Polish Annals of Medicine

Journal homepage: https://www.paom.pl

Research Paper

Exposure to electromagnetic radiation related to the change in mode of study and work to a remote form during the COVID-19 pandemic

Weronika Osmala-Kurpiewska, Anna Niesler, Joanna Domagalska, Monika Rusin

Department of Environmental Health, Faculty of Public Health in Bytom, Poland

Article info

Article history
Received: June 12, 2024
Accepted: October 10, 2024
Available online: February 13, 2025

Keywords
children
adults
electromagnetic radiation
COVID-19
remote work
remote learning

Doi
https://doi.org/10.29089/paom/194436

Abstract

Introduction: Due to the COVID-19 pandemic, many employees, students, and children had to switch to remote work and learning. This has led to an increase in the amount of time spent near devices that emit electromagnetic radiation.

Aim: The aim of the study was to determine the exposure to low frequency electromagnetic fields (EMFs) during remote working and learning. In addition, the study attempted to estimate the amount of time spent using computers or laptops and to determine the health effects resulting from exposure to EMF while studying and working remotely.

Material and methods: An original survey of 117 adults working remotely and 53 parents of children studying remotely during the COVID-19 pandemic was conducted between November 2022 and May 2023. The results were analyzed statistically. In addition, measurements of the low frequency EMF that is emitted in residential areas have been conducted.

Results and discussion: Adults and children spent an average of approximately 7 h per day in front of a computer during the pandemic, compared to an average of approximately 3 h per day during the pre-pandemic period ($P < 0.01$). An association was found between the lack of breaks in remote learning and children's irritability.

Conclusions: During the COVID-19 pandemic, the time allowed for working and learning has been significantly extended. The most common health symptoms reported by study participants were headaches, frequent fatigue, and irritability.

Corresponding author: Weronika Osmala-Kurpiewska, Department of Environmental Health, Faculty of Public Health in Bytom, Piekarska 18, 41-902, Bytom, Poland.
E-mail address: wosmala@sum.edu.pl

1. INTRODUCTION

As a result of the 2019 coronavirus pandemic (COVID-19), governments around the world have adopted policies to limit the transmission of the virus by staying home and using social distancing, which has often been referred to as 'lockdown.' While this has contributed to a change in the number of cases, it has had an impact on other aspects of life and other determinants of health.[1] Due to the pandemic, many employees, students and children had to switch to remote work and learning without preparation.[2] According to some data, up to 50% of Europeans could switch to remote working.[3] Since March 2020, more than 90% of the world's children had to switch from lessons in the classroom to remote home-schooling. Many countries have invested in distance learning to mitigate the effects of school closures.[4] The transition to remote working and learning was often associated with the need to purchase additional computer equipment.[5] The use of computers, laptops, tablets, and smartphones has remained constant for several years. However, with the outbreak of the COVID-19 pandemic, the amount of time spent on these devices has increased significantly.[6] These devices, as well as those in homes and apartments, are emitters of electromagnetic waves. In particular, children who had to stay home during the COVID-19 outbreak are believed to have had increased their exposure to electromagnetic radiation (EMR).[7] Radiation is defined as the transmission or emission of energy in the form of waves or particles through space or a material medium.[8] Electromagnetic waves include radio waves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma radiation.[9,10] There are natural and anthropogenic sources of electromagnetic waves emission. Natural sources of EMR emissions include, for example, the sun and atmospheric discharges during a thunderstorm. Anthropogenic sources include, for example, smartphones, TV sets, computers, Wi-Fi routers, radios, microwaves, home electricity and devices connected to the mains, mobile phone base stations, and telecommunication antennas.[7] Non-ionising EMR covers the frequency range from 0 Hz to 300 GHz, and the general population is most commonly exposed to extremely low-frequency electromagnetic fields (ELF-EMF) and radiofrequency electromagnetic fields (RF-EMF). ELF-EMFs are most commonly emitted by household appliances, transmission towers, and high-voltage power lines. Most often, they are related to a frequency of 50–60 Hz.[7,11] RF waves are primarily emitted by mobile phones and mobile phone base stations, including fifth-generation (5G) technologies.[7] Examples of anthropogenic EMR sources are shown in Figure 1.

Figure 1. Examples of anthropogenic sources of EMR.

