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Evaluation of ELF-MF exposure levels for elementary school students in indoor and outdoor environments.

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Abstract

This research investigation is focused on evaluating the possible health concerns that may arise for elementary school students due to their proximity to transmission and underground lines near their school. The primary goal of this research is to measure Extremely Low-Frequency Magnetic Field (ELF-MF) levels during school hours and various other times of the day to ensure that these levels are in accordance with established safety standards, thereby safeguarding the well-being of both students and the school community. A total of 32 personal exposure measurements were collected from elementary students in the Gyeonggi-do region. These measurements encompassed a continuous 24-hour period, covering time spent at school, at home, during extracurricular activities, and in daily life. Some students displayed noticeable spikes in ELF-MF values, particularly during non-school hours, with levels reaching as high as 13.96 μ T.

This study underscores the significance of acknowledging the possible health risks associated with ELF-MF exposure stemming from common household devices. It emphasizes the importance of consistently maintaining and responsibly using microwave ovens and other electronic appliances to mitigate such risks. Furthermore, the research underscores the necessity for proactive measures aimed at minimizing children's exposure to ELF-MF within the school environment.

Keywords ELF-MF Exposure Assessment, Elementary Student Safety, Emission Level Assessment, Protective Measures Implementation.

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Introduction

Childhood leukemia represents the most common form of cancer affecting children. It manifests in various subtypes, including acute lymphoblastic leukemia, acute myeloid leukemia, chronic lymphoblastic leukemia, and chronic myeloid leukemia, with each subtype presenting distinct symptoms such as bleeding, bruising, fatigue, fever, and an increased susceptibility to infections. Among these, acute lymphoblastic leukemia stands out as the predominant subtype, accounting for approximately 75% of all childhood leukemia cases [1]. Despite extensive research efforts, the exact causes of childhood leukemia remain incompletely understood. One hypothesis, introduced by Wertheimer and Leeper in 1979, posited a potential link between residential magnetic fields and the development of this disease [2]. Over the past few decades, a substantial body of scientific literature has examined the potential relationship between ELF-MF and childhood leukemia [3-6]. One significant factor contributing to this growing concern is the ubiquitous presence of ELF-MF in our daily lives. As far back as 2002, the International Agency for Research on Cancer (IARC) classified ELF-MF as a possible carcinogen for humans (Group 2B) [7]. Additionally, virtually all children in high-income countries are exposed to these electromagnetic waves to some degree, given that ELF-MF affects all residential areas. As a result of these compelling factors, there has been a rising public awareness regarding ELF-MF exposure among students, children, and adolescents. To date, only the acute effects of ELF-MF exposure have been conclusively identified, and several international exposure limit guidelines have been developed to safeguard against these effects [8]. In certain countries, such as Switzerland, Germany, and Sweden, environmental protection measures, including separation distances and facility limits, have been implemented for places like kindergartens and elementary schools. These measures are put in place to shield children from ELF-MF emitted by power facilities, base stations, broadcasting stations, and other sources [9].

A school is a place where children spend a significant portion of their day, approximately 7 hours. Our research study was focused on understanding possible health risks for children due to the presence of transmission and underground lines near the school. Our main goal was to measure the levels of ELF-MF during school hours and at other times of the day for elementary school students. The ultimate aim of our study was

to ensure that students and everyone in the school environment were not exposed to ELF-MF levels that exceeded established safety guidelines. These measurements were crucial for assessing personal exposure levels within the school premises, at home, during extracurricular activities, and in daily life.

Materials and Methods

In this research study, we collected a total of 32 personal exposure measurement samples from November 2018 to February 2019. We provided brief instructions to selected elementary school students from the Gyeonggi-do area on how to conduct personal measurements. These measurements were carried out continuously for 24 hours, encompassing both their time at school and outside of school. The out-of-school time period included tuition hours and other segments, such as time spent at home and during commutes.

