World Journal of Biology Pharmacy and Health Sciences

eISSN: 2582-5542

Cross Ref DOI: 10.30574/wjbphs

Journal homepage: https://wjbphs.com/

(Research Article)

Estimation of selected micronutrients and heavy metals in pregnant women

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World Journal of Biology Pharmacy and Health Sciences, 2026, 27(01), 063–068

Publication history: Received on 01 June 2026; revised on 12 July 2026; accepted on 14 July 2026

Article DOI: https://doi.org/10.30574/wjbphs.2026.27.1.0388

Abstract

Pregnancy is characterized by a period of rapid and profound physiological changes from conception until birth and environmental contamination with heavy metals are on the increase especially in the developing countries. This is a case-control study designed to determine the serum levels of zinc (Zn), copper (Cu), lead (Pb), and cadmium (Cd) in pregnant women. One hundred and twenty (120) apparently healthy pregnant women were randomly selected (test group) and 60 non-pregnant, apparently healthy women (control group). Zn, Cu, Pd and Cd were analyzed using AAS and data generated were subjected to independent t-test and Pearson correlation respectively. Results showed that pregnant women had lower serum levels of Zn and Cd (0.025±0.006 mg/L and (0.020 ± 0.005 mg/L) compared with non-pregnant controls (0.122±0.022 mg/L and 0.064 ± 0.008 mg/L) ($p<0.05$). While serum levels of Cu were higher in the test group (0.075 ± 0.017 mg/L) when compared to the control group (0.032 ± 0.008 mg/L) ($p<0.05$). there was no difference between the serum level of lead in both the test (0.027 ± 0.011 mg/L) and the control group (0.034 ± 0.013 mg/L) ($p>0.05$). In conclusion, there are alterations in the serum levels of micronutrient could predispose the pregnant women to complication. Hence, there is a need to evaluate these elements in pregnancy women especially in the regions where these elements are naturally occurring.

Keywords: Pregnancy; Micronutrient; Environmental Contaminants; Maternal Health.

1. Introduction

Pregnancy is a period of profound physiological, metabolic, and hormonal adaptations that begin at conception and continue until childbirth. These changes increase maternal nutritional requirements to support fetal growth and development, placental function, and maternal tissue expansion while maintaining normal maternal metabolism[1]. Consequently, adequate maternal nutrition is fundamental to ensuring healthy pregnancy outcomes. Deficiencies in essential nutrients or excessive exposure to toxic substances during pregnancy may adversely affect both maternal and fetal health. Emerging evidence also indicates that fetal nutrition has long-term consequences extending beyond birth, influencing health throughout childhood and adulthood and potentially across generations[2].

Optimal maternal nutrition depends on an adequate intake of both macronutrients and micronutrients. While macronutrients provide the energy required for maternal metabolism and fetal growth, micronutrients regulate numerous biological processes, including enzyme activity, antioxidant defense, immune function, gene expression, protein synthesis, and cellular metabolism[3,4]. The nutritional status of pregnant women is influenced by several factors, including dietary habits, socioeconomic status, geographical location, environmental conditions, maternal age, and pre-pregnancy nutritional reserves[5]. Although a balanced and diversified diet remains the preferred source of nutrients, physiological demands during pregnancy often exceed dietary intake alone, making nutritional monitoring and supplementation necessary in many settings[6].

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Adequate maternal micronutrient status has been consistently associated with improved pregnancy outcomes. For example, participation in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) before pregnancy has been associated with significant improvements in neonatal birth weight and length, emphasizing the importance of nutritional interventions even before conception[7]. Likewise, appropriate dietary intake or supplementation with essential micronutrients has been shown to reduce the risks of fetal malformations, preterm delivery, and other adverse pregnancy outcomes[8,9].

Among the essential trace elements, zinc, copper, and iron play indispensable roles during pregnancy. Zinc is required for DNA synthesis, cell division, immune function, tissue repair, and fetal growth. Maternal zinc deficiency has been associated with impaired immune function, intrauterine growth restriction, prolonged labour, low birth weight, and preterm delivery[10]. Copper is equally important because it functions as a cofactor for numerous enzymes involved in antioxidant defense, connective tissue formation, iron metabolism, and nervous system development. It facilitates iron absorption and erythropoiesis, thereby contributing to normal maternal and fetal development. Both copper deficiency and excessive copper accumulation have been associated with adverse pregnancy outcomes[4,11]. Iron remains one of the most important micronutrients during pregnancy because of its central role in haemoglobin synthesis and oxygen transport. The expansion of maternal blood volume substantially increases iron requirements, making pregnant women particularly susceptible to iron-deficiency anaemia, which is associated with maternal morbidity, fetal growth restriction, and low birth weight[6].

