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Evaluating the Serum Zinc and Testosterone Levels of Carpenters in Enugu Metropolis, South East Nigeria: A Cross-sectional Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: Exposure to wood dust remains a pervasive occupational hazard with significant health implications
Aim: This study aims to investigate the impact of occupational exposure to wood dust on the zinc and testosterone levels of carpenters and to explore its potential implications for their fertility.
Materials and Methods: This cross sectional study employed simple random sampling to recruit forty carpenters and forty administrative staff after obtaining informed consent. The ethics committee of the University of Nigeria Teaching Hospital approved of the study. Serum zinc was analyzed with atomic absorption spectroscopy while testosterone was analyzed with the Fluorescence Immunchromatogarphy. Graph pad prism version 7 was used to analyze the data obtained from the study and a p value of 0.05 was used to ascertain statistical significance.
Results: The mean zinc level of the test group (48.80 ± 0.83) µg/dl is statistically significantly lower than the reference group (52.40 ± 0.79) µg/dl, (p=0.003). The mean serum testosterone level of the test group (4.11± 0.10) ng/ml is statistically significantly lower than the reference group (4.51 ± 0.11) ng/ml, (p=0.010).
Conclusion: These findings may suggest that occupational exposure to wood dust could potentially influence the serum levels of Zinc and testosterone levels.

Keywords: Occupational exposure; carpenters; zinc; testosterone; fertility.

1. INTRODUCTION

Exposure to wood dust remains a pervasive occupational hazard with significant health implications. The International Agency for Research on Cancer (IARC) has classified wood dust as a Group 1 carcinogen, signifying its definitive carcinogenic nature in humans (Obianyido et al. 2023). Studies have shown a correlation between wood dust exposure and an elevated risk of nasopharyngeal, paranasal sinus, and nasal cancers (Obianyido 2024). Carpenters are at high risk of exposure to wood dust, a fine particulate matter produced during woodworking activities such as sanding, drilling, and cutting. The generation of substantial amounts of wood dust poses a significant health concern for carpenters due to consistent exposure (Obianyido 2024). In developing countries, the preservation of wood often involves the use of insecticides from the organophosphate class, such as Dichlorovinyl dimethyl phosphate, as well as chemicals from the organophosphorus class, including pentachlorophenol (2,3,4,5,6-pentachlorophenol), and pyrethroids such as tetramethrin and cypermethrin (Vani et al. 2022). The preservatives mentioned contain heavy metals, extensively studied and identified as endocrine disruptors (Chakraborty 2021). Moreover, they can induce oxidative stress by generating reactive oxygen species (Fu et al. 2020). Heavy metals induce oxidative stress and disrupt the metabolism of essential trace elements in the body, leading to their depletion and unavailability (Mehri et al. 2020). Zinc, a crucial micronutrient, is involved in a wide range of physiological processes such as immune modulation, enzymatic catalysis, DNA replication, and the regulation of oxidative stress (Patil et al. 2023). In addition, Zinc plays a critical role in modulating androgen synthesis, particularly testosterone, which is essential for male reproductive processes. Zinc deficiency has been associated with disruptions in androgen production, leading to alterations in sperm parameters that contribute to male infertility (Marín et al. 2024). Male factor infertility refers to the inability of a male to achieve conception in a fertile female. In human reproduction, it is responsible for 40% to 50% of infertility and affects approximately 7% of all men (Anyanwu et al. 2024).

In Africa, infertility is a significant issue due to the negative social implications, including isolation, disinheritance, stigma, and in some cases, divorce. Historically, infertility problems were primarily associated with women. Challenging this notion is crucial as it perpetuates traditional socio-cultural beliefs placing blame on women for infertility, disregarding the fact that men also require reproductive health care (Anyanwu et al. 2023). In Nigeria, male factor infertility accounts for approximately 40-50% of infertility cases (Anyiom et al. 2024).

