### **EFFECT OF CONTINUOUS EXPOSURE UNDER HIGH VOLTAGE OVERHEAD POWERLINE ON SOME PARAMETERS OF BONE METABOLISM**

**ABSTRACT**

Continuous exposures to electromagnetic field (EMF) from high-voltage overhead powerlines have been linked to alterations in biochemical and haematological indices that can impact human health negatively. This cross-sectional study investigated the effects of continuous EMF exposure from high-voltage overhead powerlines on bone metabolism parameters. Eighty (80) participants comprised of fifty (50) exposed individuals (test group) residing within 500 meters of the power lines and control group from low-EMF areas were randomly recruited. Participants were aged between 18-65years and were aged matched. Structured questionnaire was used to collect information on demographic variables, medical history, lifestyle factors and duration of residence near powerlines. Six milliliters (6 ml) of venous blood samples was collected from each participant with minimal stasis into EDTA (2 ml) and plain (4 ml) containers for the determination of Haematological parameters, Alkaline phosphatase (ALP), Calcium and Inorganic phosphate (IP). Haematological parameters were determined using three part Haematology Analyzer while serum ALP, Calcium and IP were determined using spectrophotometric methods. Of the participants, 62.0% were male and 18.0% were female, with 31.2% being middle-aged and 68.8% being young people. Traders accounted for 46.3% of occupations, followed by drivers (12.5%), artisans (15.0%), and students (18.8%). Bini (28.8%), Hausa (31.3%), Ibo (15.0%), Calabar (5.0%), Itsekiri (3.8%), Yoruba (11.3%), and Urhobo (5.0%) were among the ethnic groups represented in the sample. The mean serum ALP level and monocyte count were significantly reduced (p=0.024; 0.016) with mean corpuscular volume (MCV) significantly increased (p=0.001) in the exposed group compared to control group while Calcium and phosphate levels did not differ significantly (p>0.05). Also, females had significantly lower mean serum IP levels than in males (p=0.048). Duration of exposure analysis indicated a significant reduction in mean cell hemoglobin concentration (MCHC) (p=0.01) in those exposed for 6-10 years compared to less than 1 year. This study highlights significant biochemical and hematological alterations associated with EMF exposure from high-tension wires, emphasizing the need for further research to understand long-term health impacts.

**KEY WORDS:** Electromagnetic field exposure, high-voltage overhead powerlines, bone metabolism, Alkaline phosphatase, Calcium, inorganic phosphate, full blood count.

**INTRODUCTION**

Since life first appeared on Earth, living things have been accompanied by electromagnetic fields and radiation (Lewczuk *et al*., 2014). The human body is a dynamic electromagnetic device with astonishing parallels, with each cell functioning inside its own distinct electric circuitry (Funk *et al.,* 2009). Because of the bioelectrical currents flowing through its tissues and organs, the human body therefore emits its own magnetic field. Harmonious functioning is ensured by the smooth intercommunication of substances within the human system made possible by this internal magnetic symphony. While natural magnetic fields envelop both the internal and external realms of existence, modern human life introduces additional sources of electromagnetic influence. Humans are surrounded by artificial magnetic fields, which can be detected in everything from cell phones to computers, domestic electrical gadgets, and even the looming presence of high-voltage transmission lines (Misek *et al*., 2023). However, these technological marvels come with a caveat—their pervasive presence can disrupt the delicate electromagnetic equilibrium of the human body, potentially leading to various disturbances in physiological processes.

Electromagnetic fields (EMFs) have been implicated in the disruption of cellular functions, a phenomenon well-documented in scientific literature (Panagopoulos *et al*., 2019; Panagopoulos *et al*., 2021). The ramifications of this disruption extend to various health issues including insomnia, headaches, and heightened stress levels (Behari, 2010; Megha *et al*., 2012). Moreover, the impact of EMFs on bodily systems is profound, affecting blood biochemistry, antioxidant capacity, immune system, reproductive organs as well as the digestive and circulatory systems, thereby exacerbating health concerns (Kim *et al*., 2019; Kıvrak *et al*., 2017; [Türedi *et a*l., 2017](https://www.biomolther.org/journal/view.html?volume=27&number=3&spage=265#B115); [Kim *et al*., 2017](https://www.biomolther.org/journal/view.html?volume=27&number=3&spage=265#B57); [Altun *et al*., 2018](https://www.biomolther.org/journal/view.html?volume=27&number=3&spage=265#B4); [Kazemi *et al*., 2015](https://www.biomolther.org/journal/view.html?volume=27&number=3&spage=265#B52)). Of particular concern are the potential carcinogenic effects of EMFs (Panagopoulos *et al*., 2021), with studies highlighting a correlation between exposure to high-voltage transmission lines and an increased risk of cancer in children as well as in general population (Crespi *et al*., 2019; Carles *et al*., 2020). These findings underscore the urgent need for further investigation into the potential health risks posed by EMFs emanating from high-voltage infrastructure.

Furthermore, previous research points to the association between the risk of Alzheimer's disease among individuals with frequent exposure to EMFs (Davanipour *et al.,* 2007). Specifically, workers in occupations such as radio operators, industrial equipment workers, data processing device mechanics, phone-line workers, and those employed in electric plants and substations are observed to have significantly elevated risks of developing Alzheimer's disease (Davanipour *et al.,* 2007). This disparity is striking, with rates of Alzheimer's disease found to be four times higher in men and three to four times higher in women within these occupational groups, further emphasizing the potential health consequences associated with EMF exposure.

