Advanced Journal of Graduate Research
ISSN:2456-7108
Volume 12, Issue 1, pp. 1-10, July 2022
DOI: https://doi.org/10.21467/ajgr.12.1.1-10

GRADUATE SURVEY ARTICLE

Awareness of Mobile Phone Radiation and Its Potential Health Hazards Among Students and Working-class Population During the COVID-19 Pandemic: A Cross-sectional Survey

Joshua Paul[1], Anandi Shivaram[1], Panchami P[1], Bhumika Patel[1], Devi Jaikrishnan[1], Wilner Martinez-Lopez[2], Radha Saraswathy[1*]

[1]Department of Biomedical Genetics, School of Bio Sciences and Technology, VIT University, Vellore-632014, India

[2]Epigenetics and Genomic Instability Laboratory, Instituto de Investigaciones Biologicas Clemente, Estable, Av. Italia 3318, Montevideo, Uruguay

* Corresponding Author email:

radhasaraswathy60@gmail.com

Article History

Received: 02 October 2021
Accepted: 04 March 2022
Published: 21 March 2022

Student(s)

- Joshua Paul
- Anandi Shivaram
- Panchami P
- Bhumika Patel
- Devi Jaikrishnan

Academic Year: 2020-2021
Course Level: Master
Course Name: Biomedical Genetics
Course year: Final Year

Mentor(s)

- Dr. Wilner Martinez-Lopez
- Dr. Radha Saraswathy

ABSTRACT

COVID-19 pandemic has caused an increased dependence on mobile phones by students and working professionals. Mobile phones are indispensable gadgets with a wide range of applications. However, there are potential risks associated with its usage in terms of radiofrequency radiation. The objective of this study was to evaluate the knowledge of radiation and its biological adverse effects caused due to the usage of mobile phones among students and working professionals. An online awareness survey was conducted during the COVID-19 pandemic among 351 participants using Google forms. The questionnaire was disseminated to the WhatsApp groups of students and working professionals and the data was statistically analysed. Among the 351 subjects, 72% of the respondents used their mobile phones for more than 4 hours per day. However, less than 20% were fully aware of mobile phone radiation being listed in the possible carcinogen list by the World Health Organization (WHO). In addition, only half of the respondents considered the Specific Absorption Rate (SAR) value and information on radiation emission while purchasing a new phone. To conclude, the need for awareness of potential hazards associated with the mobile phone radiation seems crucial, especially during this time when everyone in the world and especially school and college students are highly dependent on mobile phones.

Keywords: Mobile phone radiation, Electromagnetic radiation, Specific absorption rate.

1 Introduction

In December 2019, a new virus was identified to cause illness ranging from the common cold to more severe diseases. The virus was named as "severe acute respiratory syndrome coronavirus 2 (SARS CoV-2)." Since its spread became rampant across the globe, the World Health Organization [1] declared it as pandemic on March 11, 2020. The first national lockdown of 21 days was announced on March 24, 2020, in India. This lockdown continued further until June 2020 and was lifted only for essential services with restrictions and guidelines thereon, while the schools and colleges remain closed until the writing of this paper. The lockdown has resulted in a sudden heavy reliance on mobile phones that enhanced teaching and learning during this pandemic [2]. Normal classroom turned into an e-classroom overnight and online teaching was not an option anymore. The new normal of "work from home and study from home" takes credit for this transition [3]. In a survey conducted by the National Council of Educational Research and Training (NCERT) during the lockdown, it was reported that over 84% of students rely on mobile phones for learning [4]. Though the usage of mobile phones has risen steeply, the perception of proper knowledge and awareness of the associated risks is scarce and thus it led us to the conception of this study.

Mobile phones were earlier used primarily for making and receiving calls. However, in recent times, this smart technology has replaced the laptops by its wide range of applications from connectivity to education and business. The mobile phone is one of the most significant technological revolutions in human history, and it is not a mere hyperbole [5]. The widespread use of mobile phones has drastically increased over the past decade; they are no more restricted to one age group or a particular working-class people. According to the latest data from GSMA Intelligence [6], there are 5.10 billion unique mobile subscribers in the world with a 3.72% growth, year on year. The mobile industry connects over 3.5 billion people to the internet, which is approximately 47% of the global population. It is reported that approximately 90% of total internet users, use their mobile phones for internet access. The number of mobile phone users is consistently increasing every year because of its benefits and a wide range of applications. In recent years, especially among college and university students, mobile phones are becoming an integral part of their life with regard to academics and maintaining social relationships [7].

