The Internet Journal of Nutrition and Wellness
Volume 10 Number 1

Plasma Copper and Zinc among Pregnant Women in Abakaliki, Southeastern Nigeria

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Citation

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Abstract

BACKGROUND: Nutritional deficiencies of essential trace elements which are common during pregnancy, especially in economically weaker populations are associated with adverse course and outcomes of pregnancy. OBJECTIVES: To determine the prevalence and causes of copper and zinc deficiencies in a population of pregnant Nigerians living in Abakaliki, south eastern, Nigeria. MATERIALS AND METHODS: Plasma copper and zinc concentrations of 349 apparently healthy pregnant women attending antenatal clinic of the Department of Obstetrics and Gynaecology of the Federal Medical Centre, Abakaliki between July 2007 and September, 2008 were determined by flame atomic absorption spectrophotometer. RESULTS: Of the 349 pregnant women, 45.8% and 58.2% respectively were deficient in zinc and copper with mean plasma concentrations of 2.65 ± 1.16 μmol/l for zinc and 3.26 ± 1.80 μmol/l for copper while 23.8% were deficient in both copper and zinc. Frequent intakes of carbohydrate- and cereal-based food, and sparingly intakes of meat, diary products, nuts and vegetables were associated with high prevalence of copper and zinc deficiency. Although higher levels of copper and zinc were found in economically advantaged groups and plasma zinc inversely related to parity, copper level was found to be higher in women who have had more deliveries. CONCLUSION: High prevalence of copper and zinc deficiencies was found among the pregnant women in this region, which is possibly related to sub-optimal dietary intakes. In the light of the adverse effects of copper and zinc deficiencies on pregnancy and its outcomes, it is recommended that in addition to food diversification and biofortification, supplemental copper and zinc may be considered as ways of improving child and maternal health in this population.

INTRODUCTION

Nutritional deficiencies are common during pregnancy, especially in pregnant women from economically disadvantaged settings where diets with low density of minerals and vitamins are consumed. Deficiencies of trace elements; copper and zinc have been implicated in various reproductive events like infertility, pregnancy wastage, congenital abnormalities [1], pregnancy induced hypertension, placental abruption, premature rupture of membranes, still birth and low birth weight [2]. Zinc is an essential trace element with wide range of functions in the body including the synthesis of enzymes and nucleic acids [3]. Studies of pregnant women in African countries such as Nigeria, Egypt, Zaire, and Malawi have shown lower plasma zinc or hair zinc concentrations than in pregnant women from developed countries [4-7]. Also, several studies have reported that maternal plasma zinc decreases during pregnancy from 24-33 week of gestation [8-11]. However, Meram et al.[12] while reporting comparable plasma zinc in pregnant and non pregnant women, documented decreased plasma zinc in pregnant women greater than 35 years old.

Like zinc, copper is involved in the functions of several cuproenzymes that are essential for life [13]. Copper plays a role in the mobilization of iron to plasma from the tissue stores [14] and copper deficiency during embryonic and foetal development has been found to cause numerous gross structural and biochemical abnormalities. It has been reported that more than 50% of human conception fail to implant and of those implanted, approximately 30% fail to reach term due to copper deficiency [15]. Significantly higher mean serum copper had been reported in healthy pregnant Nigerian women than their non-pregnant counterparts [9]. Similar increase in serum copper had been reported in Spanish [10] and Turkish women [12]. The paucity of data on serum levels of zinc and copper in pregnant women in the South-eastern Nigeria prompted us to carry out this study in order to provide the baseline data that may have public heath implications in the management of pregnant women in our environment.

SUBJECTS AND METHODS

The study was carried out among pregnant women attending antenatal clinic of the Department of Obstetrics and Gynaecology of the Federal Medical Centre, Abakaliki, one of the referral tertiary health institutions in the South eastern part of Nigeria. Abakaliki and the environs have ethnically heterogeneous population with the three major tribes (Hausa, Igbo and Yoruba) in Nigeria fully represented. The main occupation of the people is subsistence farming (mainly yam and cassava) with some animal husbandry. Other professions and/or activities such as civil service, trading, artisan and stone quarrying are practiced also. Malaria transmission is intense and occurs throughout the year (perennial).