Since magnetic fields are imperceptible and their effects accumulate over time, they are often overlooked. However, research on animal cells indicates that inadequate magnetic fields can disrupt biological processes, including hormone and enzyme levels, and impede tissue chemical movement (Roda-Murillo *et al.,* 2005; Frahm *et al.,* 2006; Guler *et al.,* 2006; La Vignera *et al*., 2012). Some literature suggests a correlation between living near high-voltage electric transmission lines (HVETL) and increased disease incidence (Yamazaki *et al.,* 2006), yet little is known about their impact on bone metabolism.

The continuous exposure to electromagnetic fields (EMFs) from high voltage overhead powerlines poses a potential risk to human health, including alterations in bone metabolism. However, empirical evidence linking EMF exposure to changes in bone metabolism parameters, such as Alkaline phosphatase (ALP), Calcium, and Phosphate, remains limited. This research gap underscores the need for comprehensive investigations to elucidate the potential effects of EMF exposure on bone health.

Despite the growing concern over the health implications of EMF exposure, particularly from powerlines, a thorough understanding of its impact on bone metabolism is lacking. This knowledge deficit hampers the development of evidence-based strategies to mitigate potential risks and safeguard public health. Therefore, addressing this gap through rigorous scientific inquiry is essential to inform policy making and public health interventions aimed at protecting individuals from the adverse effects of EMF exposure on bone.

Bone health is essential for overall well-being, playing a critical role in locomotion, support, and protection of vital organs. Disruption of bone metabolism can lead to debilitating conditions such as osteoporosis and osteomalacia, which significantly impair quality of life and increase healthcare costs. Despite the considerable attention given to the potential health effects of electromagnetic fields (EMFs), particularly from high voltage overhead powerlines, limited research has focused on their impact on bone metabolism. The deployment of high voltage overhead powerlines is widespread in both urban and rural environments, resulting in continuous exposure of individuals to EMFs. While the carcinogenic and neurological effects of EMF exposure have been extensively studied, its potential influence on bone health remains an area of uncertainty. Given the essential role of bone metabolism in maintaining skeletal integrity and overall health, investigating the relationship between EMF exposure and bone parameters is imperative.

Understanding the potential effects of continuous EMF exposure on bone metabolism is not only crucial for individual health but also for public health policy making. By elucidating this relationship, policy makers can develop targeted interventions to mitigate potential risks and protect vulnerable populations. Furthermore, as the prevalence of high voltage overhead powerlines continues to increase globally, preemptive measures informed by empirical research can help minimize adverse health outcomes associated with EMF exposure. Thus, our study investigates the influence of HVETL electromagnetic fields on bone metabolism.

**MATERIALS AND METHODS**

**Study Design**

This cross-sectional study was designed to investigate the effect of continuous exposure to high voltage overhead powerlines on selected parameters of bone metabolism. Cross-sectional studies are ideal for examining associations between exposure and outcome variables at a single point in time, making them suitable for assessing the relationship between electromagnetic field (EMF) exposure and bone metabolism parameters.

Structure questionnaire was used to gather information on demographic variables (age, gender, ethnicity), medical history (presence of bone diseases, metabolic disorders), lifestyle factors (smoking, alcohol consumption, physical activity), and duration of residence near powerlines.

 **Study Area**

The study area, was the region of Ugbor Benin City, located in Edo State, Nigeria, serves as the focal point for investigating the impact of continuous exposure to high voltage overhead powerlines on bone metabolism parameters. Situated approximately 320 kilometers east of Lagos, Benin City embodies a mix of urban and suburban environments within the tropical rainforest belt, experiencing distinct wet and dry seasons. The city's landscape features a diverse socioeconomic spectrum, from densely populated urban centers to sparsely populated suburban neighborhoods, reflecting varied income levels and occupational backgrounds. With its well-connected road networks, healthcare facilities, and research institutions, Benin City offers accessibility and infrastructure conducive to data collection and analysis. Moreover, its cultural richness and ethnic diversity underscore the importance of considering cultural context in understanding health behaviors and perceptions related to electromagnetic field exposure.

**Study Population and sample size**

A total of eighty (80) participants were randomly recruited for the study. The target population was consisting of individuals aged 18-65 years who reside within a defined radius (e.g., 500 meters) of high voltage overhead powerlines. A control group comprising individuals living in low-EMF exposure areas was included for comparison. Both test group and control subjects were aged matched.

**Inclusion Criteria**

Participants were included in the study based on the following criteria:

* Aged between 18 and 65 years.
* Reside within the defined radius of high voltage overhead powerlines for at least six months.
* Provide informed consent to participate in the study.

**Exclusion Criteria**

Participants were excluded from the study if they:

* Have a history of bone diseases or metabolic disorders affecting bone metabolism.
* Are pregnant or breastfeeding.
* Have received treatment known to affect bone metabolism in the past six months.

**Ethical Consideration**

Ethical approval was obtained from the Ethics Committee of Benson Idahosa University prior to commencement of the study to ensure compliance with the ethical standards and guidelines for research involving human subjects. Informed consent was also obtained from all participants before their involvement in the study, and they were assured of confidentiality and anonymity of their data. Participants were also informed of their right to withdraw from the study at any time without consequences.

**Sample Collection and preparation**

Samples for Full Blood Count (FBC) were collected in EDTA containers (2ml) and plain containers was used for the collection of samples for Calcium, Alkaline phosphatase (ALP) and phosphate (4ml). The samples collected in the plain tubes were centrifuged for 5minutes at 4000rpm to separate the serum from the whole blood and the serum was transferred into another container. The levels of serum calcium, ALP, phosphate and haematological parameters were determined.

**Laboratory Methods**

**Determination of serum calcium level**

 Serum calcium level was determined following the method described by Cali *et al.* (1973).

