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Cord Blood Serum Zinc Status and Its Determinants in Neonates Delivered at Federal Medical Centre Owerri

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ABSTRACT

Zincdeficiency in neonates is a common finding in the developing world. The serum zinc level of neonates is affected by the gestational age at delivery, maternal serum zinc level, maternal serum albumin concentration, medications, conditions leading to decreased absorption of ingested zinc as well as increased loss from the body. Zinc deficiency in neonates has been suggested to be related to poor growth, hyperbilirubinemia, seizures, necrotizing enterocolitis, retinopathy of prematurity and bronchopulmonary dysplasia by some investigators. This cross-sectional study was carried out between August 2017 and February 2018 to determine the cord blood serum zinc status and its determinants in neonates delivered at Federal Medical Centre (FMC) Owerri. The purpose of this study was to determine the cord blood serum zinc levels of neonates delivered at FMC Owerri and also to establish the effect of birth weight, gender, socioeconomic status and maternal serum zinc level on cord serum zinc levels of neonates delivered at FMC Owerri. Three hundred and thirty mother-neonate pairs who met the inclusion criteria were consecutively recruited; one hundred and eighty (54.5%) of the neonates were males while 150(45.5%) were females. Serum zinc was assayed using Flame Atomic Absorption Spectrophotometer (AAS).The normal range for serum zinc is 9.9-21.4µmol/l (equivalent to 64.7-139.9µg/dl) for cord blood and 7.6-10.7µmol/l(equivalent to 49.9-69.9µg/dl) for maternal blood.For the purpose of this study, cord serum zinc less than 64.7µg/dl and maternal serum zinc less than49.9µg/dl were considered low. The cord serum zinc levels of neonates was normal in 51.5% of cases but low in 48.5% of cases.There was a significant positive association between cord blood serum zincand maternal serum zinc however cord serum zinc level was not significantly associated withbirth weight, length, occipitofrontal circumference, gender, socioeconomic status, dietary intake of red meat, dairy products and sea foods and some maternal obstetric factors. The conclusions from this study included that the prevalence of hypozincemia was high in neonates delivered at FMC Owerri, maternal serum zinc is a strong factor influencing cord serum zinc and that low cord serum zinc is commoner among Low Birth Weight (LBW) neonates, female neonates, neonates from low socioeconomic class families and in neonates whose mothers took little of zinc-rich foods in pregnancy. This study therefore recommends improved maternal nutrition in pregnancy especially with zinc- rich foods and to give zinc supplements to pregnant mothers during antenatal care visits.

Keywords: Cord, Blood Serum, Zinc Status, Neonates and Owerri

INTRODUCTION

The world Health Organization (WHO) defines neonates as children in their first 28 days of life [1,2,3]. Neonates are grouped into preterm, termandpost-termor into Large for Gestational Age (LGA), Small for Gestational Age (SGA), and Appropriate for Gestational Age (AGA) neonates [4]. Optimal serum zinc level is required by neonates in order to avert postnatal growth failure and other far-reaching consequences of zinc deficiency bearing in mind that the fastest post-natal growth rate in humans is achieved during early infancy [5]. Zinc is an essential trace element in humans [6,7]. It is an antioxidant and free radical scavenger which mops up reactive oxygen species and protects the human body from endogenousand exogenous insults. It has a vital role in a wide range of biological activities including the maintenance of cell architecture, protein synthesis, nucleic acid metabolism and immune functions [8]. Zinc is fundamental for growth, development and reproduction while its deficiency has a negative effect on the endocrine system leading to growth failure. It is