Mobile phones emit low levels of non-ionizing radiation when in use. The radiation emitted is called the Radiofrequency (RF) radiation that are electromagnetic fields (EMF) having a frequency range between 300KHz-300MHz. Radiofrequency energy is chiefly used in the telecommunication services and the common sources of this type of radiation apart from mobile phones are microwave ovens, radars, radio and television transmitters and transceivers [8]. Some of the emitted radiofrequency radiation is absorbed into our body, and the amount of energy absorbed depends on many factors like proximity of the device, duration and the strength of the signal. The energy absorption is usually measured in terms of Specific Absorption Rate (SAR). According to the Federal Communications Commission (FCC), SAR is a measure of the rate of radiofrequency energy absorbed by the body from the source, which in our case, are the mobile phones. It is expressed in units of watts per kilogram (W/Kg) or milliwatts per kilogram (mW/Kg) [9]. Each mobile phone that comes to the market is tested and given a SAR value rate at which the body absorbs the radiofrequency energies. Although SAR values are an important tool to decide the maximum possible exposure, the amount of RF radiation exposure significantly depends on typical usage conditions of each mobile phone as mentioned above.

Several studies showed the association of mobile phones with a range of health problems that include headaches, sleep disturbances, neurological problems [10], [11] and male infertility [12]. In a review by Junji Miyakoshi, he showed the weak evidence for the genotoxicity caused by RF exposure, [13] however, Uslu et al. confirmed that RF radiation leads to significant direct genotoxic effects on Human Foetal cells [14]. Likewise, it has been demonstrated that radiation-induced chromosome exchanges increase according to SAR, conducting that SAR could affect DNA repair or alter cell death mechanisms [15].

In addition, RF exposure has also shown to diminish the embryo development and their quality in Naval Medical Research Institute (NMRI) mice [16]. According to Li et al., several dysfunctions are associated

due to the extensive use of mobile phones like Parkinson's disease or Alzheimer's disease [17]. The more critical health hazard of mobile phone usage is the risk of cancer, which is extensively studied and highly debated. In May 2011, The International Agency for Research on Cancer classified mobile phones under Group 2B, 'possibly carcinogenic to humans'. American Cancer Society stated that there could be some cancer risk associated, but the evidence was not strong enough to be considered causal.

Since there is no concrete evidence that mobile phone radiation is safe to humans, people should pay more attention to the awareness of the potential hazards of mobile phone radiation. With the increasing use of mobile phones during this COVID-19 pandemic situation, this study purposed to evaluate the awareness and knowledge on possible health risks of mobile phone radiation among the students and working-class population through a cross-sectional survey.

2 Methodology

2.1 Questionnaire

An online survey was conducted using a self-administered questionnaire. The questionnaire was carefully prepared based on the information available from the online literature databases and consisted of 30 questions on the following sections; a) Personal information and information about mobile phones b) Perception and individual's routine with mobile phone usage c) Awareness on potential health hazards and preventive measures. While the first section was to get the basic information of the responder pertaining to the survey, the latter two sections intended to evaluate the awareness of potential health hazards of mobile phones.

2.2 Participants

The questionnaire was circulated to the WhatsApp groups of students and working professionals using a Google form. Almost all of the participants were from the University where the study was conducted and 351 participants responded to the online survey between August 2020 to September 2020.

2.3 Statistical Analysis

The data were analyzed using Microsoft Excel and SPSS. Descriptive measures such as frequency and percentage were presented for qualitative data and were analyzed using Chi-Square test/ Fishers Exact as appropriate. In addition, the proportion test comparison was used to find the statistical significance of each response in multiple-choice data. Statistical significance level was at 0.05.

3 Results and Discussion

351 participants responded to the questionnaire using the google forms, which included 141 males (40%), 209 females (60%) and 1 participant who was not willing to disclose the gender identity. Out of 351 responses, 259 responses (73.7%) were from students, and 92 responses (26.2%) were from working professionals. From the variety of mobile phone brands used by the participants, Redmi tops the list with 83 (23.6%) participants using it, followed by Samsung with 74 (21.1%) participants. The different brands of mobile phones used by the respondents are represented in Figure 1.