**Determination of serum ALP activity**

ALP (E.C 3.1.3.1) activity was determined following the method described by Bessey *et al.* (1946).

**Determination of serum inorganic phosphate level**

 Serum inorganic phosphate level was determined following the method described by Daly and Ertingshausen (1972).

**Measurement of Full Blood Count**

The full blood count (FBC) parameters (White Blood Cells (WBC), Red Blood Cell Count (RBC), Platelet Count (PLT), Haemoglobin (Hb), Haematocrit/packed cell volume (HCT/PCV), Mean corpuscular volume (MCV), Mean corpuscular hhaemoglobin (MCH), Mean corpuscular hemoglobin concentration (MCHC), Lymphocyte count (LYMP), Neutrophil count (NEUT) and Monocyte count (MONO) were determined using three part haematology analyzer.

**Statistical Analysis**

Descriptive data were expressed as mean and standard error of mean for continuous variables and as percentages for categorical variables. Comparative analysis between two and more groups was done using independent sample t-test and one-way analysis of variance. Statistical significance was set at *P* < 0.05. All statistics were performed using SPSS for windows (IBM version 26.0)

**RESULTS**

The socio-demographic variables of the eighty (80) subjects in the study revealed that 68.8% were young adults and 31.2% were middle-age. Of the total subjects, 18.0% were females and 62.0% were males. Of the total subjects, 65.0% were single and 35.0% were married. Of the total subjects, 30.0% had physical activity and 62.5% had no physical activity. Of the total subjects, 46.3% were traders, 15.0% were artisans, 12.5% were drivers,18.8% were students and 2.5% were keke drivers, civil servants and barbers respectively. Of the total subjects, 25.0% had a primary level of education, 31.3% had a secondary level of education and 43.7 % had a tertiary level of education. Of the total subjects, 28.8% were Bini, 31.3% were Hausa, 15.0% were Ibo, 5.0% were from Calabar, 3.8% were from Itsekiri, 11.3% were from Yoruba and 5.0% were from Urhobo (**Table 1**)

**Table 2** shows the levels of alkaline phosphatase (ALP), calcium and phosphate among over-high tension wire exposed and unexposed subjects. It was observed that the levels of ALP were significant reduced (p<0.05) in exposed compared with unexposed subjects while the level of calcium and phosphate show no significant difference (p>0.05) in exposed compared with unexposed subjects

**Table 3** shows the levels of hematological parameters among subjects exposed and unexposed to over-high tension wire. It was observed that the levels of monocytes were significantly reduced (p<0.05) in exposed group compared with unexposed group. The level of mean corpuscular volume (MCV) show significant increase (p<0.05) in exposed group compared with unexposed group while hematological parameters shows no significant difference among each other(p>0.05).

**Table 4** shows the levels of hematological parameters among duration of exposure to over-high tension wire. It was observed that the levels of mean cell hemoglobin concentration(MCHC) was significantly reduced(p<0.05) in prolong exposure of 6-10years compared with <1year of exposure while other hematological parameters show no significant difference between of duration of exposure (p>0.05).

**Table 5** shows the levels of hematological parameters among proximity to over-high tension wire. It was observed that the levels of hematological parameters show no significant difference across the group (p>0.05).

**Table 6** shows the levels of alkaline phosphatase (ALP), calcium and phosphate among gender of the overall study population. It was observed that the levels of phosphate were significantly increase (p<0.05) in male compared with female while ALP amd calcium show no significant difference (p>0.05) in overall study population.

**Table 7** shows the levels of alkaline phosphatase (ALP), calcium and phosphate among gender exposed to over-high tension wire. It was observed that the levels of alkaline phosphatase (ALP), calcium and phosphate were not significantly difference (p>0.05) among gender.

**Table 8** shows the levels of alkaline phosphatase (ALP), calcium and phosphate between duration of exposure. It was observed that the levels of alkaline phosphatase (ALP), calcium and phosphate were non- significantly difference (p>0.05) across groups.

**Table 9** shows the levels of alkaline phosphatase (ALP), calcium and phosphate between proximity to over-high tension wire in exposure subjects. It was observed that the levels of alkaline phosphatase (ALP), calcium and phosphate between proximity to over-high tension wire were non- significantly difference (p>0.05) across groups.

**Discussion**

Electromagnetic fields (EMFs) generated by overhead high-tension electric wires are ubiquitous in modern urban environments. The potential health impacts of EMF exposure have been a subject of scientific investigation and public concern for decades. This study explored the socio-demographic characteristics and the biochemical and hematological effects of exposure to electromagnetic fields from high-tension wires on individuals in a specific population. By comparing exposed and unexposed groups, the study aims to understand the potential biological impacts of long-term EMF exposure. Previous studies have shown mixed results regarding the health impacts of EMF exposure, with some indicating potential risks such as increased cancer rates and others finding minimal or no significant effects (Davanipour *et al.,* 2007; Bortkiewicz *et al.,* 2012). This study contributes to the ongoing debate by providing detailed statistical analysis of various health parameters in the context of EMF exposure.

The socio-demographic profile of the 80 subjects involved in this study reveals a diverse group with varying levels of exposure to EMFs. The majority (68.8%) were young adults, while 31.2% were middle-aged. Gender distribution was heavily skewed towards males (62.0%) compared to females (18.0%). Marital status showed that 65.0% of the subjects were single, and 35.0% were married. Regarding physical activity, 30.0% engaged in physical activities, while a significant 62.5% did not. In terms of occupation, traders constituted the largest group (46.3%), followed by students (18.8%), artisans (15.0%), and drivers (12.5%). Smaller percentages were observed for keke drivers, civil servants, and barbers (2.5% each). Educational status varied, with 25.0% having primary education, 31.3% secondary education, and 43.7% tertiary education. Ethnic composition included Bini (28.8%), Hausa (31.3%), Ibo (15.0%), Calabar (5.0%), Itsekiri (3.8%), Yoruba (11.3%), and Urhobo (5.0%). These socio-demographic variables are crucial for understanding the context of the study and potential confounders in the analysis of health impacts due to EMF exposure.