known to undergo depletion during pregnancy and lactation [9]. In pregnancy, maternal zinc depletion is caused by increased uptake of maternal zinc by foetus and placenta, increased transfer of serum zinc to maternal erythrocytes, expansion of maternal plasma volume and decreased availability of serum albumin which binds zinc in the mother's blood. During lactation, zinc is transferred from the mother into the breast milk to nourish the neonate [10]. Some neonates have been found to suffer zinc deficiency at birth; especially the Low Birth Weight(LBW) neonates which comprises children born preterm and those with Intrauterine Growth Restriction (IUGR) [11]. The reference range for normal serum zinc in the neonate is 9.9-21.4µmol/l(equivalent to 64.7-139.9µg/dl) [12], while that for the mother in the third trimester of pregnancy is 7.6-10.7µmol/l(equivalent to 49.9-69.9µg/dl) [13]. Zinc deficiency in neonates has been suggested by some investigators to be implicated in dermatitis, low birth weight, impaired immunity, poor wound healing, necrotizing enterocolitis, seizures, bronchopulmonary dysplasia, hyperbilirubinemia and retinopathy of prematurity [14]. In the older child, it has been suggested to be associated with acrodermatitis enteropathica, growth failure, poor wound healing, anaemia, hypogonadism, poor taste and smell sensation [15,16,17]. There is paucity of data on zinc excess in neonates however a report on zinc excess in total parenteral nutrition of a preterm resulted in death from cardiac failure [18]. In older children however zinc excesspresents with abdominal pain, diarrhoea, headaches, fatigue and abdominal cramps. It has also been associated with copper deficiency [19,20]. The bulk of zinc transfer from the mother to foetus takes place in the third trimester and this, therefore, predisposes the premature neonates to zinc deficiency as enough zinc is not transferred from the mother to the foetus before it is born [21]. The IUGR neonates are also predisposed to low serum zinc [22]. The risk factors for low serum zinc in neonates are varied and include LBW, genetic defects, maternal malnutrition (from inadequate dietary intake, decreased bioavailability, decreased absorption, excessive losses and increased requirements) as well as from iatrogenic causes like poorly constituted total parenteral nutrition.[16]In addition, male gender,use of thiazide diuretics, dexamethasone, unusually low alkaline phosphatase, low albumin, large stool or ostomy output and short bowel syndrome may also cause low serum zinc in neonates [23]. The global prevalence of zinc deficiency is estimated at 31% with values ranging from 4-73% .The burden of zinc deficiency is borne most heavily by countries in Africa, the Eastern Mediterranean and South East Asia [24,25], in their study however reported that 25% of the world population is at risk of zinc deficiency. This micronutrient deficiency contributes to over half a million deaths per year in children aged 0-60 months. [25,26] reported that the prevalence of low serum zinc in neonates was 11.9%. In Sub-Saharan Africa, zinc deficiency has been found to affect an estimated 68% of the population.

AIMS AND OBJECTIVES

To determine the cord bloodserum zinc status and its determinants in neonates delivered at FMC Owerri.

SPECIFIC OBJECTIVES

1. To determine the cord blood serum zinc levels of neonates delivered at FMC Owerri.
2. To determine the effects of birth weight, gender, socioeconomic class and maternal serum zinc levels on the cord serum zinc levels of neonates delivered at FMC Owerri.

RESULTS

A total of three hundred and thirty neonates and their mothers were recruited into the study.

Table I:GENERAL CHARACTERISTICS OF MOTHERS AND THEIR NEONATES

The general characteristics of research participants are shown in table 1. The mean maternal age was 30.92±4.66 years, mean birth weight was 3.01±0.52kilograms, while the mean occipitofrontal circumference was 33.87±1.75cm. There were 180(54.5%) males and 150(45.5%) females; most 288(87.3%) of the neonates were delivered vaginally and the majority of the participants belonged to the middle socioeconomic class 152(46.1%).

Table I. General characteristics of mothers and their neonates.

MATERNAL CHARACTERISTICS	N = 330
Age (years) Mean ± SD	30.92 ± 4.66
Weight (kg)Mean ± SD	79.07 ± 12.19
Height (cm)Mean ± SD	162.87±4.85
NEONATAL CHARACTERISTICS	N = 330
Birth weight(kg)Mean ± SD	3.01 ± 0.52
Length (cm)Mean ± SD	48.44 ± 2.76
OFC (cm)Mean ± SD	33.87 ± 1.75
Gender	
Male (%)	180 (54.5)
Female (%)	150 (45.5)
Mode of delivery	
SVD (%)	288 (87.3)
C/S (%)	36 (10.9)
Vacuum (%)	6 (1.8)
Social Class	
Upper (%)	138 (41.8)
Middle (%)	152 (46.1)
Low (%)	40 (12.1)

SERUM ZINC LEVELS OF STUDY PARTICIPANTS

The mean cord serum zinc level of neonates was 65.29 ± 25.76 µg/dl while the serum zinc level of mothers was 51.68 ± 23.86 as shown in table II below.

