Literature Review

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CHILDREN ARE MORE EXPOSED TO ELECTROMAGNETIC RADIATION IN COVID-19 LOCKDOWN: A LITERATURE REVIEW

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ABSTRACT

Introduction: The COVID-19 pandemic has significantly affected people's quality of life. Unfortunately, the epidemic continues in various variants and it remains unclear how long it will continue. Children staying at home in the COVID-19 quarantine spent hours in front of the screen with online education. In addition, since they could not go out, they spent their free time in front of the screen using social media, playing computer games or watching movies. The aim of this study is to investigate the effects of low-level electromagnetic radiation (EMR) that children are exposed to at home during the COVID-19 quarantine. **Method**: The research method is literature review. **Results:** Studies have shown that, during the quarantine period, children's use of telecommunication devices such as televisions, tablets, smartphones and computers greatly increases. It was determined that the range of radio frequency (RF), Wi-Fi, power lines, visible light and Bluetooth increased in the home environment. The electric and magnetic fields emitted from these devices contain EMR and can seriously harm the health of children, who are structurally more sensitive than adults. **Conclusion:** There are growing concerns that children staying at home during the COVID-19 pandemic will face health hazards in the future as they are more exposed to EMR.

Keywords: Children, COVID-19 Lockdown, Electro-Magnetic Radiation

INTRODUCTION

After December 2019, a new disease caused by a coronavirus (COVID-19) emerged in Wuhan, the capital of Hubei Province in China. As this disease can spread through human-to-human contact, the number of detected cases has increased rapidly (Chan et al., 2020). Countries have used physical distancing policies to deal with the spread of COVID-19. Many educational institutions, schools, and colleges were closed (Bakhtiar Choudhary et al., 2020; van Lancker and Parolin, 2020). The post-COVID-19 lockdown prevented face-to-face education in nearly 191 countries, and in many countries this process took more than 41 weeks. These closures affected approximately 99.4 percent of the world's student population and changed the lifestyle of approximately 1.5 billion children (UNESCO, 2020, 2021). COVID-19 has forced children to stay indoors. Educational institutions started using Internet-based technology to reach and interact with students after the COVID-19 restriction. Countries have tried to compensate for children's education with television (TV) broadcasting and an online home-schooling system (Guan et al., 2020a; Pombo et al., 2021). Children's use of smartphones, tablets, laptops, or desktops has increased with the transition to the home education system (Bakhtiar Choudhary et al., 2020).

Computer, radio, tablets, TV, Wi-Fi, and smartphones emit RF waves, which are electric and magnetic fields of RF propagating in the atmosphere. These electromagnetic (EM) waves are induced by the electric field at the earth's surface and contain radiation (Batool et al., no date; Kumar, Ahmad and Sharma, 2010). Although devices emitting EMR are the most effective means of communication, EMR can be absorbed by the human body and cause mental, nervous, cardiovascular diseases, and cancer (Kumar, Pathak and Kangri Vishwavidyalaya, 2008; Vorobyov et al., 2010)

Children who had to stay at home during the epidemic have increased their

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exposure to EMR. In this article, we will discuss the low-level radiation sources that children are exposed to at home during the COVID-19 quarantine and their health effects.

METHODS

The research method was literature review. The data were collected through literature study from various literature sources (journals and others) related to the research subject. Qualitative research method was used in the study.

RESULTS

Electromagnetic Radiation

Radiation is the transmission or emission of energy in the form of waves or particles through space or material medium (Tripathi, 2015). EMR consists of EM waves, which are synchronized oscillations of EM fields (EMF) propagating at the speed of light in a vacuum. EM waves are radio waves, infrared radiation (IR), visible light, ultraviolet radiation (UV), X-ray, and gamma rays. EM waves are a form of radiation from ultra-high-energy cosmic rays and gamma rays with a frequency of 1018 Hz to low-energy microwave radiation of 10 GHz or radio waves of 100 MHz (Wdowiak et al., 2017).