There are extensive studies on infertility in Africa and Nigeria (Akang et al. 2023, Anyiom et al, 2024), however, there is a lack of evidence-

based data on the role of occupational exposure as a risk factor for male factor infertility. This study aims to investigate the impact of occupational exposure to wood dust on the zinc and testosterone levels of carpenters and to explore its potential implications for their fertility.

2. MATERIALS AND METHODS

2.1 Study Area

The study employed a cross-sectional survey design to evaluate the Zinc and testosterone levels of carpenters occupationally exposed to wood dust in the Enugu metropolis, Southeast Nigeria. The study was conducted between February and June 2024. Enugu metropolis, located in Southeast Nigeria, has residents employed in numerous fields, including government, commerce, the arts, and agriculture.

2.2 Study Population

The study selected carpenters and non-carpenters residing and working within the Enugu metropolis, who met the inclusion criteria. The most commonly utilized types of wood by carpenters include beechwood (Gmelina arborea), African mahogany (Khaya ivorensis), cotton tree (Ceibapetra), and Achi (Brachystegia eurycoma).

2.3 Inclusion Criteria

The study selected adults over 18 years old who have been working full-time as carpenters and have been exposed to wood dust for at least two years.

2.4 Exclusion Criteria

Participants who screened positive for Hepatitis A, B, C, or HIV or reported smoking cigarettes or using smokeless tobacco were not eligible for inclusion in the study. Additionally, individuals with a history of hypertension, liver disease, diabetes, heart disease, or other systemic conditions were also excluded from the study.

2.5 Sample Size Determination

The sample size was determined using the formula of (Naing et al. 2022), the prevalence of infertility in Nigeria was 5.0% (Esan et al. 2022).

$$\text{Sample size } n = \frac{A_2\, B\, (1-B)}{C_2}$$

Statistics for the level of 95% confidence interval (1.96)

B= % prevalence of infertility in southeast Nigeria.
C= Preferred precision; in this case, 0.05

Sample size, n= 3.842x 0.05x 0.95 / 0.0025 = 72

An extra 10% was added

A simple random sampling technique was used to recruit eighty males (forty carpenters and forty office workers) who met the inclusion criteria.

2.6 Questionnaire Administration

After obtaining informed consent, a pre-tested, semi-structured questionnaire was used to collect the subject's demographic, medical, and social history.

2.7 Blood Sample Collection

The skin at the anterior elbow was thoroughly cleaned with methylated spirit. Five milliliters of venous blood were drawn and collected in a plain bottle. The samples were then centrifuged at 1500 revolutions per minute (rpm) for 10 minutes in the laboratory. The resulting clear serum was transferred to a vial and stored in a freezer at -20°C until analysis. All samples were analyzed seven days after collection.

2.8 Specimen Analysis

Determination of zinc and testosterone in subjects' blood samples.

Atomic absorption spectroscopy was used to determine the levels of zinc in the blood samples of the study participants using the Atomic Absorption Spectroscopy Model AA-7000 (Shimadzu, Japan). The blood samples were prepared by conventional wet acid digestion to extract zinc before the actual analysis, as described by Iyengar (Iyengar et al. 1998). The wavelength of zinc used for the analysis was 213.9 nm.

In addition, the Fine Care FIA meter, a point-of-care equipment that utilizes the principle of

Fluorescence immunochromatography was used for the laboratory analysis of serum testosterone.

2.8.1 Data analysis

The statistical analysis software, Graph Pad Prism version 7 (Graph Pad Software Inc., USA), was used to analyze the data from this study. Univariate variables were expressed as frequency (percentage) and mean ± standard deviation. A chi-square test was used to compare the differences in socio-demographic characteristics of the participants. The student's t-test was conducted to compare bivariate variables such as the serum zinc and testosterone levels of the study participants. Pearson correlation was used to assess relationships between the measured parameters; (years of wood dust exposure versus the serum zinc and testosterone levels respectively). A p-value of <0.05 was used to determine statistical significance.