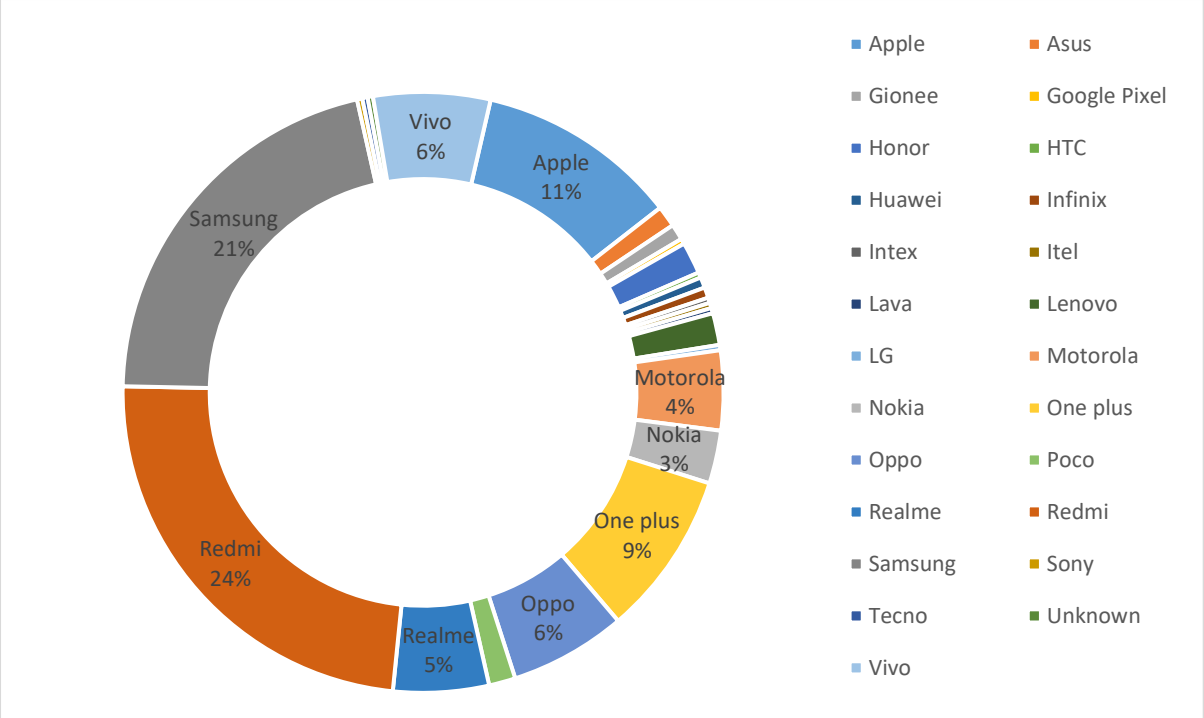

Figure 1: *Distribution of different mobile brands used by the respondent*

Among 259 students, 39.4% used their mobile phones more than 6 hours per day, and 37.5% used it for 4-6 hours a day. In contrast, only 20% of working professionals (n = 92) used their mobile phones more than 6 hours per day, as shown in Figure 2.

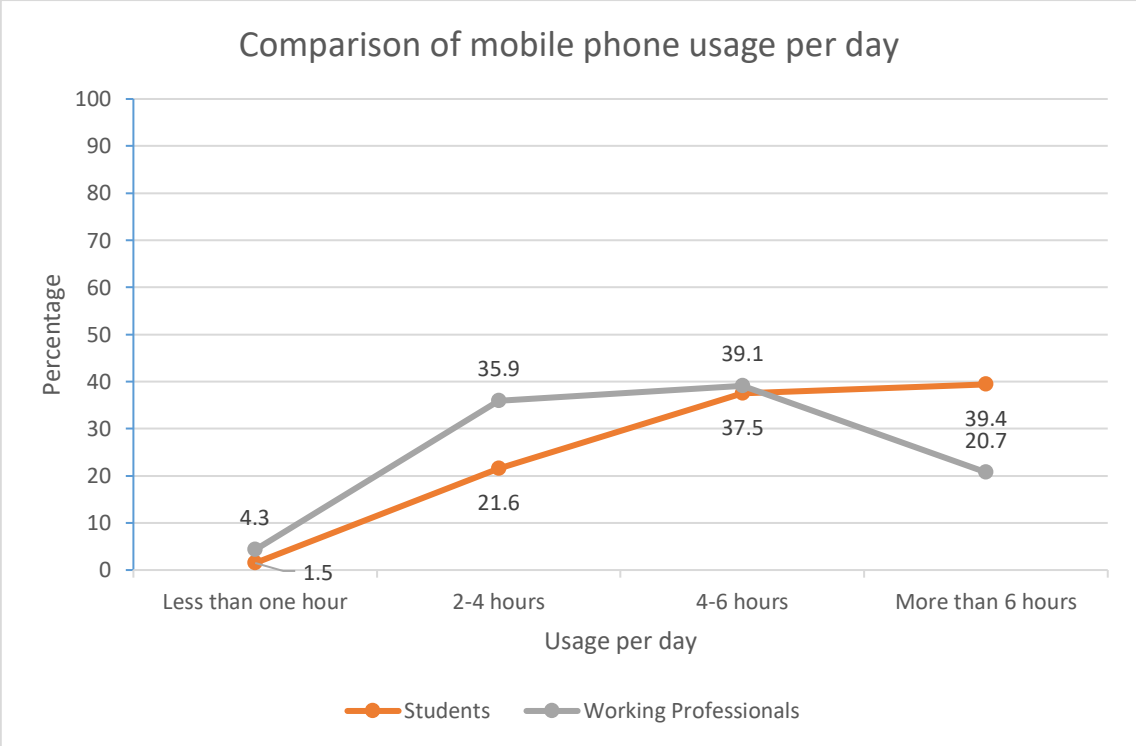

Figure 2. *Comparison of mobile phone usage between students and working professionals in a day.*

In Tables 1 and 2, the responses to the questions on the individual's routine with the usage of mobile phones and awareness about the potential health hazards of mobile phone radiation are shown respectively.