In addition to nutritional deficiencies, environmental exposure to toxic heavy metals has become an important public health concern during pregnancy. Lead and cadmium are non-essential toxic metals that readily accumulate in biological tissues and may interfere with the metabolism of essential trace elements. Lead readily crosses the placenta and has been associated with miscarriage, preterm birth, low birth weight, impaired fetal growth, and irreversible neurodevelopmental deficits in children[4,12]. Cadmium exposure has also been linked to placental dysfunction, oxidative stress, fetal growth restriction, and adverse pregnancy outcomes through disruption of nutrient transport and endocrine function. Chronic exposure to these heavy metals may therefore compromise both maternal health and fetal development.

Despite substantial evidence highlighting the importance of maternal nutrition, micronutrient deficiencies remain common worldwide. It is estimated that approximately 20–30% of pregnant women experience one or more vitamin or micronutrient deficiencies during pregnancy[1]. Although numerous systematic reviews and meta-analyses have evaluated maternal nutrition and pregnancy outcomes, most have focused on individual nutrients or specific pregnancy outcomes rather than simultaneously assessing the balance between essential trace elements and toxic heavy metals[13,14,15,16]. This study is aimed to determine the serum concentrations of zinc, iron, copper, lead, and cadmium among pregnant women and compare them with those of non-pregnant women.

2. Materials and Methods

2.1. Study Design and Study Population

This case–control, cross-sectional descriptive study was conducted to evaluate the serum concentrations of zinc (Zn), copper (Cu), cadmium (Cd), and lead (Pb) among pregnant women attending the antenatal clinic at Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State, Nigeria. The study population comprised of 120 pregnant women, aged 18 years and above, who were randomly recruited as the test group, and 60 age-matched apparently healthy non-pregnant women who served as the control group.

2.2. Inclusion and Exclusion Criteria

Pregnant women aged 18 years and above without a history of diabetes mellitus, hypertension, renal disease, liver disease, or other known pregnancy-related complications were eligible for inclusion in the test group. Age-matched apparently healthy non-pregnant women with no history of communicable or non-communicable diseases were recruited as controls.

Women who declined to provide informed consent, had chronic medical conditions, were receiving treatment for systemic illnesses, or had any condition that could influence trace element metabolism were excluded from the study.

2.3. Sample Collection and Processing

Approximately 5 mL of venous blood was aseptically collected from each participant into a plain (additive-free) blood collection tube. The blood samples were allowed to clot at room temperature and subsequently centrifuged to separate the serum. The harvested serum was transferred into appropriately labelled aliquot tubes and stored at −80°C until laboratory analysis.

2.4. Laboratory Analysis

Serum zinc, copper, cadmium, and lead concentrations were determined using an Atomic Absorption Spectrophotometer (AAS) according to the method described by Zettner (1964). Appropriate quality control procedures were followed throughout the analytical process to ensure the accuracy and reliability of the results.

2.5. Statistical Analysis

Data obtained from the study were analyzed using the Statistical Package for the Social Sciences (SPSS), version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD). Comparisons between pregnant and non-pregnant women were performed using the independent samples *t*-test. A *p*-value of less than 0.05 was considered statistically significant.

2.6. Ethical Considerations

Ethical approval for the study was obtained from the Research and Ethics Committee of Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State, Nigeria (Approval No. AE-FUTHA/REC/3/2026/661). Written informed consent was obtained from all participants before enrolment and participation was entirely voluntary

3. Result

Table 1 presents the serum concentrations of zinc, copper, cadmium, and lead among pregnant women (test group) and non-pregnant women (control group). The mean serum zinc concentration was significantly lower in the pregnant women (0.025 ± 0.006 mg/L) than in the control group (0.122 ± 0.022 mg/L; $p < 0.05$). Similarly, the mean serum cadmium concentration was significantly lower in the test group (0.020 ± 0.005 mg/L) compared with the control group (0.064 ± 0.008 mg/L; $p < 0.05$). Although the mean serum lead concentration was lower among pregnant women (0.027 ± 0.011 mg/L) than in the control group (0.034 ± 0.013 mg/L), the difference was not statistically significant ($p > 0.05$). In contrast, the mean serum copper concentration was significantly higher in the pregnant women (0.075 ± 0.017 mg/L) than in the non-pregnant controls (0.032 ± 0.008 mg/L; $p < 0.05$).

