers (7.5%), IT professionals (7.5%), call center workers (6%), businessmen (4.5%) and radio jockey (0.5%). In group B, housewives form the major group (30%) followed by students (20%), teachers (13%), private jobs (12%), shopkeepers (12%), laborers (7%), and businessmen (6%). Similarly in group C, the majority of participants were housewives (49%) followed by shopkeepers (27%) and labourers (24%).

**Table 1: Duration of mobile phone usage.**

| No of years | Group A | | Group B | | Group C | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| ≤5 | 42 | 21 | 33 | 16.50 | 64 | 32 |
| 6-10 | 109 | 54.50 | 91 | 45.50 | 108 | 54 |
| ≥11 | 49 | 24.50 | 76 | 38 | 28 | 14 |
| Total | 200 | 100 | 200 | 100 | 200 | 100 |
| Mean±SD | 8.87±3.20 | | 9.96±4.41 | | 7.70±3.01 | |
| Median | 9.00 | | 10.00 | | 8.00 | |
| Range | 4-20 | | 4-28 | | 4-20 | |

Tinnitus was the most common symptom associated with usage of mobile phones in all the groups (Group A-18.5%, Group B-9% and Group C-1%) followed by aural fullness (Group A-15%, Group B-6% and Group C-0%), headache (Group A-9%, Group B-2% and Group C-0%) and burning sensation (Group A-5.5%, Group B-2% and Group C-0%). In group A, 36,68 and 96 participants were using mobile phones for more than 4 hours, 2 to 4 hours, and 1 to 2 hours respectively. Out of these, 32 (16%) subjects had hearing loss (unilateral in 12% and bilateral in 4%). Similarly, 12 (6%) subjects had decreased hearing in group B (unilateral in 4% and bilateral in 2%). In group C, hearing loss was present in 5 (2.5%) subjects. There is a significant relationship between hearing loss and the duration of mobile phone usage (p=0.001). In group A, 25 patients had hearing loss in the right ear and 15 had in the left ear. Similarly in group B, the right ear was involved in 10 subjects and the left ear in 6. In group C, this number was 5 in the right ear and 3 in the left ear. In the present study, 28 (14%) subjects in group A had mild sensorineural hearing loss (25-40 dB) and 4(2%) had moderate sensorineural hearing loss (40-60 dB) in the same group.

**Table 2: Distribution of participants according to pattern of mobile phone usage.**

| Mobile phone conversation | Group A (n=200) | | Group B (n=200) | | Group C (n=200) | |
|---|---|---|---|---|---|---|
| | N | % | N | % | N | % |
| Office calls | 42 | 21 | - | - | - | - |
| Listening to music | 25 | 12.5 | 22 | 11 | - | - |
| Games | 18 | 9 | 2 | 1 | - | - |
| Radio Jockey | 1 | 0.5 | - | - | - | - |
| Normal Conversation | 114 | 57 | 176 | 88 | 200 | 100 |
| Total | 200 | 100 | 200 | 100 | 200 | 100 |

**Table 3: Sensorineural Hearing loss based on PTA.**

| Hearing loss | Group A (n=200) | | Group B (n=200) | | Group C (n=200) | | P value |
|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | |
| Unilateral | 24 | 12 | 8 | 4 | 0 | 0 | 0.003 ($X^2$=12.89) |
| Bilateral | 8 | 4 | 4 | 2 | 5 | 2.50 | 0.139 ($X^2$=2.18) |
| Total | 32 | 16 | 12 | 6 | 5 | 2.50 | 0.001 ($X^2$=30.03) |

**Table 4: Otoacoustic emissions.**

| Ear | DPOAE | Group A (n=200) | | Group B (n=200) | | Group C (n=200) | |
|---|---|---|---|---|---|---|---|
| | | N | % | N | % | N | % |
| Right Ear | Pass | 181 | 90.50 | 192 | 96 | 192 | 96 |
| | Refer | 19 | 9.50 | 8 | 4 | 8 | 4 |
| Left Ear | Pass | 184 | 92 | 191 | 95.50 | 192 | 96 |
| | Refer | 16 | 8 | 9 | 4.50 | 8 | 4 |
| Bilateral | Pass | 190 | 95 | 197 | 98.5 | 200 | 100 |
| | Refer | 10 | 5 | 3 | 1.5 | 0 | 0 |

## DISCUSSION

Mobile phones have become an integral part of our daily activities. The use of mobile phones started in early eighties, and since then it has increased exponentially.

There has been a substantial concern worldwide regarding the effect of long-term exposure to EMR. Various studies have been undertaken to investigate the damage caused to the inner ear by the EMR from mobile phones. A study by Ramya et al demonstrated a significant increase in

hearing threshold with an increase in duration of use of mobile phones.[12] The effect of EMRs on human body has been an area of research. Bhatia et al. reviewed the neuropsychiatric effects of the mobile phones and reported that regular usage had harmful effects which included a headache, nausea dizziness, sleep disturbance, mood swing, memory loss, lack of concentration and coordination and fatigue.[13]