Table 1. *The responses of the participants to the questions on an individual's routine with the usage of mobile phones.*

S No	Questions	Responses (n = 351)			
		Students (n = 259)		Working Professionals (n = 92)	
1	Checking your phone first thing in the morning after you wake up, while in bed.	Yes No	175 (67.6%) 84 (32.4%)	Yes No	53 (57.6%) 39 (42.4%)
2	At what age did you start using a personal mobile phone?	10-14 years 15-20 years 21+ years 30+ years	24 (9.3%) 212 (81.9%) 23 (8.8%) 0 (0.0%)	10-14 years 15-20 years 21+ years 30+ years	4 (4.3%) 38 (41.3%) 22 (24.0%) 28 (30.4%)
3	Where is the mobile phone kept while you are at work/ in your educational institution?	Pant Pocket Shirt Pocket Bag Other	108 (41.7%) 3 (1.2%) 120 (46.3%) 28 (10.8%)	Pant Pocket Shirt Pocket Bag Other	40 (43.5%) 6 (6.5%) 20 (21.7%) 26 (28.3%)
4	Do you keep your phone in bed or near your head while sleeping?	Always Sometime Never	81 (31.3%) 118 (45.5%) 60 (23.2%)	Always Sometime Never	36 (39.1%) 27 (29.4%) 29 (31.5%)
5	Do you know that wireless networks emit radiation?	Yes No	214 (82.6%) 45 (17.4%)	Yes No	75 (81.5%) 17 (18.5%)
6	Do you believe that your phone has health hazards?	Agree Maybe Disagree	166 (64.1%) 9 (3.5%) 84 (32.4%)	Agree Maybe Disagree	60 (65.2%) 4 (4.4%) 28 (30.4%)

Table 2. The responses of participants to the questions on awareness about the potential health hazards of mobile phone radiation and individual thought on preventive measures.

S No	Questions	Responses (n = 351)			
		Students (n = 259)		Working Professionals (n = 92)	
1	Phone usage can cause headache, sleep disturbance and loss of mental attention.	Strongly disagree Disagree Slightly agree Agree Strongly agree	17 (6.6%) 5 (1.9%) 39 (15.1%) 122 (47.1%) 76 (29.3%)	Strongly disagree Disagree Slightly agree Agree Strongly agree	6 (6.5%) 5 (5.4%) 27 (29.3%) 31 (33.7%) 23 (25.0%)
2	Are you aware that your phone emits a lot of radiation when it has very less charge?	Yes No	165 (63.7%) 94 (36.3%)	Yes No	70 (76.1%) 22 (23.9%)
3	Are you aware that 50-minute mobile phone exposure is associated with increased brain glucose metabolism?	Yes No	94 (36.3%) 165 (63.7%)	Yes No	26 (28.2%) 66 (71.7%)

4	Do you know the mobile phone radiation for one hour causes morphological changes and increased fibroblast activity of the skin?	Not aware Somewhat aware Very aware	142 (54.8%) 100 (38.6%) 17 (6.6%)	Not aware Somewhat aware Very aware	58 (63.0%) 27 (29.3%) 7 (7.6%)
5	Are you aware of the harmful effects of electromagnetic field on the normal activity of ovaries in the female reproductive system?	Yes No	127 (49.0%) 132 (51.0%)	Yes No	38 (41.3%) 54 (58.7%)
6	Are you aware that pulsed 900-MHz GSM mobile phone radiation affects the acrosome reaction, head morphometry and zona binding of human spermatozoa?	Yes No	89 (34.4%) 170 (65.6%)	Yes No	24 (26.1%) 68 (73.9%)
7	Are you aware that in 2011, the World Health Organization listed mobile phone radiation as a possible cause of cancer?	Not aware Somewhat aware Very aware	75 (29.0%) 130 (50.2%) 54 (20.8%)	Not aware Somewhat aware Very aware	39 (42.4%) 46 (50.0%) 7 (7.6%)
8	Are you aware that 5G internet speed poses an immense threat to human health?	Yes No	150 (57.9%) 109 (42.1%)	Yes No	33 (35.9%) 59 (64.1%)
9	Despite knowing the risk, will you prefer faster, non-buffering network over your health?	Yes No	99 (38.2%) 160 (61.8%)	Yes No	31 (33.7%) 61 (66.3%)
10	Are you aware of EMF blocking mobile-phone case available in the market?	Yes No	76 (29.3%) 183 (70.7%)	Yes No	19 (20.7%) 73 (79.3%)