Table II Cord serum and maternal serum zinc level of participants

Variables	Min (µg/dl)	Max(µg/dl)	Mean	Std. Dev	Median
Cord Serum Zinc	3.30	140.90	65.29	25.76	64.90
Maternal Serum Zinc	7.5	148.80	51.68	23.86	49.10

SERUM ZINC STATUS OF STUDY PARTICIPANTS

Amongst the neonates recruited 160(48.5%) were zinc deficient as shown in table III below

Table III Zinc status of neonates and their mothers

Zinc Status	Frequency N (%)
Cord Serum Zinc Status	
Low	160 (48.5)
Normal	170 (51.5)
High	0
Total	330 (100)
Maternal Serum Zinc Status	
Low	174 (52.7)
Normal	98 (29.7)
High	58(17.6)
Total	330 (100)

FACTORS AFFECTING ZINC STATUS OF NEONATES

Low cord serum zinc level was found to be more common among neonates whose mothers had low serum zinc level 102 (58.6%) when compared with mothers with high serum zinc level14 (24.1%) in a statistically significant relationship. Low cord serum level was also found to be commoner among low birth weight neonates, female gender, and low socioeconomic status but this did not reach statistically significant level p values were 0.247, 0.078 and 0.077 respectively as shown in table IV below.

Table IV Association between Cord Serum Zinc Level and Birth Weight, Gender, Socioeconomic class and Maternal Serum Zinc Level.

Variables	Cord Serum Zinc Status n (%)		Total	χ^2	p-value
	Low	Normal			
Birth Weight					
Low	16 (53.3)	14 (46.7)	30		
Normal	144 (48.6)	152 (51.4)	296	2.80*	0.247
High	0	4 (100)	4		
Total	160 (48.5)	170 (51.5)	330		
Gender					
Male	76 (42.2)	104 (57.8)	180		
Female	84 (56.0)	66 (44.0)	150	3.11	0.078
Total	160 (48.5)	170 (51.5)	330		
Social economic Status					
Upper	54 (39.1)	84 (60.9)	138		
Middle	80 (52.6)	72 (47.4)	152	5.125	0.077
Lower	26 (65.0)	14 (35.0)	40		
Total	160 (48.5)	170 (51.5)	330		
Maternal serum Zinc					
Low	102 (58.6)	72 (41.4)	174		
Normal	44 (44.9)	54 (55.1)	98	10.713	0.005
High	14 (24.1)	44 (75.9)	58		
Total	160 (48.5)	170 (51.5)	330		

*Likelihood ratio

THE DISTIBUTION OF CORD SERUM ZINC ACCORDING TO BIRTH WEIGHT

The distribution of cord serum zinc according to birth weight is shown in Figure1 below. Neonates with normal birth weight had normal cord serum zinc(89.4%) followed by those with low birth weight(8.2%) and macrosomic neonates(2.4%).