The study measured levels of alkaline phosphatase (ALP), calcium, and phosphate among subjects exposed and unexposed to high-tension wire EMFs. It was found that ALP levels were significantly reduced in the exposed group compared to the unexposed group, indicating a potential biochemical alteration due to EMF exposure. However, calcium and phosphate levels showed no significant difference between the exposed and unexposed groups. Alkaline phosphatase is an enzyme related to liver function and bone metabolism, and its reduction in exposed individuals could suggest potential impacts on these physiological systems. Previous studies have shown varied effects of EMF on enzymatic activity, with some reporting changes in enzyme levels due to oxidative stress induced by EMF exposure (Schuermann and Mevissen, 2021; Migdal *et al*., 2023; Kivrak *et al.,* 2017). The significant reduction in ALP levels among exposed subjects suggests potential biochemical alterations due to EMF exposure. ALP is involved in dephosphorylation and plays a role in liver function and bone metabolism. Reduced ALP levels could indicate altered liver function or bone health in individuals exposed to EMFs. This finding aligns with studies suggesting that EMF exposure can induce oxidative stress, leading to cellular damage and altered enzyme activity (Kim *et al.,* 2017; Budziosz *et al.,* 2018; Kivrak *et al.,* 2017). The lack of significant differences in calcium and phosphate levels between exposed and unexposed groups might indicate that EMF exposure does not significantly affect these mineral levels in the short to medium term. However, long-term studies are needed to fully understand the potential impacts on calcium and phosphate metabolism.

The analysis of hematological parameters revealed that monocyte levels were significantly reduced in the exposed group compared to the unexposed group. Conversely, mean corpuscular volume (MCV) showed a significant increase in the exposed group. Other hematological parameters, including white blood cell count (WBC), lymphocytes (LYMP), neutrophils (NEU), red blood cells (RBC), hemoglobin (HGB), hematocrit (HCT), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and platelets (PLT) did not show significant differences between exposed and unexposed groups. Monocytes play a role in immune function, and their reduction could indicate a suppressed immune response in individuals exposed to EMFs. Increased MCV in the exposed group might suggest changes in red blood cell morphology, which could be attributed to oxidative stress or other cellular damage mechanisms induced by EMF exposure (Havas, 2013; Obeagu *et al.,* 2024).

The observed reduction in monocyte levels in exposed subjects suggests a potential impact on the immune system. Monocytes are crucial for immune response, and their reduction could imply a weakened immune function. This finding is supported by previous studies indicating that EMF exposure can affect immune cell functions and cytokine production (Mahaki *et al.,* 2020). The increase in MCV among exposed subjects suggests changes in red blood cell morphology, potentially due to oxidative stress or other cellular damage mechanisms. Elevated MCV is often associated with macrocytic anemia, which can result from vitamin B12 or folate deficiencies, both of which could be influenced by EMF exposure (Szmigielski, 1996; Aslinia *et al.,* 2006; Killeen and Adil, 2025).

The study further analyzed hematological parameters based on the duration of EMF exposure. It was observed that mean cell hemoglobin concentration (MCHC) was significantly reduced in individuals with prolonged exposure of 6-10 years compared to those with less than 1 year of exposure. Other parameters did not show significant differences based on exposure duration. Prolonged exposure to EMF might exacerbate the observed effects on hematological parameters, particularly MCHC. Long-term exposure studies are crucial for understanding the chronic effects of EMF, as short-term studies might not capture the cumulative impact (Belyaev, 2017; Pophof *et al*.*,* 2021). The study also examined the effect of proximity to high-tension wires on hematological parameters. No significant differences were found across different proximity groups for any of the hematological parameters. This suggests that the distance from the EMF source might not significantly influence these particular health indicators within the studied range. However, the lack of significant differences does not rule out potential localized effects or other health impacts not measured in this study. Proximity analysis should consider other factors such as duration of exposure and individual susceptibility (Redmayne & Johansson, 2014; Brender *et al.,* 2011).

The significant reduction in MCHC with prolonged exposure indicates that chronic EMF exposure might exacerbate hematological changes. MCHC reduction is indicative of hypochromic anemia, suggesting potential impacts on hemoglobin synthesis or red blood cell production over time. This finding emphasizes the need for long-term studies to assess chronic EMF exposure effects comprehensively. The lack of significant differences in hematological parameters based on proximity to high-tension wires suggests that distance within the studied range does not significantly influence these health indicators. However, individual susceptibility and other environmental factors should be considered in future studies to fully understand the spatial impacts of EMF exposure.

When analyzing the duration of exposure among exposed subjects, no significant differences were found in ALP, calcium, or phosphate levels across different exposure durations. This indicates that the duration of EMF exposure did not significantly alter these biochemical parameters in the studied population. Similarly, analysis of proximity to high-tension wires in exposed subjects showed no significant differences in ALP, calcium, or phosphate levels. This further supports the finding that proximity alone, within the studied distances, does not significantly impact these biochemical parameters.

Gender-based analysis showed that phosphate levels were significantly higher in males compared to females in the overall study population, while ALP and calcium levels showed no significant differences. Among those exposed to high-tension wires, no significant differences in ALP, calcium, or phosphate levels were found between genders. These findings suggest potential gender-related differences in biochemical responses to EMF exposure, which could be attributed to physiological or hormonal variations between males and females (Vijayalaxmi and Obe, 2004).