It should be emphasized that children start using mobile phones and other devices quite early in their childhood, and their exposure will be longer than that of adults.[7] Excessive use of wireless devices raises concerns about EMF exposure.[12] Low-energy electromagnetic waves have little effect on the body, but can cause health problems if the user is close to emission sources and spends more time around them.[9] At present, effects mediated by EMF are considered in the context of thermal and non-thermal effects. In thermal effects, the interaction between EMF fields and living tissues results in energy transfer that leads to an increase in temperature. As a result, the body heats up. For example, the thermal effect can be in the ear or other part of the body when using a developed phone or laptop. Conversely, nonthermal effects are not related to temperature changes, but may contribute to tissue changes depending on the amount of energy absorbed.[7]

2. AIM

The aim of the study was to determine the exposure to low frequency EMF (LF-EMFs) during remote working and learning. In addition, the study attempted to estimate the amount of time spent using computers or laptops and to determine the health effects resulting from exposure to EMF while studying and working remotely.

3. MATERIAL AND METHODS

The study consisted of two parts: a proprietary survey questionnaire and EMF intensity measurements. The author's survey questionnaire was conducted among 117 adults working remotely and 53 parents of children learning remotely during the COVID-19 pandemic in Poland, in Silesian Voivodeship. Overall, 170 surveys were collected. The survey was conducted between November 2022 and May 2023. The survey questionnaire consisted of a metric that included the gender and age of the respondents, as well as single- and multiple-choice and open-ended questions. Questions that were asked of the respondents included, for example, how much time they spent learning and working remotely on the computer before and during the pandemic, and whether the respondents took breaks from remote learning and working. Study participants were asked about health symptoms they experienced while working or studying remotely. For the survey part of the study, statistical analysis was performed using Statistica software (StatSoft, Poland) version 13.3. Because the normality assumption was not met (Shapiro-Wilk test, $P < 0.05$) when comparing the amount of time adults and children spent working or learning remotely at a computer (before and during the COVID-19 pandemic), the nonparametric Mann-Whitney U test was used ($P < 0.01$). Chi-square test was used for other statistical analyses ($P > 0.05$).

The second part of the study consisted of measurements of the intensity of EMFs made with a Narda EHP-50F meter (Germany) in the homes of the participants who consented. EMF measurements were taken in the living areas of multi-family buildings where respondents were most likely to work or learn remotely: kitchens, living rooms, and bedrooms. Measurements of electric and magnetic fields were taken in a total of 50 rooms in multi-family buildings. For the purposes of this publication, the highest measured values are presented (Table 2).

During measurements, the EMF meter was connected to the laptop via fiber optic cable. The EHP-50F was placed on a telescopic fiberglass boom at a height of 130 cm above the ground. The operator was placed at a distance of 2 m from the EMF meter during the test. EMF measurements were made at the frequencies of 100 kHz, 200 kHz, 50 Hz, 100 Hz, 150 Hz, and 200 Hz. The maximum value in the displayed spectrum for both the electric and magnetic fields was recorded at a frequency of 50 Hz. The test involved measuring the root mean square (RMS) magnetic field strengths and the maximum measured value of the electric field.

4. RESULTS

Of the 117 adults who worked remotely, most were between the ages of 36 and 45 (34.19%). The vast majority were women (71.26%). Most of surveyed (59.48%) got university education. The majority of respondents reported that they live in multi-family buildings (65.81%). An analysis of the age of the children of the parents surveyed shows that 47.17% of the children were 6–12 years old and 52.83% were 13–18 years old. In the study population, the female children were 49.06% and the male children – 50.94%. Most of the children lived in multi-family buildings (77.36%). More than half of the adult respondents (90; 76.92%) spent a total of 1–3 h in front of a computer or laptop prior to the COVID-19 pandemic (Table 1). A similar amount of time was reported by the parents of children studying at a distance (28; 52.83%). During the COVID-19 pandemic, both adults (56; 47.86%) and children (26; 49.06%) spent between 7 h and 9 h studying and working remotely using devices. In total, 24.79% of adults spent more than 10 h using a computer or laptop. This situation also affected 12 children (22.64%). Also 28 adults (23.93%) reported that they did not take a break while working remotely. The remaining adults were taking a break from work – at the EMF-emitting device (39; 33.33%) and away from EMF-emitting devices (50; 42.74%). In the case of the children, parents reported that only 7 children did not take a break from remote learning (13.21%); 18 children (33.96%) spent their break with the EMF-emitting device. Most adults (51.28%) who worked remotely usually sit 30–40 cm away from the monitor/laptop. The children's parents reported that 23 children (43.40%) used a monitor/laptop at a distance of 30–40 cm and 24 children (45.28%) at a distance of 40–50 cm. Respondents were asked which room in their

Table 1. Responses from survey participants, *n*(%).