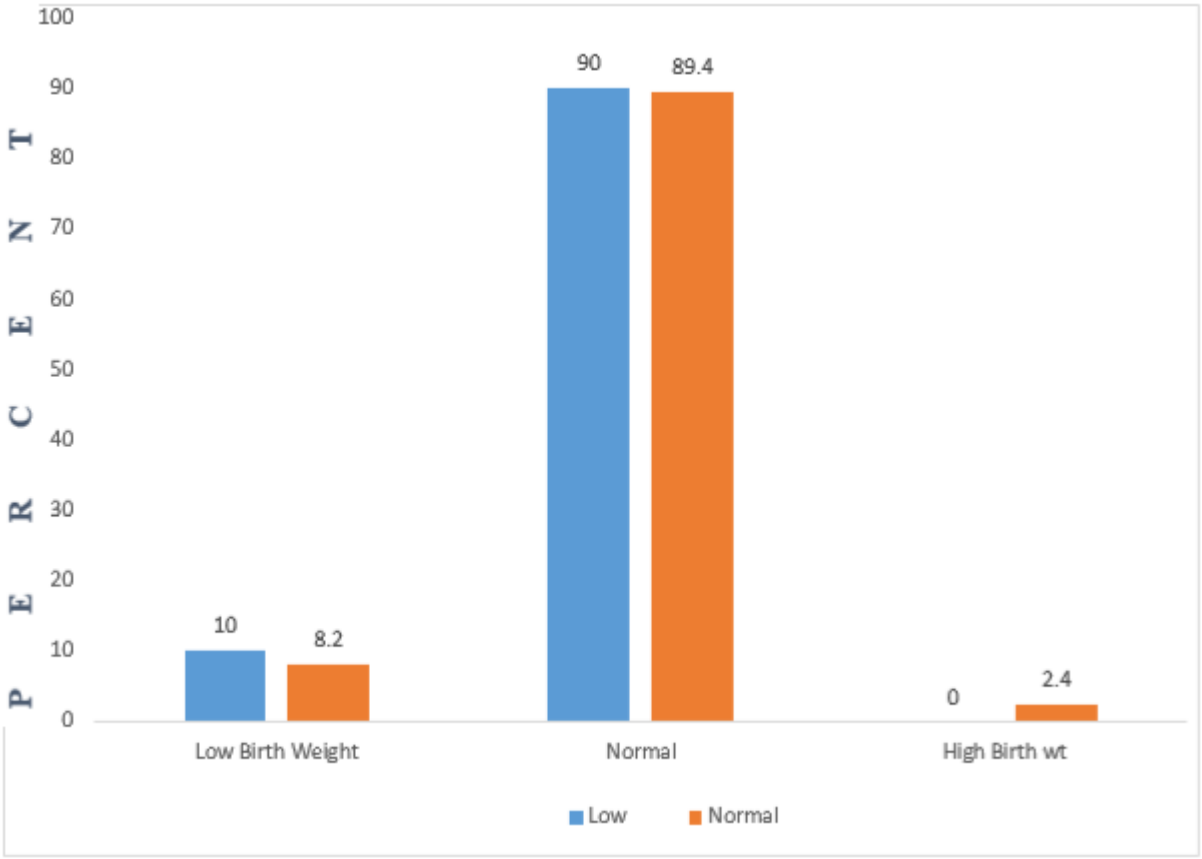

Figure 1Bar chart showing the distribution of cord serum zinc by birth weight.

THE DISRIBUTION OF CORD SERUM ZINC ACCORDING TO GESTATIONAL AGE

The distribution of cord serum zinc according to gestational age is represented in figure 2 below. Neonates delivered between 37 and 42 weeks had the highest normal cord serum zinc (95.3%) followed by those delivered below 37 weeks (4.7%) while non of those delivered after 42 weeks had normal serum zinc (0%)