ELF-MF measurements

During the study period, portable Electric and Magnetic Field Digital Exposure System (EMDEX) lite devices were used to monitor ELF-MF levels [10]. All measurements were performed within the certified effective calibration period. Dosimeters were placed on students' bodies to record continuous ELF-MF measurements, with the measuring device positioned inside their trouser or clothing pockets. The assessment of ELF-MF exposure was performed consistently throughout the entire 24-hour duration.

Ethical Considerations this research received approval from the Institutional Review Board (IRB) committee of Inje University.

Results

In this study, we gathered a total of 32 samples from an elementary school, comprising 13 males and 19 females. Each of the 32 participants underwent continuous 24-hour exposure measurements to assess ELF-MF. The collected data encompassed several key parameters: the mean value, representing the average ELF-MF exposure level over the full 24-hour duration; the range, which included the highest (maximum) and lowest (minimum) values of ELF-MF emissions recorded during the 24-hour measurement period; the median, offering insight into the central tendency of measurements; and the 95th percentiles, indicating the ELF-MF level below which 95% of the measured data fell. It's important to note that all ELF-MF measurements were recorded in units of micro-tesla (μ T). These details contribute to a comprehensive understanding of the exposure levels and variability experienced by the study participants. Table 1 presents a detailed record of continuous exposure measurements conducted over a full 24-hour period for all 32 study participants, providing a comprehensive dataset of ELF-MF exposure.

For additional clarity, we segmented the 24-hour exposure data based on activity patterns, including time spent at home, during tuition classes, and other activities (Table 2).

No.	Mean ± SD	Range	Median	95 percentiles of 24-H
1	0.02 ± 0.04	0.01–3.56	0.01	0.06
2	0.02 ± 0.03	0.01–0.41	0.02	0.1
3	0.06 ± 0.16	0.01–4.92	0.02	0.19
4	0.01 ± 0.02	0.01–0.56	0.01	0.03
5	0.02 ± 0.01	0.01–0.45	0.02	0.03
6	0.02 ± 0.03	0.01–1.37	0.02	0.04
7	0.05 ± 0.13	0.01–4.09	0.03	0.17
8	0.01 ± 0.02	0.01–0.67	0.01	0.03
9	0.04 ± 0.12	0.01–1.37	0.01	0.33
10	0.02 ± 0.07	0.01–6.69	0.02	0.04
11	0.01 ± 0.03	0.01–2.19	0	0.04
12	0.08 ± 0.15	0.01–1.64	0.04	0.52
13	0.02 ± 0.02	0.01–0.62	0.02	0.05
14	0.01 ± 0.02	0.01–0.55	0.01	0.03
15	0.01 ± 0.02	0.01–0.81	0.01	0.03
16	0.02 ± 0.13	0.01–13.96	0.01	0.05
17	0.03 ± 0.06	0.01–1.21	0.02	0.1
18	0.01 ± 0.03	0.01–2.64	0.01	0.03
19	0.02 ± 0.06	0.01–2.73	0.01	0.06

20	0.03 ± 0.08	0.01–4.90	0.02	0.12
21	0.03 ± 0.06	0.01–3.76	0.02	0.09
22	0.01 ± 0.03	0.01–1.97	0.01	0.04
23	0.78 ± 0.70	0.01–2.60	0.88	2
24	0.02 ± 0.02	0.01–1.24	0.02	0.04
25	0.03 ± 0.06	0.01–3.54	0.02	0.11
26	0.03 ± 0.06	0.01–3.35	0.02	0.05
27	0.07 ± 0.05	0.01–2.35	0.06	0.13
28	0.02 ± 0.06	0.01–7.42	0.01	0.09
29	0.02 ± 0.03	0.01–1.16	0.01	0.05
30	0.11 ± 0.08	0.01–1.52	0.12	0.22
31	0.03 ± 0.05	0.01–1.78	0.03	0.11
32	0.10 ± 0.30	0.01–3.40	0.02	0.31

Table 1: 24-hour continuous measurement data of 32 participants.