Questions	Adult responses (remote work), $n = 117$	Parent responses (children's remote learning), $n = 53$
How much total time (h) did you spend in total in front of a desktop or laptop computer at your home before the beginning of the COVID-19 pandemic?		
1–3 h	90(76.92)	28(52.83)
4–6 h	16(13.68)	23(43.40)
7–9 h	7(5.98)	2(3.77)
>10 h	4(3.42)	0(0)
How much total time (hours) did you spend in front of a desktop or laptop computer at your residence during the COVID-19 pandemic?		
1–3 h	15(12.82)	3(5.66)
4–6 h	17(14.53)	12(22.64)
7–9 h	56(47.86)	26(49.06)
>10 h	29(24.79)	12(22.64)
Did you take breaks from performing your duties while working remotely?		
No	28(23.93)	7(13.21)
Yes, but with an EMF emitting device	39(33.33)	18(33.96)
Yes, away from the EMF-emitting device	50(42.74)	28(52.83)
How far is the monitor/laptop from you when you use it?		
< 25 cm	10(8.55)	5(9.43)
30–40 cm	60(51.28)	23(43.40)
40–50 cm	43(36.75)	24(45.28)
> 60 cm	4(3.42)	1(1.89)
In which room of your house/apartment is the remote workstation located?		
In the kitchen	15(12.82)	3(5.66)
In the living room	75(64.10)	20(37.74)
In the bedroom	18(15.38)	6(11.32)
In another room (e.g. office/ child's room)	9(7.69)	24(45.28)
In which room of your house/apartment are most of the devices that emit electromagnetic radiation located?		
In the kitchen	34(29.06)	10(18.87)
In the living room	73(62.39)	33(62.26)
In the bedroom	8(6.84)	6(11.32)
In another room (e.g. office/ child's room)	2(1.71)	4(7.55)
How long during the day do you spend in the room in your house/ apartment where most of the electromagnetic radiation emitting devices are located?		
About 2 h	21(17.95)	20(37.74)
2–5 h	28(23.93)	14(26.41)
More than 5 h	68(58.12)	19(35.85)
Did you use a desktop/laptop computer on the same day after completing remote work? If yes, please indicate how long (h).		
No	71(60.68)	20(37.74)
Yes, 1–2 h	33(28.21)	16(30.19)
Yes, 3–4 h	11(9.40)	15(28.30)
Yes, 5–6 h	2(1.71)	2(3.77)

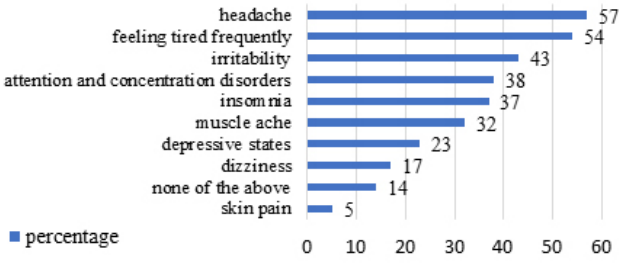

Figure 2. Frequency of health symptoms during remote work among adult respondents (n = 117).

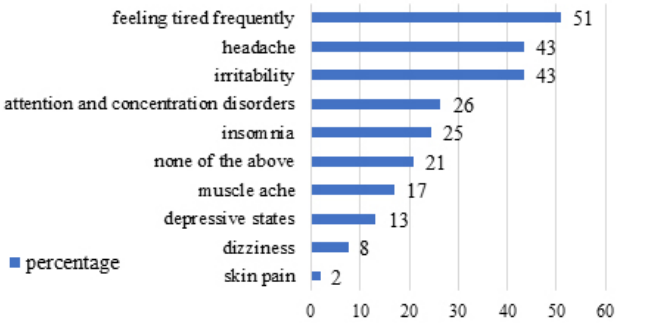

Figure 3. Prevalence of health symptoms when working remotely among 53 children (parents' responses).