Notably, the student population started using a personal mobile phone at an early age as compared to working professionals (Table 1). When asked, 84 (32.4%) students and 28 (30.4%) working professionals disagreed to believing that mobile phones have health hazards. Table 2 demonstrates the range of questions relating to the awareness of mobile phone radiation and prevention measures. These questions were framed based on the information from the official website of the National Cancer Institute [18]. A significant percentage of respondents were unaware of the potential health risks of using a mobile phone. Only 7.6% of working professionals were very much aware of mobile phone radiation listed in the possible causative agent of cancer. More than 50% of both the students and working professionals are not aware of mobile phone radiation's impact on the human reproductive system (Table 2). Performance was the most influencing factor while purchasing a new mobile phone. This result was consistent with both the groups followed by cost, brand and camera specifications with close margins (Figure 3). Majority of the respondents (87.4%) agreed that limiting the usage of mobile phones would reduce or avoid exposure to radiation (Figure 4).

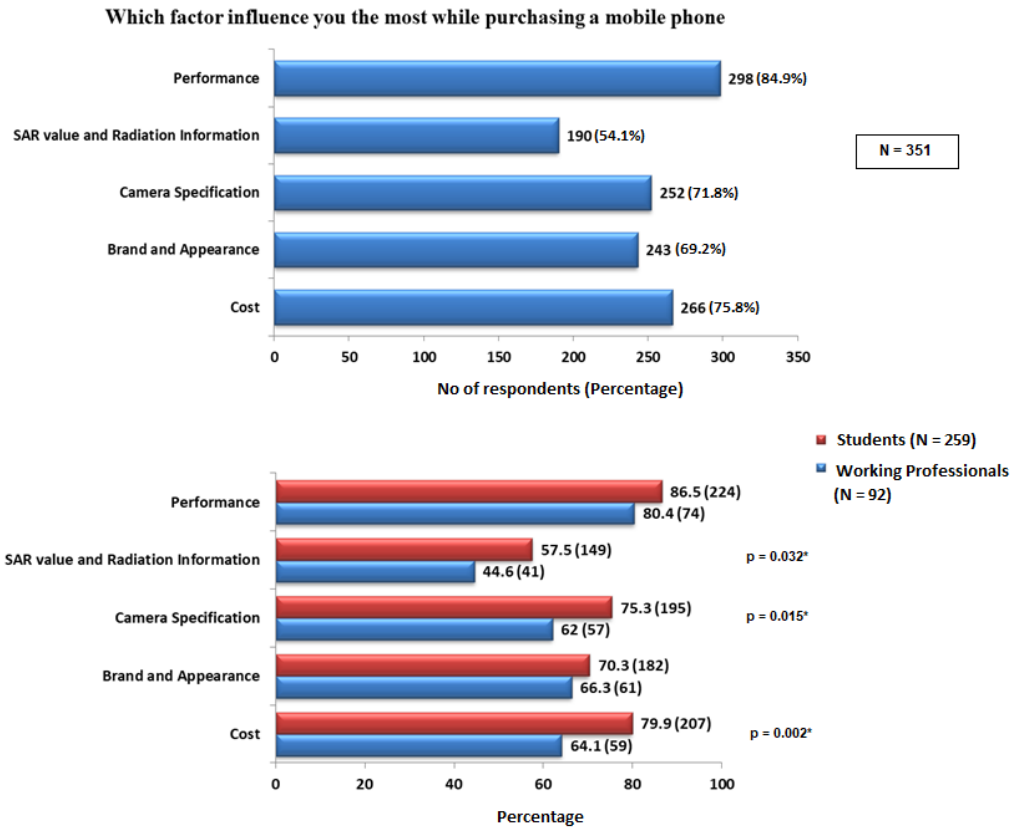

Figure 3. *Overall and comparative analysis of the responses between students and working professionals to the question of factors that influence while purchasing a new mobile phone. *p values are from the Chi-square test/Fischer exact test*