	House			Tuition class			Other activities		
No.	**Mean ± SD**	**Range**	**Median**	**Mean ± SD**	**Range**	**Median**	**Mean ± SD**	**Range**	**Median**
1	0.02 ± 0.04	0.01-1.47	0.01	0.01 ± 0.01	0.01-0.06	0.01	0.05 ± 0.07	0.01-0.85	0.03
2	0.02 ± 0.03	0.01-0.16	0.01	-	-	-	-	-	-
3	0.06 ± 0.18	0.01-4.92	0.02	-	-	-	0.02 ± 0.01	0.01-0.36	0.02
4	0.01 ± 0.01	0.01-0.29	0.01	-	-	-	0.04 ± 0.05	0.01-0.46	0.02
5	0.01 ± 0.01	0.01-0.07	0.02	0.01 ± 0.00	0.01-0.03	0.01	0.02 ± 0.03	0.01-0.21	0.02
6	0.02 ± 0.04	0.01-1.37	0.02	-	-	-	0.04 ± 0.06	0.01-0.80	0.03
7	0.06 ± 0.15	0.01-4.08	0.03	0.02 ± 0.00	0.02-0.02	0.01	0.02 ± 0.03	0.01-0.36	0.02
8	0.01 ± 0.01	0.01-0.17	0.01	0.02 ± 0.03	0.01-0.67	0.01	0.03 ± 0.04	0.01-0.33	0.02
9	0.01 ± 0.06	0.01-1.34	0.01	0.02 ± 0.02	0.01-0.34	0.01	0.17 ± 0.26	0.01-0.86	0.04
10	0.02 ± 0.08	0.01-6.69	0.02	0.01 ± 0.01	0.01-0.16	0.01	0.02 ± 0.03	0.01-0.49	0.02
11	0.01 ± 0.04	0.00-2.19	0	0.00 ± 0.00	0.00-0.07	0.01	0.03 ± 0.03	0.01-0.23	0.02
12	0.04 ± 0.01	0.02-0.20	0.04	0.46 ± 0.19	0.01-1.64	0.49	0.04 ± 0.04	0.01-0.20	0.04
13	0.01 ± 0.01	0.01-0.07	0.02	0.04 ± 0.02	0.01-0.62	0.05	0.04 ± 0.06	0.01-0.47	0.03
14	0.01 ± 0.01	0.01-0.29	0.01	0.01 ± 0.00	0.01-0.07	0.01	0.06 ± 0.06	0.01-0.50	0.05
15	0.01 ± 0.01	0.01-0.54	0.01	0.02 ± 0.00	0.01-0.09	0.01	0.04 ± 0.06	0.01-0.80	0.03
16	0.01 ± 0.05	0.01-3.62	0.01	0.03 ± 0.03	0.01-0.86	0.03	0.07 ± 0.45	0.01-13.96	0.03
17	0.02 ± 0.02	0.01-0.98	0.02	-	-	-	0.14 ± 0.18	0.01-1.21	0.1
18	0.01 ± 0.02	0.01-2.64	0	0.01 ± 0.01	0.01-0.04	0.01	0.02 ± 0.03	0.01-0.38	0.01
19	0.01 ± 0.07	0.01-2.72	0.01	0.05 ± 0.07	0.02-0.61	0.05	0.05 ± 0.07	0.01-0.88	0.04
20	0.03 ± 0.10	0.01-4.90	0.02	0.01 ± 0.01	0.01-0.14	0.01	0.05 ± 0.08	0.01-0.72	0.03
21	0.02 ± 0.06	0.00-3.75	0.02	-	-	-	0.11 ± 0.10	0.01-0.59	0.09
22	0.00 ± 0.03	0.00-1.97	0	-	-	-	0.06 ± 0.07	0.01-0.79	0.04
23	1.24 ± 0.50	0.01-2.60	1.06	0.02 ± 0.07	0.01-1.34	0.01	0.11 ± 0.14	0.01-0.85	0.06
24	0.03 ± 0.02	0.01-0.03	0.03	-	-	-	0.06 ± 0.11	0.01-1.23	0.04
25	0.01 ± 0.01	0.01-0.15	0.02	-	-	-	0.10 ± 0.18	0.01-1.57	0.04
26	0.02 ± 0.03	0.01-1.34	0.02	-	-	-	0.11 ± 0.21	0.01-3.34	0.03
27	0.08 ± 0.02	0.05-0.15	0.07	-	-	-	0.10 ± 0.12	0.01-2.35	0.09
28	0.01 ± 0.06	0.01-7.42	0.01	0.08 ± 0.07	0.07-0.12	0.08	0.04 ± 0.04	0.01-0.18	0.03
29	0.01 ± 0.01	0.00-0.36	0.01	0.01 ± 0.02	0.00-0.19	0.01	0.04 ± 0.07	0.01-0.38	0.02

