

Investigating the Relationship between the Proximity of Cell Phone Towers to Residential Areas and Health Symptoms in Adolescents: A Study from Maysan Governorate

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ABSTRACT

Background: The proliferation of cell phone towers in residential areas has prompted concerns about potential health effects, particularly on adolescents who may be more susceptible to Electromagnetic Fields (EMF). **Objectives:** This study aimed to investigate the health impacts of EMF emitted by cell phone towers on adolescents in Missan Province. **Methods:** Conducted from (January 2024 and June 2024), this study involved 150 adolescents aged 12-18 years. Participants were categorized based on their proximity to cell phone towers (100-200m, 201-350m, and 351-500m). **Results:** Adolescents living within 100-200 meters of cell phone towers reported significantly higher rates of headaches (60%), sleep disturbances (52%), and difficulty concentrating (44%) compared to those living further away. **Conclusion:** This study suggests a potential association between proximity to cell phone towers and increased prevalence of certain health symptoms among adolescents, particularly headaches, sleep disturbances, and difficulty concentrating. **Recommendations:** These findings highlight the need for further research into the long-term health effects of EMF exposure on this vulnerable age group. Given the widespread use of mobile technology, understanding these impacts is crucial for informing future health guidelines and regulatory policies.

Keyword: *Adolescents; Cell Phone Towers; Missan Province*

INTRODUCTION

The rapid proliferation of mobile communication technology has led to an increased presence of cell phone towers in residential areas, raising concerns about potential health effects, particularly on vulnerable populations such as adolescents. The age group of 12-18 years is of special interest due to their ongoing physical and neurological development, which may be more susceptible to environmental influences (Rastokina *et al.*, 2024). Electromagnetic fields (EMF) emitted by cell phone towers have been a subject of debate in the scientific community; while some studies suggest potential health risks, others argue that the levels of EMF exposure from these towers are too low to cause significant biological effects (Khalil & Hassan, 2024; Sachit *et al.*, 2025). However, adolescents may be more vulnerable to EMF effects due to several factors such as thinner skull bones, which allow for greater EMF penetration into the brain, and higher water content in their brain tissue, potentially leading to greater EMF absorption and longer lifetime exposure, as the adolescents start using mobile devices at an earlier age (Bačová *et al.*, 2025).

According to research, electromagnetic radiation may interfere with neuronal formation and structure, change related endocrine hormones and free radicals, impact neurotransmitters and receptors, and affect the physiological organization and functioning of the brain. These effects could result in the adverse occurrence of mental health conditions and sleep pattern issues (Zou *et al.*, 2025). Eskandarpour and Nooramin (2025) reported that the ongoing developmental processes raised concern that EMF exposure could potentially interfere with normal brain maturation. Some studies have suggested that EMF might affect neuronal excitability and synaptic plasticity. Also, Asad *et al.* (2024) found that EMF exposure was associated with

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changes in sleep electroencephalogram (EEG) patterns, potentially affecting sleep quality and cognitive performance.

Several studies have investigated the potential cognitive effects of EMF exposure on students, such as the study performed by Mohamed *et al.* (2025), which conducted a study on grade students and found that those who reported the most potent source of EMF radiation demonstrated faster and less accurate responses on cognitive tasks. While these could suggest potential effects on attention and cognitive processing, the authors noted that longitudinal studies are needed to establish causality. In contrast, Benke *et al.* (2024) performed a systematic review of studies examining the effects of EMF on cognitive function in children and adolescents. Only a small number of studies offered extremely low to low certainty evidence of little to no association between exposure to (Radio Frequency Electromagnetic Field) and memory and learning, organizational skills, and elaborate attention were detected in this systematic review and meta-analysis. Global cognitive function and other cognitive domains were not covered in any of the child studies. Concerns have been raised about potential health impacts of EMF exposure on adolescents. Headaches, sleep disturbances, and fatigue are among the most commonly reported symptoms in relation to EMF exposure (Frank *et al.*, 2024).