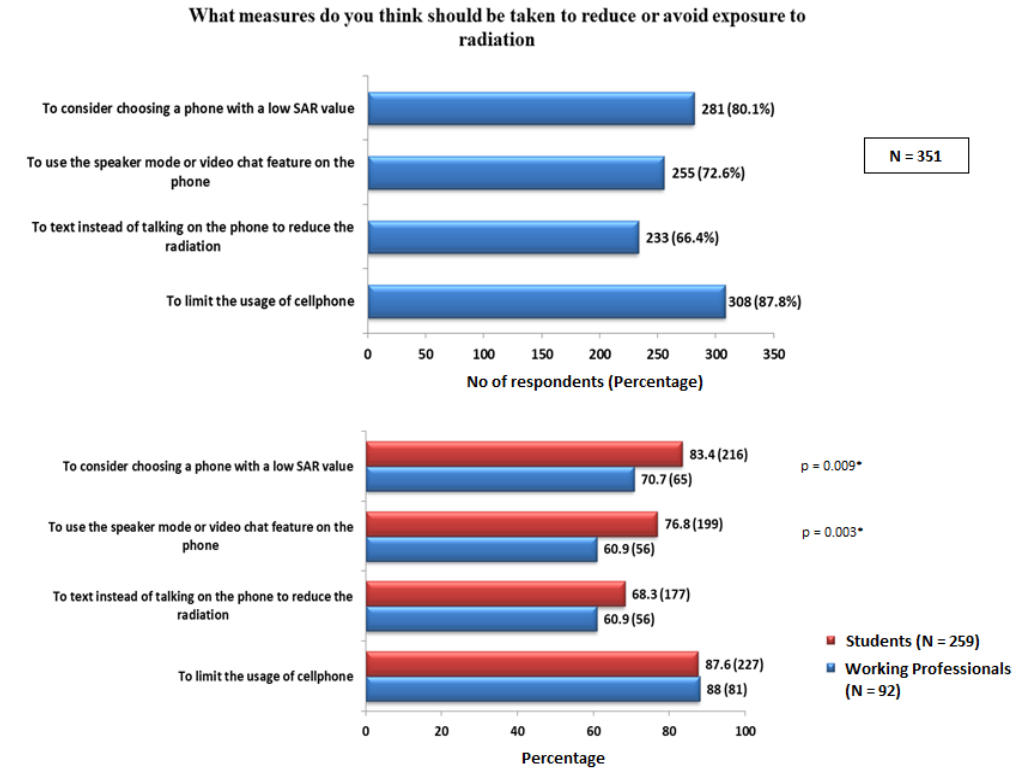

Figure 4. *Overall and comparative analysis of the responses between students and working professionals to the question of preventive measures to be taken to reduce or avoid radiation. *p values are from the Chi-square test/Fischer exact test*

Next-generation technologies are developing through decades, and wireless network users are increasing day by day [19]. During the COVID pandemic, mobile phones played a crucial role in medicine and healthcare. Its applications extended from telemedicine to contact tracking through 'Aarogya Setu' which is an application developed by the National Informatics Centre, Government of India [20], while on the other hand, there was a changing pattern observed in the usage of mobile phone both in terms of frequency and overall duration. A cohort study on Italian children and adolescents showed significant increase in the average smartphone use during the pandemic. The study also discussed the adverse physical, psychological and social effects due to the changing patterns in the smartphone use among young people [21]. Our findings from this survey shows that the awareness of mobile phone radiation and its associated health hazards is still a milestone to be achieved. More than 30% of both students and working professionals agreed that they keep their mobile phones near the head while sleeping (Table 1). This is due to the lack of awareness, despite the fact that it is an easy prevention step to follow. Similarly, SAR value and radiation information is the least influencing factor (54.1%) among both students and working professionals (Figure 3).

To the best of our knowledge, there are not many studies done to assess the awareness on mobile phone radiation associated risks across age, demographic and professional populations, especially in India. However, one similar study was performed to assess the awareness of mobile phone hazards among Malaysian medical school students a decade ago [22]. The study showed that almost 62% of students were aware of health hazards produced by the mobile phones and there was no significant difference observed in the perception between the males and females. This data was comparable with our survey results where 64% of students and 65% of working professionals believed that mobile phone usage has health hazards. The study described the results of the awareness of common health hazards that are associated with the mobile phone usage, however, the perception of mobile phone radiation and its implicated health hazards were not discussed. Most of the respondents agreed that mobile phone usage caused headache, loss of mental attention and sleep disturbances. This result correlated with our survey findings, where majority of the students and working professionals agreed to these effects to be caused by mobile phones.

Our results also showed that only 17.3% of the respondents were aware that mobile phones are listed as the possible carcinogen by the WHO. Other studies have also reported this insufficient knowledge concerning Specific Absorption Rates (SAR). They reported high level of cell phone usage and the participants experienced biological and sleep issues. Another distinct criterion addressed in these studies were the behavioural characteristics to which highly affirmative responses were obtained to the questions pertaining to presence of fatigue, lethargy, introversion and being aloof [9]. This is of particular clinical significance as the proximity and the position of the mobile phones directly influence the exposure of our body to the electromagnetic field and its associated health hazards. Mobile phone radiation increased the temperature of brain tissue when confronted with a mobile phone at a distance of 4 mm in an in vitro experiment setup [23]. Almost two-thirds of the respondents were not aware that 5G causes an immense threat to human health and more than 70% are unaware of EMF blocking mobile phone case availability in the market. Surprisingly, 38.2% of students and 33.7% working professionals agreed to prefer faster, non-buffering network to their health (Table 2).