30	0.15 ± 0.04	0.11-0.48	0.14	-	-	-	-	-	-
31	0.02 ± 0.02	0.01-1.05	0.02	-	-	-	0.04 ± 0.08	0.01-1.78	0.04
32	0.01 ± 0.02	0.01-0.32	0.01	-	-	-	0.53 ± 0.69	0.01-3.40	0.23
Note: Mean, μ T, Range (minimum value and maximum value), μ T, Standard Deviation (SD).									

Table 2: 24-hour personal exposure based on daily activity patterns.

After analyzing all the data, we used IBM SPSS Statistics version 27.0 to determine if there were any significant differences in exposure levels among the participants. Firstly, we examined the levels of ELF-MF exposure inside and outside the school premises to check for any significant differences (the p-value was 0.20 at a 95% confidence interval). However, our analysis revealed that there were no significant differences in ELF-MF exposure levels between the indoor school environment and the outdoor environment (Table 3).

Subsequently, we conducted a gender-specific analysis of ELF-MF exposure, segregating the data into male and female groups. In this investigation as well, our findings indicated that there were no statistically significant differences in ELF-MF exposures between indoor and outdoor settings for both genders. A summary of these findings is provided in Table 3.

Discussion

In our current study, we conducted measurements of students' personal exposure to ELF-MF levels within both the school environment and outside surroundings. This approach allowed us to gain a comprehensive understanding of how elementary students are exposed to ELF-MF emissions during school hours as well as during after-school activities, including tuition classes, commuting, and time spent at home. When we consider overall data school inside and out exposure level of students, the average ELF-MF exposure lower than general public recommendation of International Commission on Non-Ionizing Radiation Protection (ICNIRP) [8].

While previous studies have investigated student children's exposure to ELF-MF emissions, most of them typically provide spot measurements, meaning only one or two measurement points at a given time [11]. In our study, we conducted continuous 24-hour measurements of ELF-MF emissions for each student individually. Therefore, this study proposes meaningful methods and criteria for measuring ELF-MF exposure that can be used in future studies.

Among the 32 students, a few exhibited spontaneous surges in ELF-MF values. These values were as follows: Participant 3:4.92 μ T, participant 7:4.09 μ T, participant 10:6.69 μ T, participant 16:13.96 μ T, and participant 28:7.42 μ T. During out-of-school hours, magnetic field values of 6.69 μ T, 13.96 μ T, and 7.42 μ T were recorded, which were attributed to the usage of microwave ovens. Students frequently rely on microwave ovens for quick meal preparation, yet it is crucial to recognize the potential health risks associated with radiation exposure. These appliances operate using non-ionizing radiation to heat food. To reduce potential health hazards, owners of microwaves should consistently maintain their ovens and avoid using them if any signs of damage or malfunction become apparent. Additionally, maintaining a proper distance while using them can help mitigate the risk of high emission levels [12]. Two additional high values of 4.92 μ T and 4.09 μ T were recorded, attributed to nearby household electrical appliances.