home or apartment they use for remote working or learning. The vast majority of adults (64.10%) worked remotely in the living room. Adults (62.39%) reported having the most EMF-emitting devices in the living room. The smallest number of respondents worked remotely in another room, such as an office (9; 7.69%). In turn, the majority of the children's parents (24; 45.28%) reported that the children studied remotely in the children's room. In total, 37.74% of the children surveyed studied remotely in the living room. According to the parents' responses, it was also a room with the largest number of emitting devices. Respondents were asked how much time the adults or children of the parents surveyed spent in the room with the devices that emitted the most EMFs. Up to 68 adults (58.12%) spent more than 5 h per day in this room. For the children, it was about 2 h per day (37.34%). Slightly fewer parents (35.74%) reported that their children spent more than 5 h in the room with the most EMF-emitting devices. We wanted to find out if adults and children used a computer or laptop the same day after remote working or learning. It turned out that the vast majority of adults (71; 60.68%) did not use this device. In the case of parents, the responses were more varied. In total, 37.74% of respondents reported that their children did not use a computer/laptop on the same day; 30.19% of parents reported that their children used these devices for 1–2 after their remote learning session and 28.30% reported that they used them for 3–4 h. Only 3.77% of the children surveyed used them for 5–6 h (Table 1).

Adults (117) working remotely were asked what health symptoms they experienced while working. They could mark as many answers as they wanted. Most of the respondents (57.26%) experienced headaches. A slightly smaller percentage of respondents (54.32%) reported feeling tired; 43.21% of them reported feeling irritated and 38.29% of the adults had attention and concentration difficulties. Skin pain was experienced by the fewest respondents (5.25%) (Figure 2).

In turn, parents of children (53) responded to the same question that their children often felt tired during remote learning (50.85%), followed by headaches (42.75%) and irritability (42.70%). The fewest number of parents reported that they had observed dizziness (8.02%) and skin pain (2.26%) in their children (Figure 3).

Time spent in front of the computer before and during the pandemic was compared. Since the normality assumption was not met (Shapiro-Wilk test, $P < 0.05$), the non-parametric Mann-Whitney U test was used. The analysis showed that adults and children spent much more time using computers during the pandemic (about 7 h per day on average) than they did before the pandemic (about 3 h per day on average) (Mann-Whitney U test, $P < 0.01$) (Figures 4 and 5).

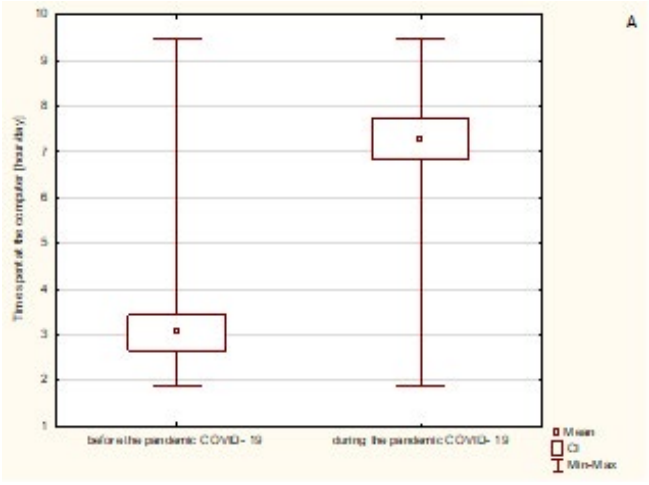

Figure 4. Comparison of the amount of time adults spent working remotely at a computer before and during the pandemic COVID-19. Comments: CI – confidence interval

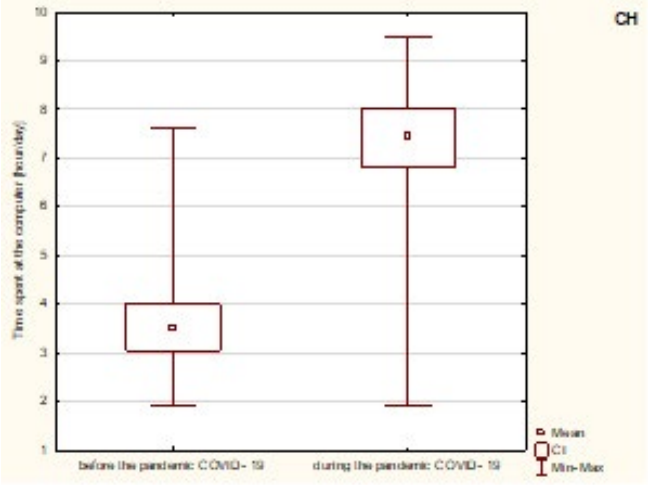

Figure 4. Comparison of the amount of time children spent remotely learning at a computer before and during the pandemic COVID-19. Comments: CI – confidence interval