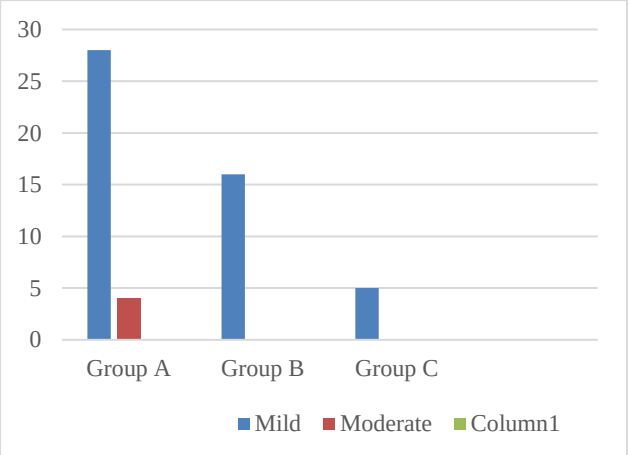


**Figure 1: Degree of hearing loss based on PTA.**

In our study, a total of 600 volunteers were examined and were further divided into three groups based on the duration of use of mobile phones. The majority of patients were between 20-30 years of age with a mean age of 27 years in groups A and B and 28 years in group C. Youngsters were more indulged in long hours of mobile phone talks. Out of these 600 participants, 345 (57.5%) were males and 255 (42.5%) were females. However, hearing loss was seen in both females and males. No significant association was observed between the gender of the participant and hearing loss.

The use of mobile phones is not only limited to making and receiving calls but also to internet services and various entertainment purposes like games, listening to music, etc. Due to these services, students and various professionals are more exposed to these hazards. In Group A, the majority of participants used mobile phones as media for office calls (21%) and mobile phones as music media in 12.5% of participants. Similarly, in group B, 11 % of participants indulged in using mobile phones to listen to music. This is similar to the findings of a study done by Priya et al in which the majority of participants were using mobile phones for listening to music (55%).[14] In the present study, tinnitus was the most common symptom associated with the use of mobile phones. (Group A-18.5%, Group B-9% and Group C-1%) followed by blocked sensation (group A-15%. Group B-6% and Group C-0%), headache (Group A-9%, Group B-2%, and Group C-0%) and burning sensation (Group A-5.5%, Group B- 2% and Group C-0%). Our finding is similar to a study done by Smithachandra et al in which tinnitus (27.7%) was concluded as the most common associated symptom in mobile phone users.[15]

Hearing loss of variable proportions was observed on PTA in all three groups in our study (Group A-16%, Group B-6%, and Group C-2.5%). But, in comparison to the three groups, subjects having hearing loss were highest in Group A followed by Group B and Group C. This clearly shows that the presence of hearing loss increases with the increase in the duration of mobile phone usage establishing a statistically significant relationship between hearing loss and duration of mobile phone use (p=0.001). Hence, duration of exposure plays an important in the development of hearing loss. This loss of hearing may be either due to exposure to sound or electromagnetic waves. Our observation is similar to Karthikeyan et al who observed a greater proportion of hearing loss in those using mobile phones for more than 2 hours a day as compared to those who use the same for less than 2 hours a day.[16] With the further categorization of the degree of hearing loss, we found that 28 (14%) subjects in group A had mild sensorineural hearing loss (25-40 dB) and 4 (2%) had moderate sensorineural hearing loss (40-60 dB) in the same group. Similarly, 16 (8%) subjects in Group B and 5 (2.5%) subjects in Group C had mild sensorineural hearing loss. Severe and profound hearing loss was not present in any of the groups. This again signifies that the longer the duration of mobile phone use, the greater the degree of hearing loss. Priya K et al in their study also found mild hearing loss in 9.3% of subjects and moderate hearing loss in 3.9% of subjects.[14] In the present study, the right ear was predominantly involved (Group A-12.5%, Group B-5%, and Group-2.5%) which is by Priya et al who also concluded predominant involvement of the right ear. The dominant ear is the one that is used more frequently for mobile conversation. Chronic exposure to electromagnetic waves and sound in the dominant ear may be the reason for hearing loss right ear.[14] In our study, DPOAE was carried out to assess the cochlear function. In group A, otoacoustic emissions response was absent in 9.5% in the right ear, 8% in the left ear, and 5% in bilateral ears. In group B, absent OAE response was seen in 4%, 4.5%, and 1.5% in the right ear, left ear, and bilateral ear respectively. Similarly, in group C, it was absent in 4% in both the right and left ear individually with no bilateral involvement. A similar study by Philip et al also shows absent otoacoustic emission response in 22 participants with mobile phone usage of more than 1 hour per day, 17 participants with mobile phone usage of less than 1 hour per day, and 8 participants with occasional users using mobile phones less than 1 hour per week. As otoacoustic emissions tell us about the health of hair cells in the inner ear, absent OAEs are the result of damage to these hair cells.[17]

***Limitations***

However, larger sample size and more studies require to further evaluate the effect of mobile phone on hearing.

## CONCLUSION

Nowadays, long talks on mobile phones are not uncommon. Chronic exposure to electromagnetic waves generated by them can have dreadful effects on the auditory system. Our study shows a statistically significant association between hearing loss and duration of mobile phone usage. This hearing loss can be permanent. People using mobile phones for long hours are at higher risk of developing hearing loss, especially in the dominant ear. Hearing loss and other effects of electromagnetic waves generated from mobile phones on human health are critical issues that require further research.

*Funding: No funding sources*
*Conflict of interest: None declared*
*Ethical approval: The study was approved by the Institutional Ethics Committee*

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**Cite this article as:** Sahni D, Singh P, Sharma P, Kaur A, Sahni P, Sahni H. Hearing assessment in mobile phone users. Int J Community Med Public Health 2023;10:4849-53.