Three hundred and fifty-one (351) consecutive women aged 15-40 years (Gestational age = 25 weeks) who gave their consent to participate in the study were recruited between July 2007 and September 2008. Those excluded from the study were women with chronic disease, women that were HIV-seropositive and those with multiple pregnancies. The protocol for this study was approved by the Ethics and Research Committee of the Federal Medical Centre Abakaliki. The sociodemographic and dietary data of the participants were collected by structured questionnaires. Dietary assessment was based on frequency of intake of food items commonly consumed in the region (Carbohydrates; consumed either as yam, gari, corn mean, “akpu”, or rice, meat, diary products, nuts, cereals and vegetables/fruits). Participants were made to answer how often they consume these food items in a week; very often if consumption is 5-6 times per week, sparingly if it is 3-4 times and rarely if consumed 1-2 times per week. Height and weight were measured with the subject in light clothes without shoes, and BMI (Kg/m2) was calculated. Five millilitres (5.0ml) of venous blood collected between 08.00-10.00 hours were dispensed into trace element-free heparinised bottle and plasma separated by centrifugation at 2000g for five minute. The plasma samples were frozen until they were analysed. Plasma copper and zinc were determined in duplicates by flame atomic absorption spectrophotometer and the mean was recorded as the absolute value of the elements.

STATISTICAL ANALYSIS

The data obtained were analysed for mean and standard deviation. 95% CI was calculated where necessary. Proportions were expressed as percentage and mean serum levels of zinc and copper were compared among groups by one-way analysis of variance (ANOVA) and the level of significance set and $p < 0.05$.

RESULTS

Of the three hundred and fifty-one pregnant women recruited, sample could not be collected from one, and one died during the study, leaving behind three hundred and forty nine pregnant women. One hundred and sixty (45.8%) were zinc deficient (mean = 2.65 ± 1.16μmol/l), 203 (58.2%) were deficient in copper (mean = 3.26 ± 1.80 μmol/l) while 83 (23.8%) were deficient in both copper and zinc.

Figure 1

Table 1: Prevalence of copper and zinc deficiency in relation to maternal age groups

Age group	No examine	Copper def	95% CI	Zinc def	95% CI
< = 19	16	10 (2.9)	38.3-86.7	9 (2.6)	31.2-80.8
20-24	85	47 (13.5)	44.2-65.8	34 (9.7)	29.4-50.6
25-29	138	85 (24.4)	53.7-70.3	60 (17.2)	35.5-49.0
30-35	107	59 (16.9)	45.4-64.6	54 (15.5)	41.3-60.7
>35	5	2 (0.6)	-3.8-83.8	3 (0.9)	16.2-103.8
Total	349	203 (58.2)	52.7-63.3	160 (45.8)	40.7-51.3

Higher prevalence of copper and zinc deficiencies were found in age groups 25-29 and 30-35 years respectively while least prevalence were seen in age groups < 19 and > 35 years respectively (table 1)