3. RESULTS

Table 1, the anthropometric and sociodemographic parameters of the study participants show that the participants were all males (100%) and were age-matched. The reference group was more educated (10% completed tertiary education) than the test group (04% completed tertiary education). The majority of the study participants were single at the time of the study.

Table 2, presents the serum zinc and testosterone levels of the study participants. The mean zinc level of the test group (48.80 ± 0.83) µg/dl is statistically significantly lower than the reference group (52.40 ± 0.79) µg/dl, (p=0.003). The mean serum testosterone level of the test group (4.11± 0.10) ng/ml is statistically significantly lower than the reference group (4.51 ± 0.11) ng/ml, (p=0.010).

The Fig. 1 presents the correlation between the carpenter's serum level of testosterone (ng/ml) and Zinc (µg/dl). A statistically non-significant positive correlation was observed (r=0.348, p=0.059)

The Fig. 2 presents the correlation between carpenter's years of wood dust exposure and the serum level of Zinc (µg/dl). A statistically significant negative correlation was observed (r= -0.395, p=0.031).

The Fig. 3 presents the correlation between the carpenters' years of wood dust exposure and the serum level of testosterone (ng/ml). A statistically significant negative correlation was observed (r= -0.380, p=0.038).

Table 1. The sociodemographic parameters of the study participants

Parameters	Test N (%)	Reference N (%)	p-value
Sex			>0.05
Male	40(100)	40(100)	
Age (years)			>0.05
<20	10(25)	10(25)	
21-30	10(25)	10(25)	
31-40	10(25)	10(25)	
>40	10(25)	10(25)	
Educational Status			<0.001*
Completed Primary school	15(37.5)	00	
Completed Secondary School	21(52.5)	30 (75.0)	
Completed Tertiary School	04(10.0)	10 (25.0)	
Marital Status			0.196
Single	19 (47.5)	25 (62.5)	
Married	17(42.5)	13 (32.5)	
Separated	01(2.5)	02 (05)	
Divorced	03(7.5)	00	

Table 2. The serum zinc and testosterone levels of the study participants

Parameters	Test Mean±SD	Reference Mean±SD	P-value
Zinc (µg/dl)	48.80 ± 0.83	52.40 ± 0.79	0.003*
Testosterone (ng/ ml)	4.11 ± 0.10	4.51 ± 0.11	0.010*

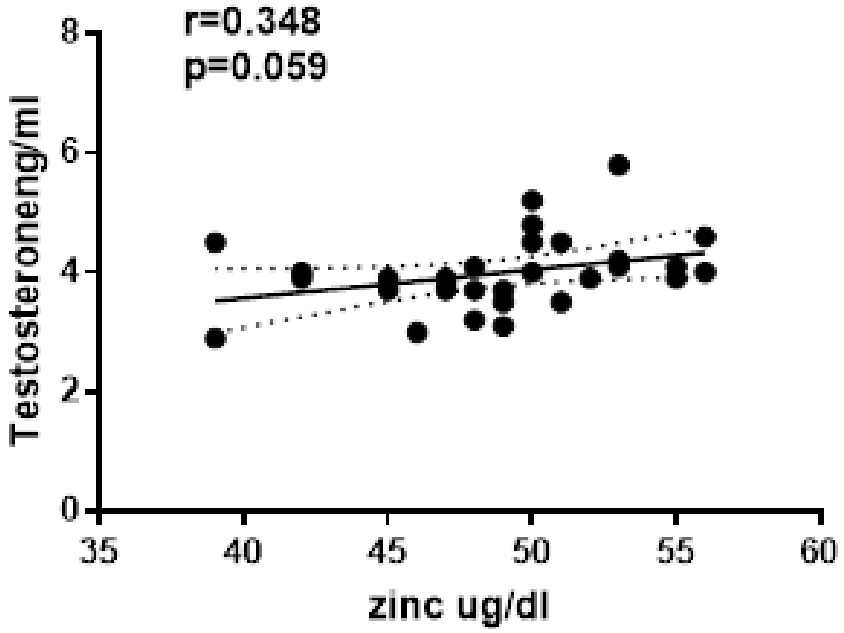

Fig. 1. The figure presents the correlation between the carpenters' serum level of testosterone (ng/dl) and Zinc (µg/dl). A statistically non-significant positive correlation was observed (r=0.348, p=0.059)