An association has been found between taking breaks in remote learning near the EMF-emitting device and the occurrence of irritability in children (chi-square test, $P = 0.029$; coefficient $\phi = -0.32$). Of the children who took breaks during the remote learning sessions but did not move away from the EMF-emitting device, up to 61.1% of them showed signs of irritability. For comparison, of the children who took breaks during the remote learning sessions and spent that time away from the EMF-emitting device, only 28.6% of them showed signs of irritability. For other symptoms, such as headache, dizziness, skin pain, attention and concentration difficulties, depression, frequent fatigue, and insomnia, no such association was found (chi-square test, $P > 0.05$). The occurrence of these symptoms in adults was not associated with taking breaks from work near the EMF-emitting device (chi-square test, $P > 0.05$). There was also no relationship between the distance from the screen during remote working/learning and the symptoms (chi-square test, $P > 0.05$). The analysis conducted did not show any association between the occurrence of chronic diseases (e.g. cardiovascular disease, asthma, type II diabetes, hypothyroidism) and remote work/learning in a room with other devices that emit EMF, the amount of time spent in a room with the highest number of such devices, and the use of a computer after remote work (adults) or remote learning (children) (chi-square test, $P > 0.05$).

Measurements were made of the EMF emitted in the low-frequency range in residential areas. With reference to the current Regulation of the Minister of Health of December 17, 2019 on permissible levels of EMFs in the environment (Journal of Laws of 2019, item 2448), the measured values of electric and magnetic fields were not exceeded.[13] Measurements showed that in residential areas (kitchen, living room, bedroom), the emission of the electrical component at the frequency of 50 Hz was dominant. The highest value was measured in the kitchen (80.16 V/m) and the lowest in the bedroom (4.97 V/m). In addition, a time-weighted average (TWA) was calculated based on the maximum time (9 h) spent on a desktop or laptop computer during the COVID-19 pandemic, which was reported by the majority of adult respondents (47.86%) and parents of children (49.06%) – Table 1, question 2 (Table 2).

5. DISCUSSION

Many governments and world organizations have implemented preventive measures, including mandatory lockdown, social distancing, and quarantine. Employees and students were

Table 2. Results of measurements of magnetic and electric fields in residential areas.

Room type	Frequency											
	100 kHz		200 kHz		50 Hz		100 Hz		150 Hz		200 Hz	
	V/m	A/m	V/m	A/m	V/m	A/m	V/m	A/m	V/m	A/m	V/m	A/m
Kitchen	0.3	0.00	0.02	0.00	12.22	0.04	0.40	0.01	0.23	0.01	0.01	0.00
	0.01	0.00	0.03	0.00	80.16	0.15	0.12	0.00	0.63	0.03	0.10	0.01
	0.04	0.00	0.05	0.00	60.75	0.18	0.10	0.00	0.64	0.02	0.08	0.00
	0.02	0.00	0.01	0.00	17.16	0.07	0.13	0.00	0.02	0.01	0.03	0.00
	0.03	0.00	0.04	0.00	33.17	0.18	0.07	0.00	0.42	0.02	0.06	0.00
Living room	0.4	0.00	0.04	0.01	5.63	0.05	0.05	0.00	0.16	0.05	0.01	0.00
	0.03	0.00	0.02	0.00	6.06	0.06	0.50	0.00	0.32	0.04	0.06	0.00
	0.04	0.00	0.03	0.00	58.99	0.13	0.00	0.00	0.62	0.02	0.08	0.00
	0.04	0.00	0.01	0.00	7.55	0.09	0.13	0.00	0.09	0.02	0.04	0.00
	0.01	0.00	0.03	0.00	25.10	0.14	0.33	0.00	0.87	0.00	0.18	0.00
Bedroom	0.4	0.00	0.03	0.00	5.34	0.08	1.83	0.01	0.07	0.01	0.03	0.00
	0.02	0.00	0.04	0.00	4.97	0.05	1.75	0.01	0.17	0.06	0.01	0.00
	0.03	0.00	0.04	0.00	41.88	0.12	0.09	0.00	0.35	0.02	0.07	0.00
	0.02	0.00	0.03	0.00	7.45	0.08	0.13	0.00	0.09	0.02	0.03	0.00
	0.01	0.00	0.03	0.00	5.16	0.11	0.73	0.00	0.02	0.00	0.15	0.00
Children's room	0.2	0.00	0.04	0.00	24.17	0.12	0.08	0.00	0.05	0.00	0.01	0.00
	0.01	0.00	0.02	0.00	6.56	0.10	0.05	0.00	0.45	0.01	0.03	0.00
	0.03	0.00	0.01	0.00	5.40	0.09	0.00	0.00	0.21	0.00	0.01	0.00
	0.01	0.00	0.03	0.00	12.45	0.06	0.00	0.00	0.02	0.00	0.03	0.00
	0.02	0.00	0.01	0.00	21.75	0.13	0.00	0.00	0.18	0.02	0.04	0.00
Max. value	0.40	0.00	0.05	0.01	80.16	0.18	1.83	0.01	0.87	0.06	0.18	0.01
Min. value	0.01	0.00	0.01	0.00	4.97	0.04	0.00	0.00	0.02	0.00	0.01	0.00
TWA	0.40	0.00	0.06	0.01	90.18	0.20	2.06	0.01	0.98	0.07	0.20	0.01