In a study that investigated the effect of increasing distance of cell phones on the temperature of central matter and gray matter of the brain tissue due to heat generated by RF waves reported significant negative correlation [23]. Recent researches demonstrate that exposure of RF-EMF in the brains of foetuses and children is a major concern as it inhibits the formation and differentiation of neural stem cells during neural development. It has also been reported that consistent exposure to high levels of RF-EMF affect the neurological, psychological and reproductive health in adults [24]. Manti et.al studied the effects of Universal Mobile Telecommunication System (UMTS) exposure on X-rays induced chromosomal aberrations in human peripheral blood lymphocytes. Although no significant variation was observed in the aberrant cells due to UMTS exposure, but the frequency of exchanges per cell increased under the impact

of SAR (2.0 W/kg). Hence SAR either influences the repair of X-ray induced DNA damage or alter DNA damage response and cell death pathways [15].

4 Conclusion

It is unequivocally accepted that the dependency on mobile phones has seen a drastic increase, particularly during this COVID pandemic. Ranging from online classes for students to online tasks for working professionals, we are slowly moving into an era of 'work and study from home', and mobile phones have become an indispensable gadget. According to our survey, 72% (N = 351) use mobile phones more than 4 hours per day. In contrast, only 54.1% consider SAR value and radiation information while purchasing a new phone. Only 17.3% of the participants said that they are aware of mobile phones being listed as a possible causative agent of cancer by FCC and WHO. Mobile phone is an asset for learning, occupation and communication, but its usage also poses a possible serious threat to the human health. Considering the fact that the future holds an immense increase in the exposure to electromagnetic radiations in the environment, there is an equally pressing need for increase in health assessment surveys and safety regulations against electromagnetic radiation. Therefore, we would like to conclude the survey emphasizing on the need for awareness on mobile phone usage and its potential health problems through various programmes and surveys. This will allow all of us to make informed choices and be vigilant on something, which is increasingly used by our children.

5 Declarations

5.1 Study Limitations

One limitation foreseen in our study has been not to include participants from different professional domains and age groups. In addition, there could have been occurred a selection bias as the participants were recruited through the WhatsApp groups. However, since the participants responded through a unique link, our survey results provided a snapshot regarding the awareness level at the group of respondents.

5.2 Competing Interests

There are no conflicts of interest that are relevant to this study for the authors of this manuscript.

5.3 Publisher's Note

AIJR remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

How to Cite this Article:

J. Paul *et al.* "Awareness of Mobile Phone Radiation and Its Potential Health Hazards Among Students and Working-class Population During the COVID-19 Pandemic: A Cross-sectional Survey", *Adv. J. Grad. Res.*, vol. 12, no. 1, pp. 1–10, Mar. 2022. https://doi.org/10.21467/ajgr.12.1.1-10

References

[1] "WHO-COVID-19-Community_Transmission-2020.1-eng.pdf." Accessed: Dec. 20, 2020. [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/331421/WHO-COVID-19-Community_Transmission-2020.1-eng.pdf

[2] J. Sandars *et al.*, "Twelve tips for rapidly migrating to online learning during the COVID-19 pandemic," *MedEdPublish*, vol. 9, Apr. 2020, doi: 10.15694/mep.2020.000082.1.

[3] S. Dhawan, "Online Learning: A Panacea in the Time of COVID-19 Crisis," *J. Educ. Technol. Syst.*, vol. 49, no. 1, pp. 5–22, Sep. 2020, doi: 10.1177/0047239520934018.

[4] "Coronavirus lockdown | Over 80% of students depend on mobiles for learning: NCERT," *The Hindu*, New Delhi, Aug. 19, 2020. Accessed: Dec. 20, 2020. [Online]. Available: https://www.thehindu.com/news/national/coronavirus-lockdown-over-80-of-students-depend-on-mobiles-for-learning-ncert/article32397305.ece

[5] A. Harris and M. Cooper, "Mobile phones: Impacts, challenges, and predictions," *Hum. Behav. Emerg. Technol.*, vol. 1, no. 1, pp. 15–17, 2019, doi: https://doi.org/10.1002/hbe2.112.

[6] ["research-file-download.pdf." Accessed: Dec. 20, 2020. [Online]. Available: https://data.gsmaintelligence.com/api-web/v2/research-file-download?id=39256194&file=2712-250219-ME-Global.pdf

[7] J. A. Roberts, L. H. P. Yaya, and C. Manolis, "The invisible addiction: cell-phone activities and addiction among male and female college students," *J. Behav. Addict.*, vol. 3, no. 4, pp. 254–265, Dec. 2014, doi: 10.1556/JBA.3.2014.015.

[8] V. Sinik, D. Z. Despotovic, S. Stefanov Ketin, and U. Marčeta, "RADIATION OF HIGH FREQUENCY ELECTROMAGNETIC FIELDS BIOLOGICAL EFFECTS AND HEALTH CONSEQUENCES," Oct. 2019.