Figure 2

Impact of indices of maternal socio-economic status

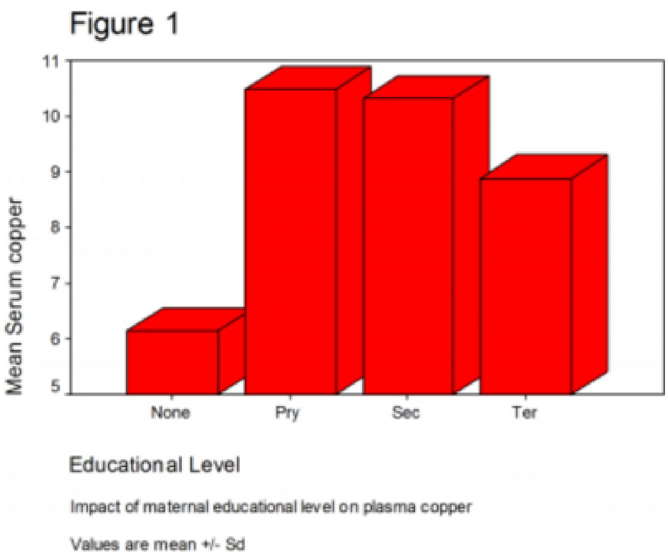

Figure 3

Impact of indices of maternal socio-economic status

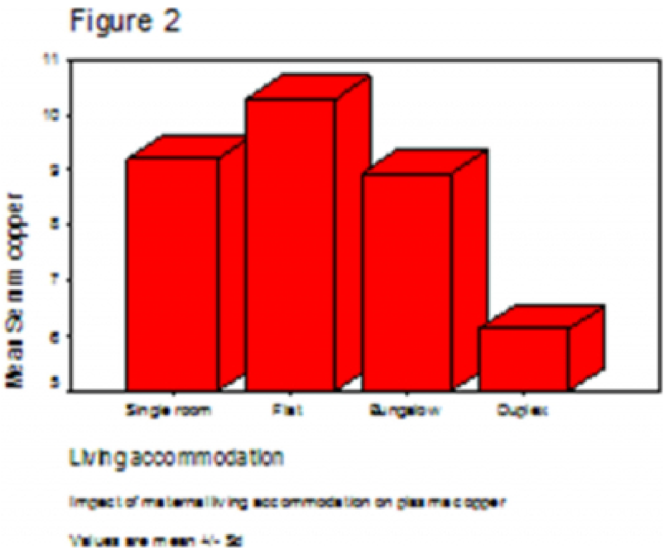

Figure 5

Impact of indices of maternal socio-economic status

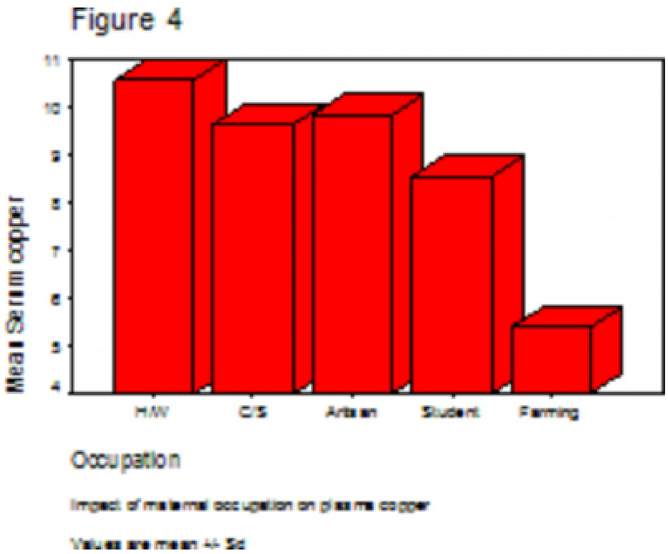

Figure 4

Impact of indices of maternal socio-economic status

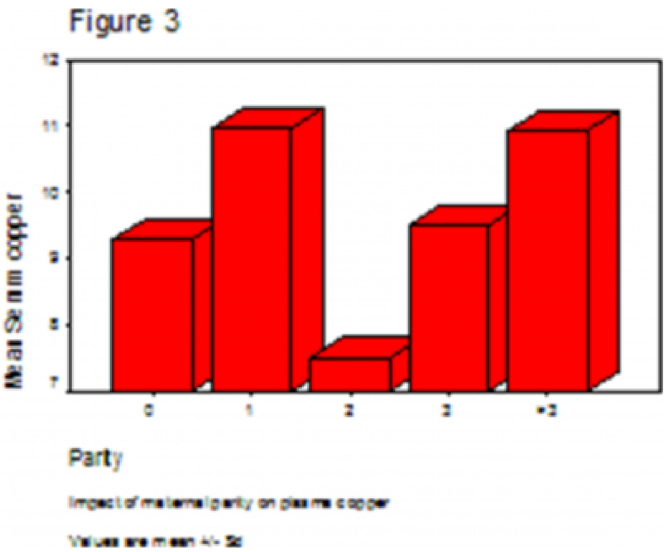

Figure 6

Impact of indices of maternal socio-economic status

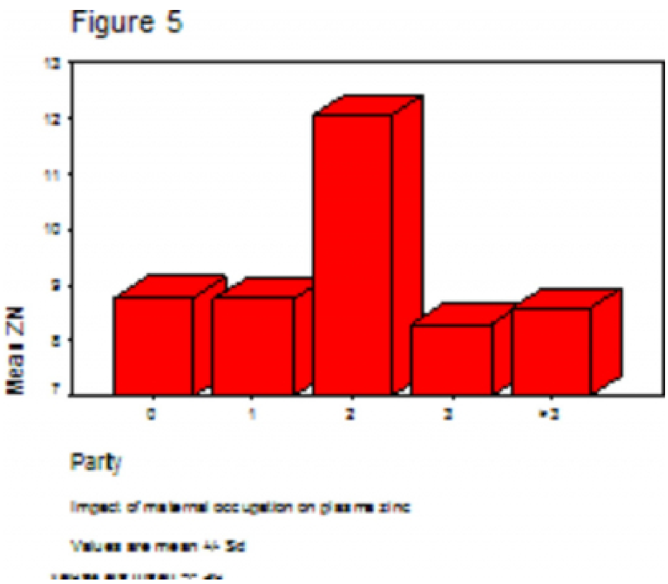

Figure 7

Impact of indices of maternal socio-economic status

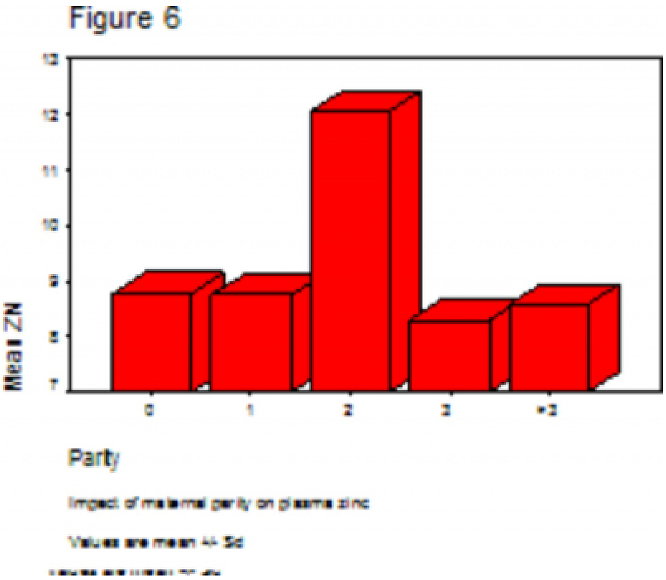

Figure 8

Impact of indices of maternal socio-economic status

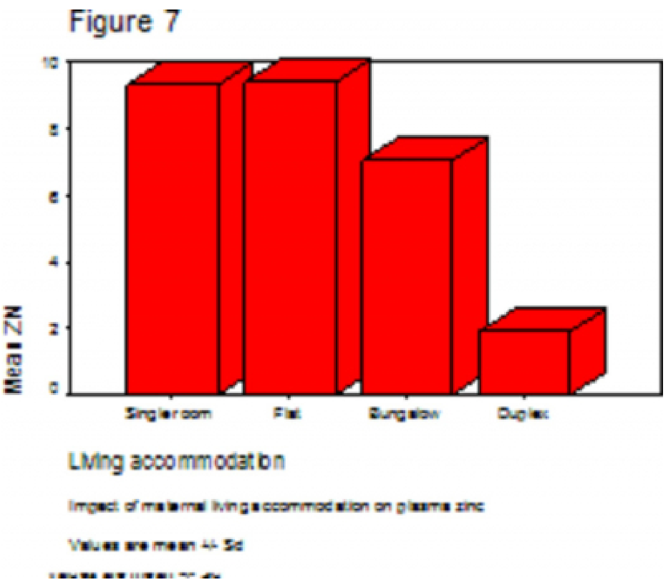

Figure 9

Impact of indices of maternal socio-economic status