According to the study done by Söylemez *et al.* (2024), individuals who use cellphones excessively are more likely than those who use them less frequently to suffer from hearing, tinnitus, balance, falling, and anxiety issues. One possible risk factor for these issues could be excessive smartphone use. However, the authors cautioned that these findings prove causation and could be influenced by other factors such as lifestyle and personality traits. Concerns have been raised about potential carcinogenic effects of EMF. The International Agency for Research on Cancer (IARC) has classified radiofrequency EMF as "possibly carcinogenic to humans" (Hardell & Nilsson, 2025).

When an adolescent complains of health issues linked to local cell phone towers, the nurse must first verify the patient's experience, recognizing that symptoms like exhaustion and headaches are serious and upsetting. Thereafter, the nurse switches the focus to a comprehensive assessment, giving priority to more widespread causes, including stress, poor sleep hygiene, and mental health issues, which are very common in this age range (Purnama *et al.*, 2025). Lastly, the nurse offers concise, evidence-based instruction, citing the worldwide scientific consensus (such as the WHO) that low-level radiofrequency from towers has not been shown to have these negative health impacts (Gulati *et al.*, 2024). The objective is to reduce excessive worry and guarantee that the adolescent obtains a precise diagnosis and suitable treatment for the actual underlying problem (Li *et al.*, 2024).

The precautionary principle, as outlined by the World Health Organization, suggests that in the face of potential serious or irreversible harm, lack of full scientific certainty should not be used as a reason for postponing cost-effective measures to reduce exposure (Sadeleer, 2020; OECD, 2023). This principle has been increasingly applied to EMF exposure, particularly concerning children and adolescents (Amerio & Lagorio, 2024). Given the debate surrounding EMF effects on adolescent health and the limited research specifically focusing on this age group, there is a clear need for more targeted studies. This research aims to address this gap by investigating the potential health effects of EMF exposure from cell phone towers, specifically on adolescents aged 12-18 years in Missan Province.

The primary objectives of this study are to assess the prevalence of self-reported health symptoms among adolescents living at varying distances from cell phone towers, to investigate potential associations between proximity to cell phone towers and the occurrence of specific health symptoms in adolescents, and to contribute to the growing body of evidence on EMF exposure effects in this vulnerable age group, potentially informing future research directions and policy considerations.

METHODOLOGY

Settings

The study was conducted in Maysan Governorate, Iraq.

Study Design

This research utilized a descriptive cross-sectional study design to determine the correlation between the

proximity of cellular towers to residential zones and health complaints among adolescents.

Study Sample

The target population of the study involving 150 adolescents (80 males and 70 females) aged 12-18 years (mean age 15.3 years) from various neighborhoods in Missan Province. Participants were selected based on their proximity to cell phone towers, with distances ranging from 100m to 500m.

Inclusion Criteria

Residence located in an area where distance to the nearest cell phone tower can be determined (e.g., via GIS/coordinates/address verification). The participants were able to understand and complete the symptom questionnaire/interview.

Exclusion Criteria

Insufficient residential stability (e.g., living at the current address for < 12 months) because proximity-to-tower exposure cannot be meaningfully linked to reported symptoms over time. Unable to complete the questionnaire reliably (e.g., significant cognitive/communication limitation that prevents valid self-report). Major pre-existing or acute medical/psychiatric conditions (or current medications) that can strongly explain the same outcomes being measured (e.g., chronic migraine disorder, diagnosed sleep disorders, severe anxiety/depression under active treatment) to reduce confounding in symptom-based analyses.

Data Collection

The study was conducted between January 2024 to June 2024. A questionnaire was developed to collect information on demographic data (age, gender, residential area), distance from the nearest cell phone tower, and reported symptoms (after demonstrating the symptoms to the participants and asking whether they experienced any of them), including headaches, sleep disturbances, difficulty concentrating, fatigue, mood changes and memory issues (Sailo *et al.*, 2025; Bodewein *et al.*, 2022).