encouraged to work and study at home.[14–16] This has contributed to adults and children spending more time at home with screen devices. Pisot et al. showed that participants in their study reported 65% more screen time.[17] In our study, we found that adults and children spent an average of about 7 h per day using computers during the pandemic, compared to an average of about 3 h per day during the pre-pandemic period (Mann-Whitney U test, P <0.01). Many employees and students were forced to perform their duties in modified conditions – at the kitchen table, in the living room, or in the bedroom.[18] In our study, we found that adults most often worked remotely in the living room (64.10%). It was also the room where adults (62.39%) reported having the most EMF-emitting devices. On the other side, children most often studied in their (children's) room (45.28%). Parents reported that most EMF-emitting devices were in the living room (62.26%). The outbreak of the COVID-19 pandemic has created significant challenges for employees and students, primarily due to concerns about their mental health.[16] It was found that the children who spent a lot of time at home had a lack of friendship and a sense of loneliness. They suffered from sadness, anxiety, sleep problems, and depression.[19,20] In our study, we asked adults who worked remotely and parents of children who learned remotely during the COVID-19 pandemic what health symptoms they observed while performing their duties (working or learning remotely); they could give many answers. Adults most commonly reported headaches (57%), frequent fatigue (54%) and irritability (43%). In total, 23% of adults reported depressive symptoms. In the case of the children, the most frequent symptoms were fatigue (51%), headache and irritability (43%). Depressive symptoms affected 13% of children. Working and learning remotely could be very important in the context of the health symptoms mentioned above. The aforementioned health symptoms may be related to electromagnetic hypersensitivity (EMH); however, the exact mechanism behind the occurrence of these symptoms, including headaches after exposure to electromagnetic fields, remains unknown.[21] Corpley et al. showed that the lack of frequent breaks during the working day was associated with an increased risk of reporting headaches, and those who reported less frequent breaks were twice as likely to report headaches compared to those who reported frequent breaks during the day.[18] In our study, we found that nearly 24% of adults surveyed do not take breaks while working remotely. The remaining people took a break from work (76.07%), of which 42.74% took a break from work away from the EMF-emitting device. A similar trend was observed for children: 13.21% of children did not take a break from remote learning. The rest of the children took a break from learning, 52.83% of them away from the EMF-emitting device. Importantly, our study showed an association between the lack of breaks from remote learning and irritability in children (61.1%). There are a small number of studies that address the issue of EMF exposure during the COVID-19 pandemic. And this is justified because of the extension of the time of use of EMF-emitting devices, not only laptops and computers, but also smartphones and tablets.[22] In our survey, 100% of adult respondents and 100% of parents of children said they had a smartphone at work and at a remote learning location. Serra et al. showed an increase in smartphone use among Italian children and adolescents during the COVID-19 pandemic to the pre-epidemic period, and a significant increase in abuse and addiction was observed. In addition, adverse clinical changes have been observed, including sleep and visual disturbances, and psychological effects (distraction, mood changes, loss of interest).[23] Many of the devices in everyday use emit not only low level EMFs, but also high level EMFs (RF-EMFs). A major limitation of our own research was measuring EMF only at low frequencies. However, it is worth noting that the house is dominated by the emission of electromagnetic fields at 50 Hz frequency from many devices. Currently, the International Agency for Research on Cancer identifies ELF-EMF and RF-EMF as potentially carcinogenic to humans (Group 2B). Therefore, exposure to weak EMFs may be of concern.[12] Low-energy EMFs are believed to have minimal impact on the body, although prolonged exposure can lead to health issues.[8] This is particularly important in the context of children's health, as they are believed to be more sensitive to EMFs than adults. For example, the nervous system of children is more sensitive to EMFs than adults.[24] They also have thinner skull bones and higher water content in brain tissue, which may contribute to greater susceptibility to EMR.[25,26] Some epidemiological studies show that the incidence of childhood leukemia and brain cancer is higher in children exposed to EMFs.[12]