EM sources are found in the world both naturally and as human-made. Natural EM sources include the sun, some distant stars, world magnetic fields, and atmospheric discharges such as thunder. The world magnetic field at its surface ranges from 25 to 65 μT or 0.25 to 0.65 G (G; Gauss and T; Tesla) (Finlay et al., 2010). Human-made (or unnatural) EM sources include smartphones, TV, computers, Wi-Fi, radio, microwave, electrical current in the house, base stations, telecommunications antennas (Hossmann and Hermann, 2003; Avendaño et al., 2012)

EMR with low frequencies (LF) is called non-ionizing radiation. Radiation emitted from many electrically operated household appliances are non-ionizing radiation (Wisz, 2002). Non-ionizing EMR falls into two basic categories. The first of these is extremely low frequency (ELF) and the other is RF waves. In recent years, high voltage power lines or transmission towers have been used to generate ELF-EMF. ELF-EMFs are generated from electricity, electrical machinery, transmission towers, and high voltage lines. The ELF operates in the range of 3–300 Hz and mostly at an average frequency of 50–60 Hz (de Groot, Kock and Westerink, 2014). RF waves can be generated from mobile phones, base stations, and radars. Such devices operate in the frequency range of 100 kHz–300 GHz (D'Andrea, Ziriax and Adair, 2007). Radio or TV transmitters and base stations can be significant sources of RF exposure.

Developing 5th generation (5G) Technologies are also among the RF sources. 5G frequency occurs between 3.5 GHz and 28 GHz (Moon, 2020). Microwave communication links operate in frequency bands between 1GHz and 60 GHz. IR, visible light, and UV light have frequencies over 300 GHz (Zamanian and Hardiman, 2005). Table 1 presents some EMF sources and frequency ranges. People are exposed to natural EMR every day, whether they want it or not. In addition to natural EMR, due to developing technology, many people are exposed to human-made EMR with the environment they are in and the technological devices they use (Carlberg et al., 2019).

Table 1. EMF sources and frequency range. National Cancer Institute (NCI) Fact Sheet "Electromagnetic Fields and Cancer" Electromagnetic spectrum

Sources	Frequency Range	EMF category
Power Lines	50-60 Hz	ELF-EMF
Computer	60-100Hz	ELF-EMF
AM Radio	520-1610kHz	ELF-EMF/RF-EMF
FM Radio	87.5-108MHz	RF-EMF

Sources	Frequency Range	EMF category
TV Broadcast	54-700MHz	RF-EMF
Smart Meter	0.9-2.45 GHz	RF-EMF
Mobile Phone	1.9-2.2 GHz	RF-EMF
Wi-Fi	2.4-2.5GHz /5-5.8GHz	RF-EMF
Remote Control	5,8GHz	RF-EMF
Microwave	3-30GH	MW-EMF
Infrared and Ultraviolet	Above 300 GH	IR-EMF/ UV-EMF

Hz: Hertz (kHz: kilohertz=103Hz; MHz: Megahertz s=106Hz; GHz: Gigahertz=109Hz)

Internet and Children

The history of the Internet dates back to the early 1960s. In 1983, 500 computers were able to connect to the Internet, and this number increased to 1024 computers in 1984. In the 1990s, the accessibility, multiple applications, and decentralized nature of the Internet began to grow and develop rapidly. After 1998, approximately 150 million people, representing approximately 2.5 percent of the world's population, were using the Internet in more than 60 countries. In 2000, 361 million people were connected to the Internet on their computers (Cohen-Almagor, 2011). With the development of mobile phones, the first smartphone with many features such as e-mail, Internet, fax, web browsing, and camera was produced in 2007 and became rapidly widespread (Gowthamip and Venkatakrishnakumarp, 2016). Currently, as of January 2021, there are 4.66 billion active Internet users worldwide (59.5 percent of the global population); 92.6 percent (4.32 billion) of this total have access to the Internet from their mobile devices (Statista, 2021).

Developing technology has made the Internet an indispensable part of our lives. Studies have reported large increases in children's mobile phone ownership in recent years (Böhler and Schüz, 2004). Some factors today (decreased prices, increased Internet network coverage, increasing popularity, advertisements for children, applications, games, etc.) have greatly increased the use of mobile devices among children (Schüz, 2005). Children have started to spend hours on smartphones, tablets, and laptops (Markov and Grigoriev, 2015). Rapid developments in EMF technologies and communication have led children to be exposed to EMFs at an increasingly early age (Kheifets et al., 2005). Since today's children start using mobile phones at an early age, they will be exposed to RF fields from mobile phone use for a longer period than adults.