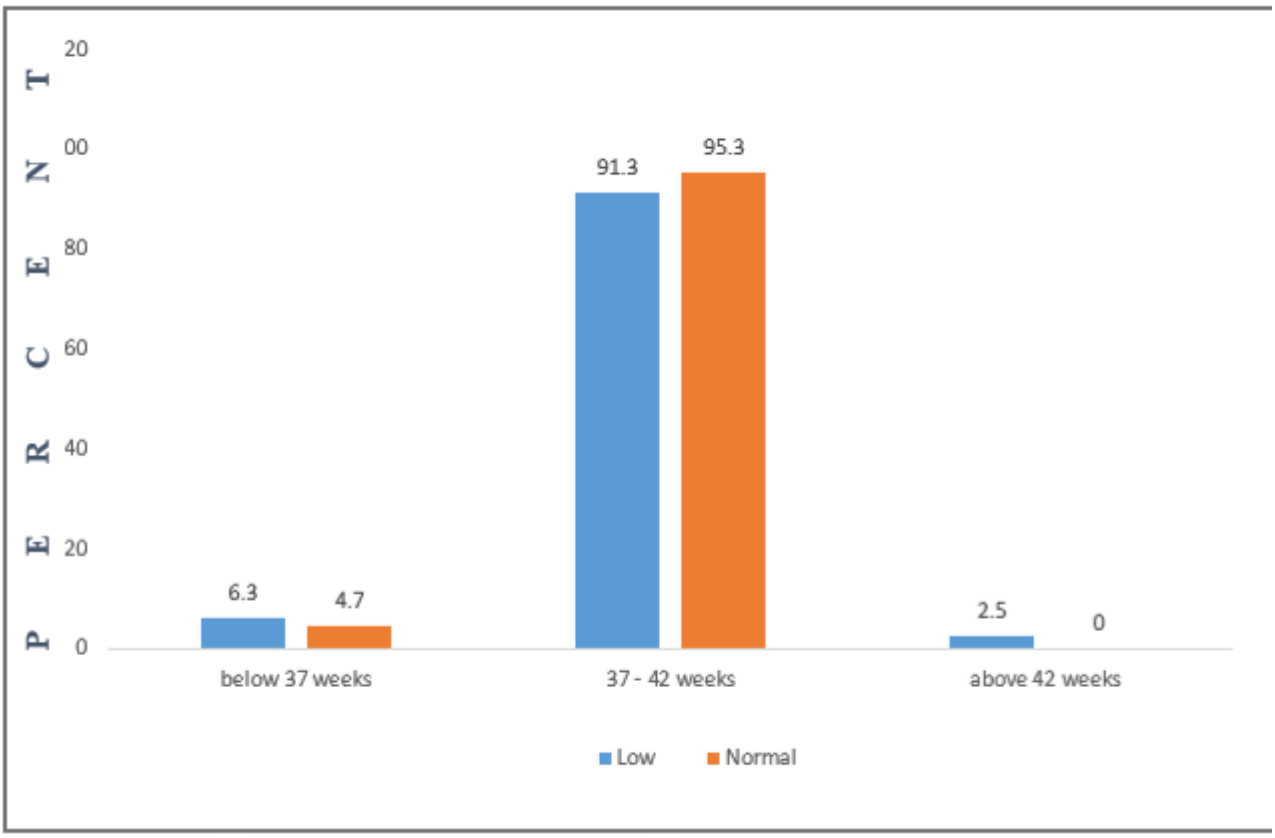

Figure 2 Bar chart showing the distribution of serum zinc status by gestational age.

THE RELATIONSHIP BETWEEN MATERNAL SERUM ZINC LEVEL AND CORD SERUM ZINC

Linear relation in the cord serum zinc level was found to increase with increase in maternal serum zinc level as displayed by the positive scatter plot below $R^2 = 0.154$, figure 1.