5.1. Recommendations for public health

Although there are not many studies that explain the effects of low-frequency field emissions on children's health, even the smallest impact should not be overlooked. Given the limited research, it seems important to stay as far away as possible from sources that produce EMF and to use them for as short a time as possible (ALARA principle). There are also methods to limit exposure to EMFs that can be used when working and learning remotely in a home or apartment; including:

1. Study and remote work stations should be furnished with desks made of natural materials that do not retain electrical charges.
2. Remote work and learning stations should be positioned away from walls containing electrical wiring or where there is a significant amount of equipment (e.g., kitchen appliances).
3. The distance from the computer monitor should be as large as possible – the intensity of EMR decreases with the square of the distance.
4. For remote work and study, it is recommended to utilize natural light to minimize the need for artificial lighting. However, if artificial lighting is necessary, it is preferable to use LED lighting due to its low electromagnetic emissions and high energy efficiency.
5. Shielded cables should be utilized whenever feasible to reduce electric field emissions.[27]

5. CONCLUSIONS

1. Time spent working and studying on a computer or laptop increased significantly during the COVID-19 pandemic.
2. The most common subjective health symptoms reported by adult study participants were headache, feeling tired frequently and irritability. For children, the most common health symptoms reported by parents as a result of remote learning were feeling tired frequently, headache and irritability.
3. Children should take breaks from remote learning away from EMF emitters – this reduces the likelihood of irritability in children.
4. It is recommended that research into the effects of low- and high-frequency EMFs emitted by everyday devices be continued, taking into account external sources of EMF emissions.

Conflict of interest
None declared.

Funding
Scientific Research PCN-1-032/N/1/Z.

Ethics
The study did not require the approval of the Bioethics Committee (letter PCN/CBN/0052/KB/198/22 to the Bioethics Committee of the Medical University of Silesia in Katowice). All methods were carried out in accordance with relevant guidelines and regulations and consent was obtained from the participants to conduct the study.

Acknowledgement
All the authors of this publication would like to express their gratitude to the reviewers for their valuable comments and suggestions.

References

1 Chiesa V, Antony G, Wismar M, Rechel B. COVID-19 pandemic: health impact of staying at home, social distancing and 'lockdown' measures-a systematic review of systematic reviews. *J Public Health (Oxf)*. 2021;43(3):e462-e481. https://doi.org/10.1093/pubmed/fdab102.

2 Galanti T, Guidetti G, Mazzei E, Zappalà S, Toscano F. Work From Home During the COVID-19 Outbreak: The Impact on Employees' Remote Work Productivity, Engagement, and Stress. *J Occup Environ Med*. 2021;63(7):e426-e432. https://doi.org/10.1097/JOM.0000000000002236.

3 Eurofound (2020), Living, working and COVID-19, COVID-19 series, Publications Office of the European Union, Luxembourg. https://www.stackscale.com/wp-content/uploads/2021/04/living-working-covid-19-ef20059en.pdf. Accessed: 2023.11.15.

4 Mascheroni G, Saeed M, Valenza M, et al. Learning at a Distance: Children's remote learning experiences in Italy during the COVID-19 pandemic, Innocenti Research Report, UNICEF Office of Research – Innocenti, Florence. https://www.unicef-irc.org/publications/1182-learning-at-a-distance-childrens-remote-learning-experiences-in-italy-during-the-covid-19-pandemic.html. Accessed 2023.11.15.

5 Ford D, Storey MA, Zimmermann T, et al. A tale of two cities: software developers working from home during the COVID-19 pandemic. *ACM Trans Softw Eng Methodol*. 2021;31(2):1–37. https://doi.org/10.1145/3487567.

6 Bahkir FA, Grandee SS. Impact of the COVID-19 lockdown on digital device-related ocular health. Indian *J Ophthalmol*. 2020;68(11):2378–2383. https://doi.org/10.4103/ijo.ijo_2306_20.

7 Karaca S. Children are more exposed to electromagnetic radiation in covid-19 lockdown: A literature review. *IJPH*. 2023;18(1):169–178. https://doi.org/10.20473/ijph.v18i1.2023.169-178.

8 Tripathi H. Thermal distribution in different tissues due to mobile phone tower at 800 MHz. *Int J Environ Sci*. 2015;4:35–45.

9 Wdowiak A, Mazurek PA, Wdowiak A, Bojar I. Effect of electromagnetic waves on human reproduction. *Ann Agric Environ Med*. 2017;24(1):13–18. https://doi.org/10.5604/12321966.1228394

10 Sowa P, Rutkowska-Talipska J, Sulkowska U, Rutkowski K, Rutkowski R. Electromagnetic radiation in modern medicine: Physical and biophysical properties. *Pol Ann Med*. 2012;19(2):139–142. https://doi.org/10.1016/j.poamed.2012.07.002.