Ethical Considerations

The researchers obtained ethical clearance from the College of Nursing, Iraq, with reference number 231 on 12th December 2023.

In addition, the privacy of the participants and the confidentiality of their answers were guaranteed. Efforts were made to minimize any potential harm or psychological distress to the participants and they were keen to inform all participants of their right to withdraw from the study at any time without consequences.

Statistical Analysis

Data was analyzed using both descriptive and inferential statistics. Participants were categorized into three distance-based exposure groups: Group A (100–200 m), Group B (201–350 m), and Group C (351–500 m). Continuous variables, including age and symptom severity scores, were presented as mean \pm standard deviation (SD), whereas categorical variables, such as gender, school grade, and symptom prevalence, were summarized as frequencies and percentages.

Differences in continuous variables among the three groups were examined using one-way analysis of variance (ANOVA), while differences in categorical variables were assessed using the Pearson chi-square (χ^2) test. In addition, multivariable logistic regression analysis was performed to identify symptoms independently associated with group exposure, and the results were reported as Adjusted Odds Ratios (AORs) with 95% confidence intervals (CIs). A *p*-value of less than 0.05 was considered statistically significant.

RESULTS

The researcher used the Chi-square (χ^2) and one-way ANOVA in interpreting the result, where the χ^2 is appropriate because the researchers are often comparing categorical variables: Tower proximity category (near/medium/far) \times symptom status (yes/no) or symptom type (headache/dizziness/insomnia). The Chi-square test is used to determine whether symptom frequencies or proportions differ significantly across

proximity groups. In contrast, one-way ANOVA is appropriate when the outcome variable is continuous (numeric) and is used to compare mean values across three or more proximity groups (e.g., near, medium, and far). Examples include mean symptom score, frequency of headaches per week, or sleep-disturbance scores. This test determines whether there is a statistically significant difference in the mean values among the groups.

Demographic Characteristics

Table 1: Demographic Characteristics of Study Participants by Exposure Group

Characteristic	Group A (100-200m)	Group B (201-350m)	Group C (351-500m)	p-Value
Sample (n)	50	50	50	-
Age (mean ± SD)	15.2 ± 1.7	15.4 ± 1.9	15.3 ± 1.8	0.857
Gender (n, %)				
- Male	27 (54%)	26 (52%)	27 (54%)	0.923
- Female	23 (46%)	24 (48%)	23 (46%)	0.856
School Grade (n, %)				
- Primary or below	10 (20%)	12 (24%)	11 (22%)	0.989
- Secondary	24 (48%)	23 (46%)	25 (50%)	0.876
- Tertiary	16 (32%)	15 (30%)	14 (28%)	0.934

Note: No significant differences in demographic characteristics among the three exposure groups

A total of 150 adolescents participated in the study, with a mean age of 15.3 years. The sample consisted of 80 males (53.3%) and 70 females (46.7%). Table 1 presents the demographic characteristics of the participants across the three exposure groups. Through exposure assessment, the mean self-reported distance from cell phone towers was compared with the objectively measured distance using GPS. A strong positive correlation was found ($p < 0.05$), suggesting that participants had a reasonably accurate perception of their proximity to cell phone towers.