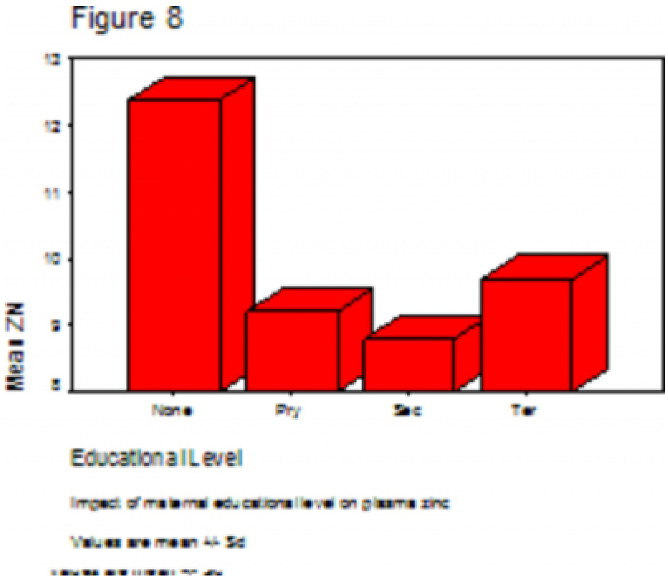

Figure 1-8 show the impact of indices of maternal socio-economic status (occupation, educational level, living accommodation) and parity and on plasma copper and zinc concentrations. Although there was no definite trend on the impact of parity and socio-economic status on the levels of copper and zinc among pregnant women in this population, higher levels of copper and zinc were found in economically advantaged groups and while lower plasma zinc were found in women with higher parity, copper level was found to be higher in women who have had more deliveries.

Figure 10

Table 2: Prevalence of copper and zinc deficiencies in relation to dietary intake (percentage in parenthesis)

	Carbohydrate		Meat		Diary products		Nuts		Cereals		Vegetables	
	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu	Zn	Cu
V. often	155 (44.5)	197 (56.6)	55 (15.8)	60 (17.2)	17 (4.9)	28 (7.4)	50 (14.3)	70 (20.1)	78 (21.8)	91 (26.1)	58 (16.6)	73 (20.9)
Sparingly	5 (1.4)	6 (1.7)	53 (15.2)	79 (22.6)	80 (22.9)	105 (30.1)	89 (25.5)	104 (29.8)	60 (17.2)	80 (22.9)	70 (20.1)	92 (26.4)
Rarely	-	-	52 (14.9)	64 (18.3)	63 (18.1)	72 (20.6)	21 (6.0)	29 (8.3)	24 (6.9)	32 (9.2)	32 (9.2)	38 (10.9)

From table 3, frequent intakes of carbohydrate- and cereal-based food, and sparingly intakes of meat, diary products, nuts and vegetables were associated with high prevalence of copper and zinc deficiency. On the other hand, low intakes of cereal-based food were found to be associated with low prevalence of copper and zinc deficiencies.