The higher phosphate levels in males compared to females in the overall population could indicate gender-specific metabolic responses to EMF exposure. Phosphate is crucial for energy metabolism and bone health, and its regulation might differ between genders due to hormonal influences. Further research is needed to elucidate the mechanisms behind these gender differences (Vijayalaxmi and Obe, 2004).

While this study provides valuable insights into the biochemical and hematological effects of EMF exposure, several limitations should be addressed. The sample size is relatively small, and the cross-sectional design limits the ability to establish causality. Longitudinal studies with larger sample sizes are needed to confirm these findings and understand the long-term health impacts of EMF exposure. Additionally, the study did not account for potential confounding factors such as dietary habits, lifestyle choices, and other environmental exposures that could influence the observed health parameters. Future studies should incorporate these variables to provide a more comprehensive analysis.

**Conclusion**

This study highlights significant biochemical and hematological alterations associated with EMF exposure from high-tension wires. Reduced ALP levels and altered monocyte and MCV levels in exposed individuals suggest potential impacts on liver function, immune response, and red blood cell morphology. Prolonged exposure appears to exacerbate certain hematological changes, emphasizing the need for long-term studies. The findings also suggest potential gender differences in biochemical responses to EMF exposure, warranting further investigation. Overall, this study contributes to the understanding of EMF health impacts and underscores the need for continued research to inform public health policies and safety regulations regarding EMF exposure.

**Recommendations**

Based on the findings of this study regarding the impact of electromagnetic field (EMF) exposure from overhead high-tension wires on biochemical and hematological parameters, several recommendations can be made to address potential health risks and inform public health policies. These recommendations are aimed at mitigating the adverse effects of EMF exposure, enhancing public awareness, and guiding future research.

**1. Enhancement of Public Health Awareness**

Public awareness campaigns should be launched to educate the population about the potential health risks associated with prolonged exposure to electromagnetic fields from high-tension wires. These campaigns should inform the public by providing clear, evidence-based information on the possible health impacts of EMF exposure, including alterations in biochemical and hematological parameters. Furthermore, engaging community leaders and collaborating with health professionals to disseminate information effectively ensures that it reaches vulnerable populations.

**2. Policy and Regulation Enhancements**

Regulatory bodies should consider revising existing policies and implementing new regulations to limit EMF exposure from high-tension wires. These regulations should include establishing safe distance guidelines by defining and enforcing minimum safe distances between residential areas and high-tension wires based on the latest scientific evidence.

**3. Implementation of Protective Technologies**

Encouraging the development and adoption of technologies designed to reduce EMF exposure can be beneficial. Recommendations include promoting EMF shielding by using materials and devices that shield or reduce EMF exposure in residential and occupational settings. Implementing smart grid technologies can also help, as these advanced electrical grid technologies minimize EMF emissions while maintaining efficient power distribution.

**4. Occupational Health and Safety Measures**

For individuals who work in environments with high EMF exposure, specific occupational health and safety measures should be implemented. Regular health screenings should be conducted for workers exposed to EMFs to detect and address potential health issues early. Providing appropriate personal protective equipment and training can help reduce EMF exposure among workers in high-risk occupations. Moreover, establishing and enforcing workplace regulations that limit EMF exposure ensures a safe working environment.

**5. Support for Vulnerable Populations**

Special attention should be given to protecting vulnerable populations, such as children, pregnant women, and individuals with preexisting health conditions. Specific measures include developing targeted education campaigns with materials and programs tailored to vulnerable populations, highlighting the importance of minimizing EMF exposure. Implementing health monitoring programs for these populations can track health outcomes related to EMF exposure and provide necessary interventions.

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**Table 1: Socio - Demographic Characteristics of the Participants**

|  |  |  |
| --- | --- | --- |
| Characteristics | Number of Subjects | Percentage |
| ***Gender****Females**Males* | 6218 | 77.522.5 |
| ***Educational Status*** |  |  |
| *Primary* | 20 | 25.0 |
| *Secondary* | 25 | 31.3 |
| *Tertiary* | 35 | 43.7 |
| ***Age Groups****Young Adults**Middle-Aged* | 5525 | 68.831.2 |
| *Marital Status**Married**Single* | 2852 | 35.065.0 |
| ***Occupation****Traders**Artisans**Students**Drivers**Keke riders**Barbers**Civil servants* | 37121510222 | 46.315.018.815.42.52.52.5 |
| ***Physical activity*** |  |  |
| *Yes* | 30 | 37.5 |
| *No* | 50 | 62.5 |
| ***State of Origin****Bini**Hausa**Ibo**Calabar**Itsekiri**Yoruba**Urhobo* | 2325124394 | 28.831.315.05.03.811.35.0 |

**Table 2: Level of Alkaline Phosphatase, Calcium and Phosphate Among Over High Tension Wire Exposed and Unexposed Subjects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameters | Study Group | N | Mean | Std. Error Mean | T-value | P-value |
|  ALP (IU/L) | Exposed To EMF | 50 | 143.26 | 3.30 | -2.36 | 0.024\* |
| Unexposed To EMF | 30 | 165.57 | 8.86 |
|  Calcium (mg/dl) | Exposed To EMF | 50 | 9.99 | 0.43 | -1.54 | 0.126 |
| Unexposed To EMF | 30 | 11.02 | 0.46 |
| Phosphate (mg/dl) | Exposed To EMF | 50 | 3.96 | 0.20 | -1.50 | 0.137 |
|  | Unexposed To EMF | 30 | 4.46 | 0.25 |  |  |