Prevalence of Reported Symptoms (Symptom Prevalence by Distance from Cell Phone Towers)

Table 2: Prevalence of Reported Symptoms Stratified by Exposure Group

Symptom	Group A (100-200m)	Group B (201-350m)	Group C (351-500m)	χ^2	df	p-value
Headaches	60% (n=30)	46% (n=23)	30% (n=15)	9.60	2	0.008*
Sleep Disturbances	52% (n=26)	38% (n=19)	24% (n=12)	8.40	2	0.015*
Difficulty Concentrating	44% (n=22)	32% (n=16)	20% (n=10)	7.20	2	0.027*
Fatigue	36% (n=18)	30% (n=15)	22% (n=11)	2.52	2	0.284
Mood Changes	32% (n=16)	26% (n=13)	18% (n=9)	2.70	2	0.259
Memory Issues	24% (n=12)	18% (n=9)	12% (n=6)	2.42	2	0.298

Note: *Statistically significant at $p < 0.05$. Chi-square tests revealed statistically significant differences among exposure groups for headaches, sleep disturbances, and difficulty concentrating

The overall prevalence of reported symptoms across all participants is presented in Table 2 and found headaches were the most commonly reported symptom (45%, n=68), followed by sleep disturbances (38%, n=57) and difficulty concentrating (32%, n=48).

Symptom Severity Analysis Using ANOVA

Table 3: Mean Symptom Severity Scores by Exposure Group

Symptom	Group A (100-200m)	Group B (201-350m)	Group C (351-500m)	f-value (df1, df2)	p-value
Headaches	2.1 ± 1.2	1.7 ± 1.1	1.3 ± 1.0	$f(2,147) = 7.22$	0.001*
Sleep Disturbances	1.9 ± 1.1	1.5 ± 1.0	1.2 ± 0.9	$f(2,147) = 6.18$	0.003*
Difficulty Concentrating	1.8 ± 1.0	1.4 ± 0.9	1.1 ± 0.8	$f(2,147) = 5.76$	0.004*
Fatigue	1.6 ± 1.0	1.4 ± 0.9	1.2 ± 0.8	$f(2,147) = 2.34$	0.100
Mood Changes	1.5 ± 0.9	1.3 ± 0.8	1.1 ± 0.7	$f(2,147) = 2.12$	0.124
Memory Issues	1.3 ± 0.8	1.1 ± 0.7	1.0 ± 0.6	$f(2,147) = 1.98$	0.142

*Statistically significant at $p < 0.05$. ANOVA tests revealed significant differences between Group A and Group C for headaches, sleep disturbances, and difficulty concentrating ($p < 0.05$)

The mean symptom severity scores were compared across exposure groups using one-way ANOVA. Results are presented in Table 3 it shows the adjustment for potential confounding factors; multiple logistic

regression analyses were performed for each symptom, with exposure group as the primary predictor and age, gender, parental education, and daily mobile phone usage acts as covariates. After adjusting for confounding factors, living closer to cell phone towers (Group A) was associated with significantly higher odds of reporting headaches, sleep disturbances, and difficulty.

Table 4: Adjusted Odds Ratios for Reported Symptoms

Symptom	Adjusted OR	95% CI	p-value
Headaches	2.84	1.42-5.68	0.003*
Sleep Disturbances	2.51	1.26-5.01	0.009*
Difficulty Concentrating	2.37	1.18-4.75	0.015*
Fatigue	1.68	0.84-3.36	0.142
Mood Changes	1.75	0.87-3.52	0.116
Memory Issues	1.61	0.79-3.28	0.189

Note: *Statistically significant at $p < 0.05$ between Group A and Group C for headaches, sleep disturbances, and difficulty concentrating

In Table 4, headaches showed the strongest association with the outcome, with an adjusted odds ratio of 2.84 (95% CI: 1.42–5.68, $p = 0.003$), indicating that participants in Group A had nearly three times higher odds of reporting headaches compared with Group C. Sleep disturbances were also significantly associated with the outcome (adjusted OR = 2.51, 95% CI: 1.26–5.01, $p = 0.009$), followed by difficulty concentrating (adjusted OR = 2.37, 95% CI: 1.18–4.75, $p = 0.015$). In contrast, fatigue, mood changes, and memory issues did not reach statistical significance. Overall, these findings suggest that headaches, sleep disturbances, and difficulty concentrating may represent the most clinically relevant symptom correlates of the outcome in this model, whereas the associations observed for fatigue, mood changes, and memory issues should be interpreted with caution.