11 Mahmoudinasab H, Saadat M. Expression levels of PDYN and OPRM1 genes in SH-SY5Y cells exposed to 50 Hz electromagnetic field. *Pol Ann Med*. 2019;26(1):36–40. https://doi.org/10.29089/2017.17.00038.

12 Redmayne M. International policy and advisory response regarding children's exposure to radio frequency electromagnetic fields (RF-EMF). *Electromagn Biol Med*. 2016;35(2):176–185. https://doi.org/10.3109/15368378.2015.1038832.

13 Regulation of the Minister of Health of 17 December 2019 on permissible levels of electromagnetic fields in the environment, *Journal of Laws R.P.* [Dz. U.], 19/12.2019, Item 2448.

14 Tyagi A, Prasad AK, Bhatia D. Effects of excessive use of mobile phone technology in India on human health during COVID-19 lockdown. *Technol Soc*. 2021;67:101762. https://doi.org/10.1016/j.techsoc.2021.101762.

15 Wang B, Liu Y, Qian J, Parker SK. Achieving effective remote working during the COVID-19 pandemic: A work design perspective. *J Appl Psychol*. 2021;70(1):16–59. https://doi.org/10.1111/apps.12290.

16 Liu W, Xu Y, Ma D. Work-related mental health under COVID-19 restrictions: A mini literature review. *Front Public Health*. 2021;9:788370. https://doi.org/10.3389/fpubh.2021.788370.

17 Pišot S, Milovanović I, Šimunič B, et al. Maintaining everyday life praxis in the time of COVID-19 pandemic measures (ELP-COVID-19 survey). *Eur J Public Health*. 2020;30:1181–1186. https://doi.org/10.1093/eurpub/ckaa157.

18 Cropley M, Weidenstedt L, Leick B, Sütterlin S. Working from home during lockdown: the association between rest breaks and well-being. *Ergonomics*. 2023;66(4):443–453. https://psycnet.apa.org/doi/10.1080/00140139.2022.2095038.

19 Jiao WY, Wang LN, Liu J, et al. Behavioral and emotional disorders in children during the COVID-19 epidemic. *J Pediatr*. 2020;221:264–266.e1. https://doi.org/10.1016/j.jpeds.2020.03.013.

20 Yeasmin S, Banik R, Hossain S, et al. Impact of COVID-19 pandemic on the mental health of children in Bangladesh: A cross-sectional study. *Child Youth Serv Rev*. 2020;117:105277. https://doi.org/10.1016/j.childyouth.2020.105277.

21 McCarty DE, Carrubba S, Chesson AL, et al. Electromagnetic hypersensitivity: Evidence for a novel neurological syndrome. *Int J Neurosci*. 2011;121(12):670–676. https://doi.org/10.3109/00207454.2011.608139.

22 Bakhtiar Choudhary MS, Choudary AB, Jamal S, Kumar R, Jamal S. The impact of ergonomics on children studying online during COVID-19 lockdown. *J Adv Sport Phys Edu*. 2020;3(8):117–120. 10.36348/jaspe.2020.v03i08.001.

23 Serra G, Lo Scalzo L, Giuffrè M, Ferrara P, Corsello G. Smartphone use and addiction during the coronavirus disease 2019 (COVID-19) pandemic: Cohort study on 184 Italian children and adolescents. *Ital J Pediatr*. 2021;47:150. https://doi.org/10.1186/s13052-021-01102-8.

24 Mustafa N. Impact of the 2019–20 coronavirus pandemic on education. *Int J Health Prefer*. 2020;1–12.

25 Gandhi OP. Yes the children are more exposed to radiofrequency energy from mobile telephones than adults. *IEEE Access*. 2015;3:985–988. https://doi.org/10.1109/ACCESS.2015.2438782.

26 Warille AA, Onger ME, Turkmen AP, et al. Controversies on electromagnetic field exposure and the nervous systems of children. *Histol Histopathol*. 2016;31(5):461–468. https://doi.org/10.14670/hh-11-707.

27 Algumbari GA, Nagy G. Interior Design Guidelines for Reducing the Negative Impacts of Electromagnetic Fields at Residential Workspace. *IOP Conf Ser Earth Environ Sci*. 2022;1056:012005. https://doi.org/10.1088/1755-1315/1056/1/012005.