COVID-19 and Transition to Online Education

The consequences of the COVID-19 epidemic, which emerged in 2019, spread rapidly and caused the death of many people, and continue to negatively affect societies. The World Health Organization (WHO) declared COVID-19, which emerged on March 15, 2020, a global epidemic. The COVID-19 virus is transmitted from person to person through coughing, sneezing, respiratory droplets or close contact with an infected person (Chakraborty and Maity, 2020; Phan et al., 2020). Along with pharmaceutical interventions, social distancing has been an important tool to slow the spread of COVID-19 (Eubank et al., 2020). After the epidemic, many countries began to take unprecedented measures. To prevent social interaction, they closed shopping malls, restaurants and shops, cancelled social activities and forced the public to stay in their own homes. Although the COVID-19 symptoms seem less severe in children, they were heavily affected by the epidemic (Zimmermann and Curtis, 2021). Children staying at home were also deprived of friendships and physical activities (Jiao et al., 2020; Moore et al., 2020). Various problems such as feeling of loneliness,

depression, anxiety, tension, sadness and sleep problems have occurred in children (Yeasmin et al., 2020; Pierce et al., 2021).

After the rapid spread of COVID-19, educational institutions preferred to close traditional (face-to-face) teaching activities to prevent the spread of the virus, transferring their teaching activities online (Butnaru et al., 2021).China, the first country where the COVID-19 epidemic started, became the first country to switch to online education during the closure period, with the strategy of "nonstop teaching and learning". In a short time, millions of students had to stay at home and take classes online (Bao, 2020; Guan et al., 2020b) . Afterwards, all developed countries switched to online education to facilitate learning and save time. But in developing countries, the transition to e-learning has not been easy. People living in developing countries such as Pakistan have limited computer and Internet access (Sattar Khan et al., 2011; Mustafa, 2019). Social and civil society organizations of some countries provided access to computers, tablets, and the Internet for those who did not have a means of communication at home. For example, Colombia provided free online access for education and training to continue online. Many countries such as Chile, Greece and Portugal offered many services such as laptop and Internet package increase (OECD, 2020). Therefore, during the COVID-19 process, children and adolescents have had more access to the Internet and use Internet-enabled devices for significantly longer. It is also revealed that some children who have never had Internet access before also encountered extra EMF with the COVID-19 epidemic. Some of the EMF sources to which children are exposed appear in Figure 1.

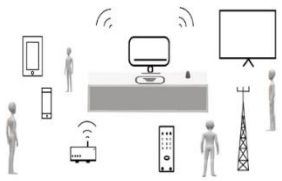

Figure 1. Some of the EMF sources that children are exposed to

Biological Effects of EMFs on Children

The rapid development of satellite communication, then wireless communication, and recently Wi-Fi technology significantly affects the electromagnetic environment that people are exposed to in daily life (Kheifets et al., 2005). Surprisingly excessive use of wireless devices by children raises concern about children's low-dose EMF exposure (Redmayne, 2016). When low-energy EM waves penetrate the organism, EM can be absorbed by organisms (Vorobyov et al., 2010). There are not many studies investigating the biological effects of low frequency (ELF) radiation on humans (Santini, Rainaldi and Indovina, 2009; Cifra, Fields and Farhadi, 2011). Low-energy EM waves have a low effect on the organism, but they may cause health problems as the user approaches and spends more time (Tripathi, 2015). Exposure to EMF can cause a series of biological, physiological, and functional changes in the organism (Vorobyov et al., 2010; Singh and Kapoor, 2014; Schoeni, Roser and Röösli, 2015).

The biological effects caused by EMF can be determined as thermal and non-thermal effects. In the thermal effect, every interaction between EMF fields and living tissues creates an energy transfer that causes an increase in temperature (Megha et al., 2012). This interaction causes the body tissues to heat up and a heat load is imposed on the whole body ("ICNIRP_STATEMENT_ON_THE__GUIDELINES_FOR_LIMITING.9 (1)," no date). For example, warm sensations may occur in the ear or part of the body during cell phone or laptop computer use. Non-thermal effects, on the other hand, are not directly related to temperature changes, but include some other changes in tissues depending on the amount of energy absorbed. Electromagnetic hypersensitivity syndrome or neurodevelopmental disorders are examples. The non-thermal effects of EMF are the least researched topic (Challis, 2005; Kheifets et al., 2005). Some studies

show that excessive cell phone use and prolonged exposure to microwave radiation cause many thermal and non-thermal effects such as skin effects, infertility, brain problem, stress, mental disorder, behavioural changes, visual impairment, ear damage, and cancer (Singh, Jyoti and Singh Tomar, no date).