Subgroup Analysis

Certainly, the table summarizes the subgroup analysis results:

Table 5: Comparison of Difficulty Concentrating by Age Group in the Subgroup Analysis

Subgroup	Symptom	12–15 years	16–18 years	χ^2 (df)	p-value
Age Group	Difficulty concentrating	36%	52%	4.12 (1)	0.042

Note: No significant gender differences were observed.; Significant difference in symptom reporting of difficulty concentrating between age groups (16-18 years vs. 12-15 years)

Through conducted subgroup analyses to explore potential differences in symptom reporting based on gender and age group (12-15 years as compared with 16-18 years). No significant gender differences were observed in symptoms reporting across exposure groups. The 16-18 age group reported significantly higher rates of difficulty concentrating in group 16-18 years compared to the group 12-15 age group (52%, 36%, $\chi^2 = 4.12, p = 0.042$).

DISCUSSION

The study investigated the health effects of EMF from cell phone towers on adolescents aged 12-18 years in Missan Province. A significant association between proximity to cell phone towers and several self-reported health symptoms, where adolescents living closer to cell phone towers (within 100-200 meters) reported higher rates of headaches, sleep disturbances, and difficulty concentrating compared to those living further away. The prevalence of headaches was notably higher among those living within 100-200 meters of cell phone towers (60%) compared to those living further away (30% in the 351–500-meter group). The severity of headaches also showed a significant increase with proximity to the towers. This finding aligns with previous research that has suggested a potential link between EMF exposure and headaches (Frank *et al.*, 2024; Traini *et al.*, 2024); also, the higher levels of radiofrequency EMF were found to cause headaches and poorer sleep quality in children and adolescents (Yaakoubi *et al.*, 2024).

According to Zeba *et al.* (2024), younger people who use their phones extensively are more likely to have symptoms including headaches and sleeplessness. Given the correlations between such factors, it may be concluded that extended cell phone use may result in additional health issues, including the development of tumors and malignancies. Sleep disturbances were reported more frequently among adolescents in closer proximity to cell phone towers. The severity of sleep disturbances was also higher in adolescents living closer to cell phone towers (within 100–200 meters). This is consistent with findings from Kaewpradit *et al.* (2025), who also discovered that poor sleep quality affected 61.9% of individuals who aged from (15–24) years, and Bijlsma *et al.* (2024), who

reported RF-EMF exposure resulted in a substantial ($p < 0.05$) and clinically significant decrease in sleep quality.

Lee *et al.* (2024) reported that electromagnetic waves (EMWs) are among the persistent environmental pollutants that may adversely affect the nervous and immune systems and may also influence the development and functioning of the reproductive system among adolescents. Difficulty concentrating was significantly higher in adolescents living near cell phone towers. This result supports the findings of Poujol *et al.* (2022), who found that the attention performance of healthy teenagers who report more screen time may be impacted. Also, a study done by Maeneja *et al.* (2025) on a total of 231,117 children and adolescents from nine nations across three continents were included in ten studies for analysis. The majority of research showed that executive functions, specifically working memory, inhibitory control, cognitive flexibility, and attention, are adversely affected by excessive information and communication technology use. Multitasking, poor sleep quality, and increased screen time were associated with negative impacts.

The results of this study are in line with several previous studies that have explored the effects of EMF on health. Molua's (2024) study highlighted that teenagers were the group most exposed to cell phones, due to their developing neurological systems. Similarly, the researchers in a systematic review discovered weak but suggestive evidence that children and adolescents who use mobile phones more frequently may have worse mental health. This discrepancy might be attributed to the study's focus on a specific age group and geographical location, which could influence the results (Girela-Serrano *et al.*, 2022).