\*Statistically significant at p<0.05

**Table 3: Level of Hematological Parameter Among Over High Tension Wire Exposed and Unexposed Subjects**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameters | Study Group | N | Mean | Std. Error Mean | T-value | P-value |
| WBC(X109/L | Exposed To EMF | 50 | 4.08 | 0.12 | 0.536 | 0.594 |
| Unexposed To EMF | 30 | 3.94 | 0.28 |
| LYMP(%) |  Exposed To EMF | 50 | 43.77 | 1.93 | -0.805 | 0.423 |
| Unexposed To EMF | 30 | 45.60 | 1.22 |
| MONO(%) | Exposed To EMF | 50 | 10.67 | 0.39 | -2.466 | 0.016\* |
| Unexposed To EMF | 30 | 12.44 | 0.64 |
|  NEU(%) |  Exposed To EMF | 50 | 42.07 | 1.87 | -0.705 | 0.483 |
| Unexposed To EMF | 30 | 48.16 | 10.75 |
| RBC X1012/L | Exposed To EMF | 50 | 5.46 | 0.08 | -0.975 | 0.336 |
| Unexposed To EMF | 30 | 26.36 | 21.37 |
| HGB(g/dl) |  Exposed To EMF | 50 | 13.50 | 0.23 | 0.733 | 0.466 |
| Unexposed To EMF | 30 | 13.22 | 0.32 |
|  HCT(%) | Exposed To EMF | 50 | 42.17 | 1.31 | 1.760 | 0.082 |
| Unexposed To EMF | 30 | 38.94 | 0.91 |
| MCV(fL) |  Exposed To EMF | 50 | 80.15 | 1.39 | 5.250 | 0.001\* |
| Unexposed To EMF | 30 | 72.21 | 0.60 |
| MCH(pg) | Exposed To EMF | 50 | 24.96 | 0.28 | 1.656 | 0.102 |
| Unexposed To EMF | 30 | 24.23 | 0.31 |
|  MCHC(g/dL) |  Exposed To EMF | 50 | 31.83 | 0.42 | -1.507 | 0.136 |
| Unexposed To EMF | 30 | 32.85 | 0.52 |
| PLT(X109/L) |  Exposed To EMF | 50 | 157.10 | 7.57 | 1.171 | 0.245 |
| Unexposed To EMF | 30 | 143.17 | 8.77 |

\*Statistically significant at p<0.05, EMF- Electromagnetic wave generated by overhead high tension electric wire, WBC-white blood cell count, LYMP-lymhocyte, MONO-Monocyte,RBC-Red blood cells count, HCT- Hematocrit, NEUT-neutrophil, HGB-haemoglobin, MCV- Mean corpuscular volume, MCH- Mean corpuscular hemoglobin, MCHC- Mean corpuscular hemoglobin concentration, PLT- platelet.

**Table 4: Level of Hematological Parameters Among Duration of Exposure**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | N | Mean | Std. Error |  Range |  Statistics |
| Minimum | Maximum | F-value | P-value |
| WBC(X109/L |  <1YRS | 6 | 4.00a | 0.22 | 3.30 | 4.60 | 0.234 | 0.872 |
|  1-5YRS | 37 | 4.12a | 0.16 | 2.00 | 6.90 |
|  6-10YRS | 2 | 3.60a | 0.10 | 3.50 | 3.70 |
|  >10YRS | 5 | 4.10a | 0.26 | 3.50 | 4.90 |
| LYMP(%) | <1YRS | 6 | 41.42a | 3.46 | 32.80 | 53.00 | 0.500 | 0.684 |
| 1-5YRS | 37 | 44.82a | 2.49 | .00 | 76.80 |
| 6-10YRS | 2 | 33.50a | 0.80 | 32.70 | 34.30 |
| >10YRS | 5 | 42.92a | 3.26 | 35.50 | 53.10 |
| MONO(%) |  <1YRS | 6 | 11.56a | 0.37 | 10.00 | 12.80 | 0.753 | 0.526 |
|  1-5YRS | 37 | 10.37a | 0.50 | 0.00 | 15.80 |
| 6-10YRS | 2 | 12.70a | 0.50 | 12.20 | 13.20 |
| >10YRS | 5 | 11.20a | 1.07 | 8.30 | 14.20 |
|  NEU(%) | <1YRS | 6 | 47.02a | 3.60 | 35.40 | 56.60 | 0.943 | 0.428 |
| 1-5YRS | 37 | 40.22a | 2.34 | 0.00 | 60.40 |
| 6-10YRS | 2 | 48.80a | 5.30 | 43.50 | 54.10 |
| >10YRS | 5 | 47.18a | 3.78 | 33.80 | 54.30 |
|  RBC X1012/L | <1YRS | 6 | 5.58a | 0.25 | 4.64 | 6.60 | 0.162 | 0.921 |
| 1-5YRS | 37 | 5.45a | 0.09 | 3.90 | 6.20 |
| 6-10YRS | 2 | 5.29a | 0.20 | 5.09 | 5.49 |
|  >10YRS | 5 | 5.48a | 0.24 | 4.68 | 5.98 |
| HGB(g/dl) | 1 <1YRS | 6 | 14.05a | 0.78 | 11.20 | 15.80 | 0.289 | 0.833 |
| 1-5YRS | 37 | 13.43a | 0.27 | 9.40 | 16.00 |
| 6-10YRS | 2 | 13.05a | 1.15 | 11.90 | 14.20 |
|  >10YRS | 5 | 13.60a | 0.69 | 12.10 | 16.00 |
| HCT(%) | <1YRS | 6 | 42.18a | 2.48 | 33.70 | 49.50 | 0.225 | 0.878 |
| 1-5YRS | 37 | 41.83a | 1.69 | 0.00 | 56.30 |
|  6-10YRS | 2 | 47.45a | 3.75 | 43.70 | 51.20 |
| >10YRS | 5 | 42.56a | 2.21 | 35.80 | 49.50 |
|  MCV(fL) | <1YRS | 6 | 76.63a | 3.09 | 68.60 | 89.80 | 0.924 | 0.437 |
| 1-5YRS | 37 | 80.42a | 1.63 | 59.40 | 95.50 |
|  6-10YRS | 2 | 89.60a | 3.70 | 85.90 | 93.30 |
| >10YRS | 5 | 78.58a | 5.42 | 61.20 | 94.20 |
| MCH(pg) |  <1YRS | 6 | 25.70a | 0.49 | 23.90 | 27.50 | 0.471 | 0.704 |
| 1-5YRS | 37 | 24.95a | 0.34 | 19.40 | 30.00 |
|  6-10YRS | 2 | 24.55a | 1.25 | 23.30 | 25.80 |
| >10YRS | 5 | 24.30a | 1.11 | 21.00 | 27.20 |
|  MCHC(g/dL) | <1YRS | 6 | 33.35b | 0.95 | 28.80 | 34.90 | 2.13 | 0.010\* |
| 1-5YRS | 37 | 31.77ab | 0.49 | 25.20 | 35.40 |
|  6-10YRS | 2 | 27.45a | 0.25 | 27.20 | 27.70 |
| >10YRS | 5 | 32.24ab | 1.24 | 27.50 | 34.30 |
| PLT(X109/L) | <1YRS | 6 | 132.00a | 15.58 | 95.00 | 197.00 | 2.01 | 0.115 |
|  1-5YRS | 37 | 154.51a | 8.63 | 62.00 | 289.00 |
|  6-10YRS | 2 | 154.00a | 46.00 | 108.00 | 200.00 |
| >10YRS | 5 | 207.60a | 25.22 | 150.00 | 279.00 |