[9] A. İkinci keleş and C. Uzun Şahin, "Exposure to electromagnetic field, cell phone use behaviors, SAR values, and changes in health following exposure in adolescent university students," *Arq. Neuropsiquiatr.*, vol. 79, no. 2, pp. 139–148, Feb. 2021, doi: 10.1590/0004-282x-anp-2020-0283.

[10] C. Haarala *et al.*, "Pulsed and continuous wave mobile phone exposure over left versus right hemisphere: Effects on human cognitive function," *Bioelectromagnetics*, vol. 28, no. 4, pp. 289–295, 2007, doi: https://doi.org/10.1002/bem.20287.

[11] C.-S. Hung, C. Anderson, J. A. Horne, and P. McEvoy, "Mobile phone 'talk-mode' signal delays EEG-determined sleep onset," *Neurosci. Lett.*, vol. 421, no. 1, pp. 82–86, Jun. 2007, doi: 10.1016/j.neulet.2007.05.027.

[12] K. K. Kesari, A. Agarwal, and R. Henkel, "Radiations and male fertility," *Reprod. Biol. Endocrinol. RBE*, vol. 16, no. 1, p. 118, Dec. 2018, doi: 10.1186/s12958-018-0431-1.

[13] J. Miyakoshi, "Cellular and Molecular Responses to Radio-Frequency Electromagnetic Fields," *Proc. IEEE*, vol. 101, no. 6, pp. 1494–1502, Jun. 2013, doi: 10.1109/JPROC.2013.2248111.

[14] N. Uslu, O. Demirhan, M. Emre, and G. Seydaoğlu, "The chromosomal effects of GSM-like electromagnetic radiation exposure on human fetal cells," *Biomed. Res. Clin. Pract.*, vol. 4, no. 4, 2019, doi: 10.15761/BRCP.1000192.

[15] L. Manti *et al.*, "Effects of modulated microwave radiation at cellular telephone frequency (1.95 GHz) on X-ray-induced chromosome aberrations in human lymphocytes in vitro," *Radiat. Res.*, vol. 169, no. 5, pp. 575–583, May 2008, doi: 10.1667/RR1044.1.

[16] D. Fatehi, M. Anjomshoa, M. Mohammadi, M. Seify, and A. Rostamzadeh, "Biological effects of cell-phone radiofrequency waves exposure on fertilization in mice; an in vivo and in vitro study," *Middle East Fertil. Soc. J.*, vol. 23, no. 2, pp. 148–153, Jun. 2018, doi: 10.1016/j.mefs.2017.10.002.

[17] J. Li, S. Liu, W. Liu, Y. Yu, and Y. Wu, "Suppression of firing activities in neuron and neurons of network induced by electromagnetic radiation," *Nonlinear Dyn.*, vol. 83, no. 1, pp. 801–810, Jan. 2016, doi: 10.1007/s11071-015-2368-7.

[18] "Cell Phones and Cancer Risk Fact Sheet - National Cancer Institute," Jan. 14, 2019. https://www.cancer.gov/about-cancer/causes-prevention/risk/radiation/cell-phones-fact-sheet (accessed Dec. 21, 2020).

[19] K. Cengiz and M. Aydemir, "Next-Generation Infrastructure and Technology Issues in 5G Systems," *J. Commun. Softw. Syst.*, vol. 14, Mar. 2018, doi: 10.24138/jcomss.v14i1.422.

[20] "Aarogya Setu App : COVID-19 Tracker launched to alert you and keep you safe. Download now!," *MyGov.in*, Apr. 03, 2020. https://mygov.in/task/aarogya-setu-app-covid-19-tracker-launched-alert-you-and-keep-you-safe-download-now/ (accessed Dec. 20, 2020).

[21] G. Serra, L. Lo Scalzo, M. Giuffrè, P. Ferrara, and G. Corsello, "Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: cohort study on 184 Italian children and adolescents," *Ital. J. Pediatr.*, vol. 47, p. 150, Jul. 2021, doi: 10.1186/s13052-021-01102-8.

[22] L. R. Kumar, K. D. Chii, L. C. Way, Y. Jetly, and V. Rajendaran, "Awareness of mobile phone hazards among university students in a Malaysian medical school," *Health (N. Y.)*, vol. 03, no. 07, pp. 406–415, 2011, doi: 10.4236/health.2011.37068.

[23] F. Forouharmajd, H. Ebrahimi, and S. Pourabdian, "Mobile Phone Distance from Head and Temperature Changes of Radio Frequency Waves on Brain Tissue," *Int. J. Prev. Med.*, vol. 9, p. 61, Jul. 2018, doi: 10.4103/ijpvm.IJPVM_70_17.

[24] S. Kaplan *et al.*, "Electromagnetic field and brain development," *J. Chem. Neuroanat.*, vol. 75, no. Pt B, pp. 52–61, Sep. 2016, doi: 10.1016/j.jchemneu.2015.11.005.