Regarding fatigue, mood changes, and memory issues, there was no significant association with exposure to EMFs, which is credible for various methodological and clinical reasons. The results in teenagers are quite general and are greatly affected by their sleep habits, stress levels, and how much they use their phones or screens, which might hide any small effects from exposure (Benke *et al.*, 2024; Bodewein *et al.*, 2022). In order to address the impacts of teenage exposure to EMFs from cell phone towers, nurses are essential in teaching, promoting safety, and tracking health trends among teenagers exposed to radiation from cell phone towers, even if scientific consensus on EMF hazards is still developing (Ananthi, 2026; Velladurai & Devi, 2024). The nurses should give adolescents and parents evidence-based information regarding potential dangers such as headaches, anxiety, sleep problems and safety precautions. Dispel myths and distinguish between exposure to high-risk and low-risk electromagnetic fields. Encourage doable ways to lessen exposure, such as putting cell phones on speaker mode, restricting their use, and keeping electronics away from the body. Examine and monitor symptoms (such as exhaustion, trouble concentrating, or sleep issues) that may be linked to exposure to electromagnetic fields. Work together with school nurses to identify patterns in the health problems that affect adolescents (Calderón-Garcidueñas *et al.*, 2025; World Health Organization, 2016).

Limitations

It is important to note that this study has several limitations, including that symptoms reported by study participants may be subject to bias and have a high degree of reliability, external environmental factors that could influence health symptoms were not significantly controlled for, and actual EMF measurements were not performed; proximity to towers was used as a proxy for exposure levels. Despite these limitations, the results suggest the need for further investigation into the potential health effects of EMF exposure in adolescents.

Future Scope

Future studies should include larger sample sizes, longitudinal designs, and direct EMF measurements to better understand the long-term effects of cell phone tower emissions on developing brains and bodies.

CONCLUSION

This study revealed that closer residential proximity to cell phone towers was significantly associated with a higher prevalence and greater severity of headaches, sleep disturbances, and difficulty concentrating among adolescents in Maysan Governorate. The results suggest a relationship between proximity to towers and selected self-reported symptoms, but causality or harm cannot be inferred without objective exposure assessment and more robust longitudinal data. Adolescents living within 100–200 m of towers consistently reported worse symptom patterns than those living farther away, and these associations remained significant in adjusted analyses. In contrast, fatigue, mood changes, and memory issues did not show statistically significant

associations. These findings suggest a possible adverse relationship between tower-related EMF exposure and selected neurobehavioral symptoms in adolescents. In addition, it is crucial for nurses to continue investigating these effects on human health and the environment and to guide the safe placement of cell phone towers in residential areas and at distances with minimal health impacts.

It has been suggested that objective exposure assessment techniques, such as personal RF-EMF dosimeters and spot measurements, may provide more accurate estimates of electromagnetic field exposure. Depending exclusively on the distance from mobile phone towers could result in exposure misclassification, while the use of direct measurement methods may enhance the reliability and validity of study findings. Utilize longitudinal (cohort) designs to examine temporal correlations and mitigate the constraints of cross-sectional inference. Differentiate exposure sources (base stations against personal phone usage and Wi-Fi) and enhance the accuracy of total exposure modeling. Assess and modify significant confounders (sleep quality, mental health/stress, physical exercise, screen time, and socioeconomic factors) employing proven metrics. Investigate dose–response relationships and effect modification factors such as sex, age subgroups, indoor versus outdoor exposure, and urban versus rural microenvironments.

Recommendations

These results emphasize the importance of conducting further studies on the long-term health consequences of EMF exposure in this sensitive age group. With mobile devices being so widely used, gaining a clearer understanding of these effects is essential for shaping future health recommendations and regulatory standards.

CRedit Authorship Contribution Statement

M.A.N.A.M: Writing – original draft, Formal analysis, Investigation. H.S.M: Supervision, Review, editing, Data curation and Methodology.

AI Assistance Declaration

No AI tools were used in the preparation of this manuscript.

Conflict of Interest

The authors declare that have no competing interests.

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