Mean values in column with same superscript are not significantly different from each other(p>0.05), Mean values in column with different superscript are significantly different from each other(p<0.05),EMF- Electromagnetic wave generated by overhead high tension electric wire**,** WBC-white blood cell count, LYMP-lymhocyte, MONO-Monocyte,RBC-Red blood cells count, HCT- Hematocrit, NEUT-neutrophil, HGB-haemoglobin, MCV- Mean corpuscular volume, MCH- Mean corpuscular hemoglobin, MCHC- Mean corpuscular hemoglobin concentration, PLT- platelet.

**Table 5: Level of Hematological Parameters Among Proximity to Over High Tension Wire**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | N | Mean | Std. Error | Range | Statistics |
| Minimum | Maximum | F-value | P-value |
| WBC(X109/L | <100m | 17 | 4.10a | 0.13 | 3.10 | 4.90 | 0.768 | 0.470 |
| 100-500m | 30 | 4.01a | 0.16 | 2.00 | 6.20 |
| 600-1000m | 3 | 4.67a | 1.19 | 2.80 | 6.90 |
| LYMP(%) | <100m | 17 | 45.23a | 3.69 | 23.40 | 76.80 | 0.161 | 0.852 |
| 100-500m | 30 | 42.87a | 2.45 | 0.00 | 70.90 |
| 600-1000m | 3 | 44.47a | 5.17 | 38.90 | 54.80 |
| MONO(%) | <100m | 17 | 10.91a | 0.43 | 7.60 | 13.30 | 0.349 | 0.707 |
| 100-500m | 30 | 10.69a | 0.61 | 0.00 | 15.80 |
| 600-1000m | 3 | 9.43a | 0.94 | 8.00 | 11.20 |
| NEU(%) | <100m | 17 | 42.08a | 2.77 | 20.50 | 57.30 | 0.812 | 0.450 |
| 100-500m | 30 | 42.99a | 2.51 | 0.00 | 60.40 |
| 600-1000m | 3 | 32.77a | 10.53 | 13.10 | 49.10 |
| RBC X1012/L | <100m | 17 | 5.68a | 0.09 | 5.04 | 6.15 | 2.69 | 0.078 |
| 100-500m | 30 | 5.37a | 0.11 | 3.90 | 6.60 |
| 600-1000m | 3 | 5.09a | 0.05 | 5.02 | 5.20 |
| HGB(g/dl) | <100m | 17 | 13.59a | 0.42 | 10.40 | 16.00 | 1.17 | 0.321 |
| 100-500m | 30 | 13.59a | 0.29 | 9.40 | 16.00 |
| 600-1000m | 3 | 12.10a | 1.00 | 10.60 | 14.00 |
| HCT(%) | <100m | 17 | 43.56a | 2.01 | 30.70 | 55.70 | 0.284 | 0.754 |
| 100-500m | 30 | 41.46a | 1.82 | 0.00 | 56.30 |
| 600-1000m | 3 | 41.30a | 5.42 | 31.10 | 49.60 |
| MCV(fL) | <100m | 17 | 77.98a | 2.76 | 59.40 | 95.50 | 0.783 | 0.463 |
| 100-500m | 30 | 81.57a | 1.54 | 68.60 | 95.50 |
| 600-1000m | 3 | 78.17a | 8.34 | 61.50 | 86.80 |
| MCH(pg) | <100m | 17 | 24.88a | 0.63 | 19.40 | 30.00 | 0.276 | 0.760 |
| 100-500m | 30 | 25.08a | 0.27 | 22.60 | 28.50 |
| 600-1000m | 3 | 24.20a | 1.85 | 20.90 | 27.30 |
| MCHC(g/dL) | <100m | 17 | 31.81a | 0.66 | 26.70 | 35.40 | 0.002 | 0.998 |
| 100-500m | 30 | 31.84a | 0.59 | 25.20 | 35.20 |
| 600-1000m | 3 | 31.90a | 1.86 | 28.20 | 34.00 |
| PLT(X109/L) | <100m | 17 | 168.41a | 14.23 | 76.00 | 289.00 | 0.591 | 0.558 |
| 100-500m | 30 | 150.60a | 9.21 | 62.00 | 266.00 |
| 600-1000m | 3 | 158.00a | 36.62 | 107.00 | 229.00 |