DISCUSSION

The prevalence of copper, zinc or/and copper and zinc deficiencies in this population are 45.8, 58.2 and 23.8% respectively. Zinc deficiency prevalence of 45.8% recorded in this population is higher than 22.5% reported among pregnant women in southern Nigeria [16]. It is also higher than 36% reported in pregnant Malawian women at 24 weeks gestation [7], but however lower than 49% and 73.5% among pregnant women in Iran [17] and in rural area of Hayarna state of India [18] respectively. Although studies have consistently demonstrated that plasma copper increases with gestational age [16,19, 20], there is limited data on the prevalence of copper deficiency in pregnant women. Only one study among pregnant women in rural area of India [21] reported copper deficiency prevalence of 2.7%. This is quite lower than 58.2% reported in the present study. The causes of zinc and copper deficiencies during pregnancy are multiple. These include low dietary intake as in malnutrition, malabsorption and GIT diseases [22], elemental interactions during supplementations [23], environmental and physiological conditions such exercise, infections, inflammation, diabetes mellitus, hypertension, and effect of dietary inhibitors such as consumption of diets high in phytate/and fructose [24-29]. In the present study higher prevalence of copper and zinc deficiencies were found among women who consumed carbohydrate and cereals very often and in women with sparingly intakes of meat, diary products, and vegetables, thus showing the influence of dietary intakes on serum levels of copper and zinc. Zinc and copper are abundantly found in meat (especially organ meat) and diary products as well as in vegetables (green leafy vegetable) [30] and their sub-optimal/low intakes may partly have contributed to the high prevalence of deficiencies of these two essential trace elements. Again low prevalence rates of copper and zinc deficiency among pregnant women with sparingly intakes of cereal-based diets reaffirms the adverse effect of phytic acid on the bioavailability of zinc. Hence our subjects may be considered to be at high risk of copper and zinc deficiencies as both low dietary intakes of animal protein (exemplified by low intake of meat and diary products) and high intake of cereal-based diets have been associated with low bioavailability of zinc and copper [31]. Although there is no data on the use of micronutrient supplementation among the pregnant women studied, the high prevalence rates of copper and zinc deficiency may also be partly attributed to interactions between zinc and copper and with other divalent metal ions, such as iron, calcium and magnesium especially, with the current wave of micronutrient supplementation. An intriguing interactions appear to exist between copper, zinc and iron in absorption and utilisation. For example, on one hand, supplementation of iron has been reported to affect bioavailability of zinc and copper in iron deficiency anaemia by inter-element competition in the bowel, while on the other hand, bioavailability of copper and iron are affected by zinc supplementation [32]. Studies have documented a negative effect of supplemental iron on plasma zinc level in both animal and human studies [33] during pregnancy [34] and lactation [35]. The negative effect of iron supplementation on plasma zinc is most dramatic if iron is administered in solution or as a separate supplement rather than incorporated into a meal [36]. However, data on the effect of calcium supplementation on zinc homeostasis have been conflicting [37, 38]. The concurrent deficiency of copper and zinc (23. 8%) in this population, suggests that deficiencies may be most likely due to sub-optimal intake of the two elements rather than due to elemental interactions. Interestingly, we found higher plasma copper and zinc levels among the socio-economically advantaged than the disadvantaged groups. Although zinc homeostasis is maintained by alterations in intestinal zinc absorption, gastrointestinal secretion, renal [39] and release from maternal tissues [40], studies in animals suggest that changes in intestinal zinc absorption may be the primary homeostatic adjustment in zinc metabolism to meet the needs for pregnancy [41]. The reason for lower prevalence of copper and zinc deficiencies among the age groups < 19 year and in those > 35 years compared to age groups 25-29 and 30-35 years respectively is not clear, but it may be due to the few number of participants in that age group when compared with other age groups. However, it has been shown that maternal micronutrient status decreases with parity and reduced inter-pregnancy intervals due to maternal depletion [12]. Hence while women in age group < 19 years are yet to experience any appreciable nutritional depletion due to reproductive events, the women > 35 years are most likely to be multiparous and are much more likely to experience nutritional deficit. Taking together, we conclude that high prevalence of copper and zinc deficiencies exist among pregnant women in Abakaliki, south eastern Nigeria possibly due to sub-optimal dietary intakes. As a result of the documented evidence of the adverse effects of copper and zinc deficiencies on pregnancy and its outcomes, it is recommended that efforts should be intensified to enlighten members of the public, especially women of child bearing age on the importance of food diversification in improving child and maternal health in economically weak setting. Biofortification of locally available food stuffs as well as supplemental zinc and copper may also be considered.

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