The results of prior research have revealed concerning levels of ELF-MF exposure, particularly in their potential impact on the well-being of children. It is clear that these exposure levels have the capacity to affect various aspects of children's health and development. Previous studies have established a link between ELF-MF exposure and an increased risk of childhood leukemia, a severe and life-threatening condition. This connection underscores the urgent need to address and mitigate ELF-MF exposure to safeguard the health of children [13-15]. Furthermore, earlier research has identified associations between ELF-MF exposure and various adverse health outcomes in children, including cognitive disorders, issues with

	Category	**No. of participants**	**GM**	**Median**	**Mean ± SD**	**p value**
Inside exposure level	Male	9	0.02	0.02	0.02 ± 0.01	0.23
	Female	23	0.03	0.03	0.03 ± 0.01	
	Total	32	0.03	0.02	0.03 ± 0.02	
Outside	Male	9	0.02	0.02	0.03 ± 0.02	0.45
	Female	23	0.02	0.02	0.07 ± 0.04	
	Total	32	0.03	0.02	0.06 ± 0.16	
Note: Mean; μ T, Range (minimum value and maximum value); μ T, Standard Deviation (SD), Geometric Mean (GM).						

Table 3: Statistical analysis for exposure levels of male and female.

memory performance, frequent headaches, and disruptions in sleep patterns. These findings raise significant concerns regarding the broader cognitive and neurological consequences of ELF-MF exposure in children [16-20]. Therefore, it is imperative that we take immediate action to protect our children from these potential health risks. Given these findings, we recommend the implementation of a comprehensive policy aimed at substantially reducing ELF-MF exposure levels for children. Such a policy should encompass a range of measures, including stricter regulations on electromagnetic field sources in proximity to schools and residential areas, the development of guidelines for safe technology usage by children, and public awareness campaigns to educate parents, caregivers, and educators about the potential risks associated with ELF-MF exposure.

In classrooms, ELF-MF primarily originates from electrical sources such as distribution boxes, wiring, and devices like air conditioners and projectors. Our research has revealed that the number of electrical devices presents in a classroom, their proximity to students, as well as the condition of wiring and distribution boxes, all contribute to the extent of ELF-MF exposure that students experience. To mitigate this exposure, it is essential to ensure that students maintain a safe distance from these devices, and we can assess it by measuring exposure levels at various distances.

Regular monitoring of ELF-MF levels in areas where students spend their time during school hours is of paramount importance. Our study demonstrates that adhering to guidelines that advocate maintaining a proper distance from electronic devices and implementing protective measures such as shielding for wiring can significantly reduce ELF-MF exposure. This underscores the necessity of actively managing ELF-MF within schools, including arranging seating to minimize students' exposure within the classroom.

However, it's important to acknowledge a limitation in our study. We only measured ELF-MF for a small group of students on a single weekday, so these findings may not be universally applicable. Future research should encompass different schools and various time periods. Additionally, there is a need to develop comprehensive guidelines for managing ELF-MF exposure in schools and investigate potential health effects on children during their school hours. This is crucial for ensuring the well-being and safety of students in educational environments.

Conclusions

Amidst the increasing prevalence of electrical devices, electric vehicles, and rapid urbanization, concerns have arisen regarding the potential impact of ELF-MF exposure on children. To gain deeper insights into the distribution of ELF-MF intensity within school premises, we conducted comprehensive measurements of ELF-MF exposure levels for students both inside and outside the school environment. Our study revealed that all participating students consistently maintained ELF-MF exposure levels well below the ICNIRP standard. While occasional spikes in exposure were observed among certain participants, primarily linked to factors such as electric distribution boxes, electrical wiring, and electronic appliances, the overall ELF-MF exposure levels remained within safe limits. This positive outcome can be attributed to the prudent distancing maintained between students and potential sources of electromagnetic fields, as well as the effective shielding of electrical wiring.

Considering these positive findings, it becomes imperative to take proactive steps aimed at minimizing children's exposure to ELF-MF within the school environment. This can be accomplished through continuous monitoring of ELF-MF levels, reducing the use of electronic devices, ensuring an appropriate separation between students and such devices, and optimizing the arrangement of student seating. Undertaking these deliberate measures is crucial for safeguarding the well-being and health of children amidst our ever-evolving technological landscape.