Mean values in column with same superscript are not significant difference from each other(p>0.05), Mean values in column with different superscript are significant difference from each other(p<0.05),EMF- Electromagnetic wave generated by overhead high tension electric wire, WBC-white blood cell count, LYMP-lymhocyte, MONO-Monocyte,RBC-Red blood cells count, HCT- Hematocrit, NEUT-neutrophil, HGB-haemoglobin, MCV- Mean corpuscular volume, MCHC- Mean corpuscular hemoglobin concentration, PLT- platelet

**Table 6: Level of Alkaline Phosphatase, Calcium and Phosphate Among Gender in Overall Study Population**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameters | Study Group | N | Mean | Std.Error Mean | T-value | P-value |
| ALP(IU/L) | Female | 18 | 142.35 | 7.39 | -1.234 | 0.221 |
| Male | 62 | 154.32 | 4.76 |
| Calcium (mg/dl) | Female | 18 | 10.033 | 0.82 | -0.566 | 0.573 |
| Male | 62 | 10.47 | 0.35 |
| Phoshate (mg/dl) | Female | 18 | 3.56 | 0.42 | -2.011 | 0.048\* |

\*Statistically significant at p<0.05, EMF- Electromagnetic wave generated by overhead high tension electric wire, ALP- Alkaline phosphatase

**TABLE 7: Level of Alkaline Phosphatase, Calcium and Phosphate Among Gender in Subjects Exposed to Over High Tension Wire**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameters | Study Group | N | Mean | Std. Error Mean | T-value | P-value |
| ALP(IU/L) | Female | 11 | 138.53 | 6.01 | -0.731 | 0.468 |
| Male | 39 | 143.95 | 3.55 |
| Calcium(mg/dl) | Female | 11 | 10.71 | 0.97 |  -0.345 | 0.732 |
| Male | 39 | 11.05 | 0.45 |
| Phosphate(mg/dl) | Female | 11 | 3.67 | 0.57 | -0.27 | 0.209 |
| Male | 39 | 4.08 | 0.19 |

\*Statistically significant at p<0.05, EMF- Electromagnetic wave generated by overhead high tension electric wire, ALP- Alkaline phosphatase

**Table 8: Level of Alkaline Phosphatase, Calcium and Phosphate Between Duration of Exposure in Exposed Subjects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | N | Mean | Std. Error | Range | Statistics |
| Minimum | Maximum | F-value | P-value |
| ALP(IU/L) | <1YRS | 6 | 141.17a | 10.15 | 106.50 | 178.40 | 0.466 | 0.708 |
| 1-5YRS | 37 | 141.46a | 3.34 | 102.40 | 202.70 |
| 6-10YRS | 2 | 144.10a | 0.40 | 143.70 | 144.50 |
| >10YRS | 5 | 153.66a | 14.65 | 117.30 | 190.50 |
| Calcium(mg/dl) | <1YRS | 6 | 10.90a | 1.87 | 4.10 | 16.60 | 0.216 | 0.885 |
| 1-5YRS | 37 | 11.06a | 0.45 | 5.00 | 17.30 |
| 6-10YRS | 2 | 9.35a | 3.15 | 6.20 | 12.50 |
| >10YRS | 5 | 11.10a | 0.55 | 9.20 | 12.30 |
| Phosphate(mg/dl) | <1YRS | 6 | 3.63a | 0.52 | 2.05 | 5.31 | 1.012 | 0.396 |
| 1-5YRS | 37 | 4.01a | 0.22 | 0.00 | 6.05 |
| 6-10YRS | 2 | 5.48a | 1.32 | 4.16 | 6.80 |
| >10YRS | 5 | 3.72a | 0.66 | 2.11 | 5.16 |

Mean values in column with same superscript are not significantly different from each other(p>0.05), Mean values in column with different superscript are significantly different from each other(p<0.05), EMF- Electromagnetic wave generated by overhead high tension electric wire, ALP- Alkaline phosphatase

**Table 9:** **Level of Alkaline Phosphatase, Calcium and Phosphate Among Proximity to Over High Tension Wire in Exposed Subjects**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameters | N | Mean | Std. Error | Range | Statistics |
| Minimum | Maximum | F-value | P-value |
| ALP(IU/L) | <100m | 17 | 137.97a | 4.39 | 102.40 | 172.90 | 0.841 | 0.438 |
| 100-500m | 30 | 144.43a | 3.88 | 106.50 | 190.50 |
| 600-1000m | 3 | 153.03a | 25.08 | 122.10 | 202.70 |
| Calcium(mg/dl) | <100m | 17 | 10.51a | 0.72 | 5.00 | 16.60 | 0.619 | 0.543 |
| 100-500m | 30 | 11.09a | 0.50 | 4.10 | 17.30 |
| 600-1000m | 3 | 12.43a | 2.48 | 7.70 | 16.10 |

\*Statistically significant at p<0.05.