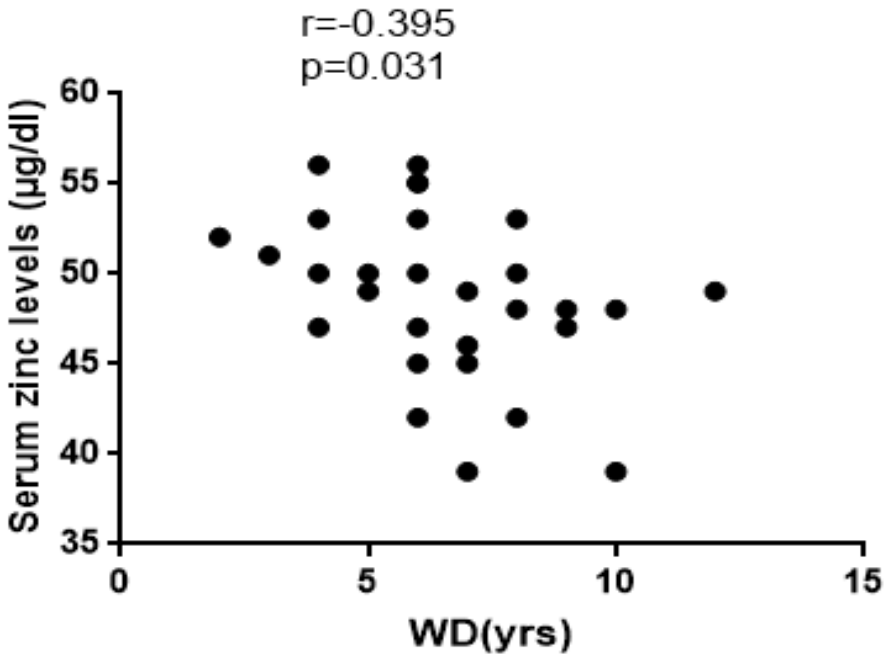

Fig. 2. The figure presents the correlation between carpenters' years of wood dust exposure and the serum level of Zinc (µg/dl). A statistically significant negative correlation was observed (r= -0.395, p=0.031)

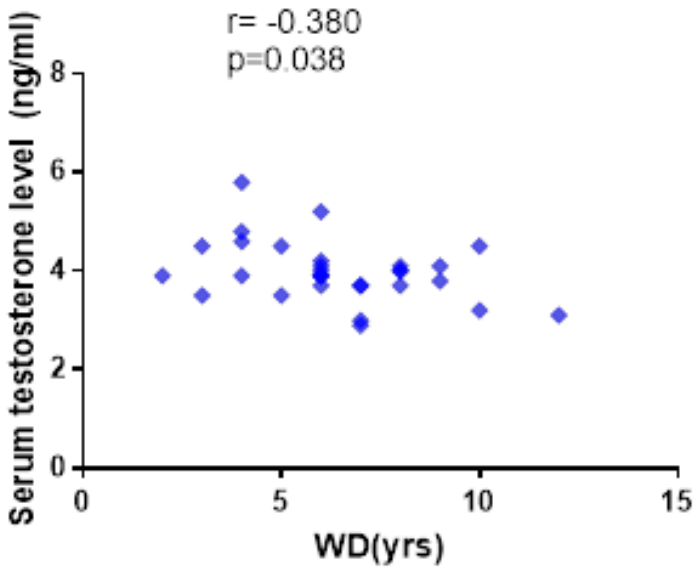

Fig. 3. The figure presents the correlation between the carpenters' years of wood dust exposure and the serum testosterone level (ng/ml). A statistically significant negative correlation was observed (r= -0.380, p=0.038)

4. DISCUSSION

Zinc plays a crucial role in the male reproductive system, particularly in gonadal development, spermatogenesis, motility, and hormone synthesis. Its significance in these processes cannot be overstated (Te et al. 2023). This study represents the first exploration in South-East Nigeria of the effects of occupational wood dust exposure on zinc and testosterone levels in carpenters in the Enugu metropolis. It also sheds light on the occupational risk factors associated with male fertility.