Table 1 Heavy Metal Levels Between Test and Control Groups

Parameter (mg/L)	Test (n=120)	Control (n=60)	t-value	p-value
Zinc (Zn)	0.025 ± 0.006	0.122 ± 0.022	16.606	<0.001*
Lead (Pb)	0.027 ± 0.011	0.034 ± 0.013	1.827	0.075
Cadmium (Cd)	0.020 ± 0.005	0.064 ± 0.008	19.023	<0.001*
Copper (Cu)	0.075 ± 0.017	0.032 ± 0.008	11.376	<0.001*

Values are presented as mean ± standard deviation. *Mean difference significant at p≤0.05

Table 2: shows the correlations of heavy metals in the test group. Zinc showed a moderate positive statistical significant correlation with lead (r = 0.428, p = 0.018). All other pairwise correlations among zinc, lead, cadmium, and copper in the test group were weak and not statistically significant (p > 0.05).

Table 2 Correlations of Heavy Metals in Test Group

Parameter Pair n=120	R	p-value
Zn vs Pb	0.428	0.018*
Zn vs Cd	0.098	0.607
Zn vs Cu	−0.137	0.471
Pb vs Cd	−0.072	0.706
Pb vs Cu	0.13	0.495

Cd vs Cu	0.045	0.815

r=Pearson Correlation Coefficient, *Correlation significant at $p<0.05$; Zn =Zinc, Pb = Lead, Cd = Cadmium, Cu = Copper

4. Discussion

Environmental contamination with metals remain persistent especially in developing countries where mining is poorly regulated, social amenities are lacking and agriculture is still a major source of living. In this present study, serum zinc concentration was significantly lower in pregnant women than in non-pregnant controls. This could be attributed the increased requirements or increased demand for zinc by the developing child, haemodilution or poor dietary intake. Zinc is essential for cellular proliferation, immune function, and fetal development. Previous studies had reported reduced zinc levels in pregnant women[17,18].

In contrast, serum copper levels were significantly higher in pregnant women compared with controls. This may be attributed to estrogen induced synthesis of a copper binding protein which could lead to more copper being maintained in circulation. Previous studies have reported increased levels of copper in different phases of pregnancy [18,19,20]. While increased copper supports oxidative metabolism and iron mobilization, excessive levels may promote oxidative stress, particularly when zinc is depleted, highlighting the importance of micronutrient balance. Previously, [22] Walker *et al*, (2011) reported that increased copper in pregnancy is associated with intrauterine growth retardation, neurological defect and pre-eclampsia. Although, our study showed reported decreased zinc level and increased copper level in pregnant women but, a weak negative correlation exists between copper and zinc. A recent study has equally reported a non-statistically significant relationship between copper and zinc in pregnant women[23].

Serum cadmium levels were lower among pregnant women than non-pregnant controls. This may be accrued to haemodilution, reduced exposure to possible combination sites, non-availability of cadmium in the environment or lifestyle modification associated with pregnancy. Similar pattern has been reported previously[24,25]. [26]Ugwuja *et al*., (2015) reported elevated plasma Cd with apparent impact on the levels of plasma Zn in an average adult. In this present study, we observed a weak non-significant positive correlation between Cd and zinc. Cadmium remains a public health concern due to its cumulative toxicity and placental transfer. Contrary to our finding, [27]Solomon *et al*., (2021) reported no difference between the serum levels of cadmium in pregnant and non-pregnant women. The variation in the finding may be accrued to differences in the study location.

Furthermore, our study reported non-significant lower levels of lead in the pregnant women compared to non-pregnant women. A similar finding has been reported group by [27,28] though, they further reported that lead concentration was higher in the third trimester group when compared to the first and second trimester group. Furthermore, a significant strong positive correlation was observed between lead and zinc among the pregnant women. Hence, these findings underscore the interaction between physiological demands, nutrition, and environmental exposure during pregnancy and support the need for integrated nutritional and environmental health strategies to improve maternal and fetal outcomes.

5. Conclusion

This study showed alterations in the serum levels of zinc (Zn), cadmium (Cd) and copper (Cu), that may predispose the mother and child to complications.

Recommendation

We recommend that essential trace and heavy metal evaluation during antenatal visit especially in the regions where these elements are naturally abundant.

Compliance with ethical standards

Acknowledgments

The authors acknowledge the support of the staff of Alex Ekwueme Federal University Teaching Hospital Abakaliki and the respondents who participated in this study.

Disclosure of conflict of interest

The authors declare no conflict of interest

Statement of informed consent

Written informed consent was obtained from all participants before enrolment and participation was entirely voluntary.

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