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Data Availability Statement

"We conducted this study independently, collected the data using our own time, and have not previously published this dataset in any other journal. All analysed data and associated materials are included with this paper draft."

Conflict of Interest Statement

"We would like to declare no conflicts of interest related to this research and conducted the study independently and have no financial, personal, or professional affiliations that could influence the objectivity of the research."

References

1. Brabant C, Geerinck A, Beaudart C, et al. Exposure to magnetic fields and childhood leukemia: A systematic review and meta-analysis of case-control and cohort studies. Rev Environ Health 2022; 38(2):229-253.
2. Wertheimer N, Leeper ED. Electrical wiring configurations and childhood cancer. Am J Epidemiol 1979;109(3): 273-284.
3. Ahlbom A, Day N, Feychting M, et al. A pooled analysis of magnetic fields and childhood leukaemia. Br J Cancer 2000; 83(5):692-698.
4. Kabuto M, Nitta H, Yamamoto S, et al. Childhood leukemia and magnetic fields in Japan: A case-control study of childhood leukemia and residential power-frequency magnetic fields in Japan. Int J Cancer 2006; 119(3):643-650.
5. Linet MS, Hatch EE, Kleinerman RA, et al. Residential exposure to magnetic fields and acute lymphoblastic leukemia in children. N Engl J Med 1997; 337(1):1-8.
6. McBride ML, Gallagher RP, Theriault G, et al. Power-frequency electric and magnetic fields and risk of

childhood leukemia in Canada. Am J Epidemiol 1999;149(9):831-842.

7. World Health Organization. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans 2002; 80: ISBN-13 978-92-832-1280-1285.
8. International Commission on Non-Ionizing Radiation Protection. Guidelines for limiting exposure to time-varying electric and magnetic fields (1 Hz to 100 kHz). Health Phys 2010; 99(6):818-836.
9. Park J, Jeong E, Seomun G. Extremely low-frequency magnetic fields exposure measurement during lessons in elementary schools. Int J Environ Res Public Health 2020;17(15):5284
10. McDevitt JJ, Breysse PN, Bowman JD, et al. Comparison of extremely low frequency (ELF) magnetic field personal exposure monitors. J Expo Anal Environ Epidemiol 2002;12(1):1-8.
11. Electric and magnetic field levels generated by AC power systems-Measurement procedures with regard to public exposure. 2009.
12. Arpansa. Microwave ovens and health. Australian Government.
13. Kheifets L, Ahlbom A, Crespi CM, et al. Pooled analysis of recent studies on magnetic fields and childhood leukaemia. Br J Cancer 2010; 103(7):1128-1135.
14. Schüz J, Dasenbrock C, Ravazzani P, et al. Extremely low-frequency magnetic fields and risk of childhood leukemia: A risk assessment by the ARIMMORA consortium. Bioelectromagnetics 2016;37(3):183-189.
15. Huang J, Tang T, Hu G, et al. Association between exposure to electromagnetic fields from high voltage transmission lines and neurobehavioral function in children. PLoS One 2013; 8(7):67284.
16. Pall ML. Microwave frequency electromagnetic fields (EMFs) produce widespread neuropsychiatric effects including depression. J Expo Anal Environ Epidemiol 2016;75:43-51.
17. Say F, Altunkaynak BZ, Coşkun S, et al. Controversies related to electromagnetic field exposure on peripheral nerves. J Chem Neuroanat 2016;75:70-76.
18. W. PREECE KA WESNES GR IWI A. The effect of a 50 Hz magnetic field on cognitive function in humans. Int J Radiat Biol 1998;74(4):463-470.
19. Standard for safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz amendment 1: Specifies ceiling limits for induced and contact current, clarifies distinctions between localized exposure and spatial peak power density. 2005. IEEE EISBN:978-0-7381-6207-2.
20. Zhi WJ, Wang LF, Hu XJ. Recent advances in the effects of microwave radiation on brains. Mil Med Res 2017;4(1):1-4.

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