Extremely low frequency (ELF) EM radiation is emitted by laptops, computers and computer components, televisions, telephones, power lines, and other electronic devices (Carlberg et al., 2019). ELF-EMF causes weak electric current in the body and has low energy to break chemical bonds or change body temperature (Singh and Kapoor, 2014).The effect of exposure to EMF on the cell is shown in Figure 2.

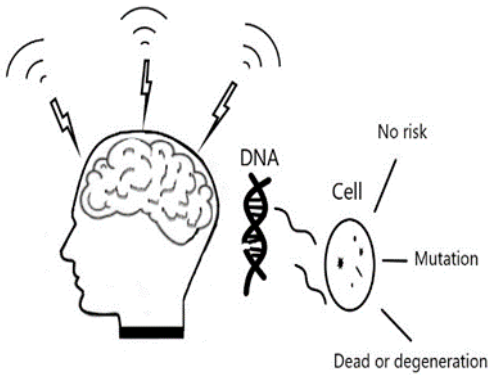

Figure 2. EMF exposure effect on cell

Children are exposed to EMFs at an increasingly early age as a result of rapid developments in EMF technologies and communication. Whether children are vulnerable to low-dose EMF and how often children are exposed to these fields has been debated over the last 20 years. The central nervous system is one of the most sensitive organs targeted by EMR (Santini, Rainaldi and Indovina, 2009). Children's nervous systems are more vulnerable to EMF effects than adults (Hardell and Sage, 2008; Mustafa, 2019). In addition, children's thinner skulls and the higher water content of their brain tissues, and the rate of development make them more susceptible to the effects of EMR (Wiart et al., 2005; Gandhi, 2015; Warille et al., 2016). The International Agency for Research on Cancer has identified RF-EMF as a possible human carcinogen (Group 2B). This raises concerns about possible adverse health effects from exposure to EMR (Baan et al., 2011). Some studies indicate that low-level EMR exposures increase the permeability of the blood-brain barrier (Salford et al., 2003; Nittby et al., 2008). Exposure of children's brains to EMFs can be more damaging than in adults (Gandhi et al., 2012). Consistent evidence from epidemiological studies is presented that the occurrence of childhood leukemia and brain cancers is increased in children exposed to EMF (Redmayne, 2016). In some of the studies, it has been reported that there is a relationship (exposure-response relationship) between the mobile phone used by children and adolescents and the risk of brain cancer (Aydin et al., 2011). Human and animal model studies have revealed some results such as increased headache, and sleep disturbance, neurotransmitter release due to mobile phone use (Hocking and Westerman, 2003; Maskey et al., 2010). Today, 5G technologies using electromagnetic waves have become widespread. The long-term effects of 5G on children's health have yet to be determined (Zamanian and Hardiman, 2005). In addition, some studies have provided no indication that exposure to ELF-EMFs is associated with childhood cancer or biological effects (“Hatch”, no date; Foster and Moulder, 2013).

CONCLUSION

The COVID-19 pandemic has significantly affected people's quality of life. Unfortunately, the epidemic continues with various variants and it remains unclear how long it will continue. Children staying at home in the COVID-19 quarantine spent hours in front of the screen with online education. In addition, since they could not go out, they spent their free time in front of

the screen, using social media, playing computer games, or watching movies. Most children worldwide have been more exposed to EMF in the lockdown than before the COVID-19 outbreak. Although there are not many studies that clarify the health effect of low-level EMR on children, even the slightest effect should not be overlooked. Because children are our most valuable asset, it is the duty of parents, teachers, health professionals, and state administrators to keep them away from all possible dangers by providing them with suitable living spaces. In protection from low-dose EMR, staying as far away as possible from sources producing EMR and using these sources for the shortest possible time can reduce exposure. Monitoring the health of children during and after the COVID-19 epidemic and developing planned health policies are other important issues. The damage brought by this universal distress will perhaps last a lifetime on children. With the right guidance activities, it is necessary to ensure that children get through this process with the least damage.

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