The study showed a statistically significant reduction in serum zinc levels among carpenters compared to the reference group. Zinc, an essential trace element, possesses antioxidant properties that aid in shielding cells from oxidative stress by stabilizing membranes and decreasing reactive oxygen species (Wróblewski et al. 2024, Gaspari et al. 2021, Gaspari et al. 2022, Ismanto et al. 2022, Cannarella et al. 2023). It is well documented that wood dust contains heavy metals, which can lead to the accumulation of reactive oxygen species and oxidative stress (Obianyido et al. 2023, Nwajei et al. 2007, Ibama et al. 2018). Carpenters, occupationally exposed to heavy metals may experience a reduction in the levels of this important antioxidant as their bodies strive to counteract the impact of oxidative stress. Furthermore, Zinc is a crucial dietary mineral that must be obtained from food sources, as the body cannot produce it (Duan et al. 2023). Our research has identified suboptimal dietary habits among carpenters, who often subsist on meager incomes due to their artisanal work. Our results did not align with those of Kalio and Umar in 2018, potentially due to discrepancies in the study location (Kalio 2018). The primary dietary source of zinc is seafood, and considering that their study was conducted in the riverine area of Nigeria, where the seafood is readily accessible and affordable, this could have contributed to the disparity in findings.

We observed a statistically significant decrease in serum testosterone levels in carpenters compared to the reference group. To the best of our knowledge, this is the first study to investigate the serum levels of testosterone in carpenters. Carpenters commonly come into contact with pesticides, known to be endocrine-disrupting chemicals (Ghosh et al. 2022, Samad et al. 2021, Samad et al. 2022), which may adversely affect serum testosterone levels. Figà-Talamanca 2011 and Zeng et al. (2022) reported a decrease in testosterone levels among individuals exposed to pesticides, corroborating our findings (Figà-Talamanca et al. 2001, Zeng et al. 2022). Carpenters are particularly at risk due to exposure to pesticides used in wood

preservation, often applied without proper personal protective equipment.

Furthermore, a deficiency in zinc hampers the function of the angiotensin-converting enzyme (ACE), leading to decreased testosterone levels, reduced sperm quality, and an increased incidence of male infertility (Xiao et al. 2022). We correlated the serum zinc levels of carpenters with their serum testosterone levels and observed a positive correlation. This observation is in agreement with that of Figà-Talamanca et al. 2001. In our observations, we found a non-statistically significant negative correlation between serum zinc levels of the carpenters and their number of years of wood dust exposure. In addition, a negative non-statistically significant negative correlation was also observed between the serum testosterone levels of the carpenters and their years of wood dust exposure.

5. CONCLUSION

These findings may suggest that occupational exposure to wood dust could potentially influence the serum levels of Zinc and testosterone levels. It's important to note that this study was conducted with a small sample size, and further research with a larger sample size is necessary to validate these findings. It is recommended that carpenters use personal protective equipment, undergo regular health checks, and consume antioxidant-rich foods to mitigate these effects.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

CONSENT

As per international standards or university standards, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

The study (NHREC/05/01/2008B-FWA00002458-1RB00002323) conducted at the University of Nigeria Teaching Hospital in Enugu was reviewed and approved by the Ethical Committee. All procedures followed the guidelines outlined in the 1964 Declaration of Helsinki, and strict measures were taken to protect the privacy of the participants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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