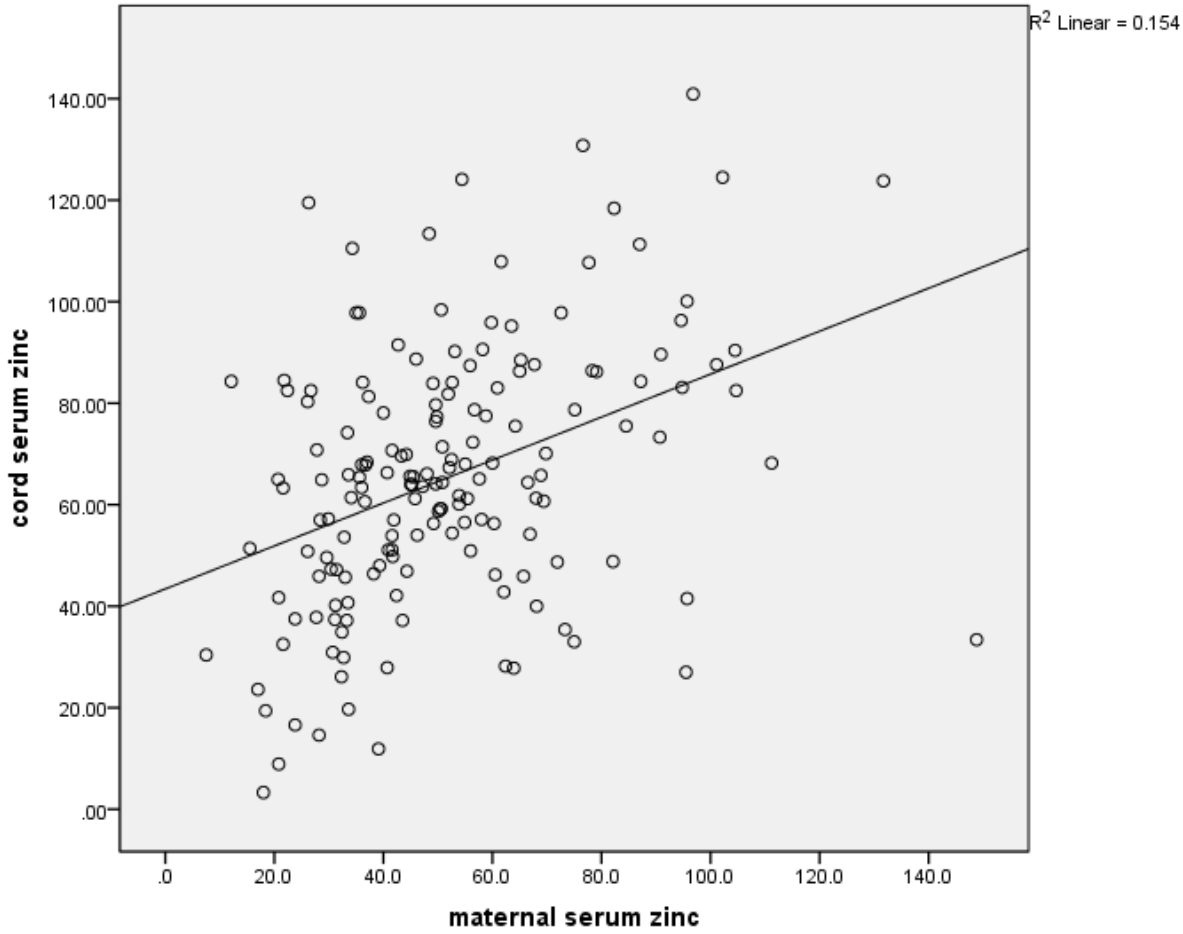

Figure 3 Scatterplot showing the relationship between maternal serum zinc level and cord serum zinc level.

RELATIONSHIP BETWEEN CORD SERUM ZINC AND MATERNAL SERUM ZINC

Pearson correlation showed a significant positive relationship between maternal serum zinc level and cord serum zinc level, p – value <0.001. As the maternal serum zinc increased, the cord serum zinc also increased. Also a significant positive correlation was found between gestational age at delivery and maternal serum zinc Level, p – value 0.014 as shown in table V below.

Table V Pearson Correlation between Maternal Serum Zinc Level, Birth Weight, Gestational Age and Cord Serum Zinc Level.

Variables (N =330)		Maternal serum zinc	Cord Serum Zinc	Birth Weight	Gestational Age
Maternal Serum Zinc	R	1	0.392	0.110	0.190
	p-value		<0.001	0.159	0.014
Cord Serum Zinc	r		1	-0.001	-0.065
	p-value			0.987	0.404
Birth Weight	r			1	0.545
	p-value				<0.001
Gestational Age	R				1
	p-value				

r = Pearson Correlation Coefficient

ASSOCIATION BETWEEN DIETARY FACTORS AND CORD SERUM ZINC LEVEL

Prevalence of low cord serum zinc level was noticed to be least in babies whose mothers took red meat, dairy products and sea food daily when compared with those whose mothers took these items three days or less in a week. However the difference was not statistically significant p-values 0.17, 0.26 and 0.37 respectively as shown in table VI below.

Table VI Association between dietary factors and cord serum zinc level

Dietary factors	Cord Serum Zinc level		Total	$\chi 2$	p-value
	Low	Normal			
Red Meat Intake					
Daily	40 (37.0)	68 (63.0)	108		
4 6 days/week	76 (54.3)	64 (45.7)	140		
1 – 3 days/week	38 (51.4)	36 (48.6)	74	5.02	0.17
None	6 (75.0)	2 (25.0)	8		
Total	160 (48.5)	170 (51.5)	330		
Dairy Intake					
Daily	22 (33.3)	44 (66.7)	66		
4 – 6 days/week	84 (53.8)	72 (46.2)	156		
1 – 3 days/day	50 (50.0)	50 (50.0)	100	4.05¥	0.26
None	4 (50.0)	4 (50.0)	8		
Total	160 (48.5)	170 (51.5)	330		
Sea Food					
Daily	40 (39.2)	62 (60.8)	102		
4 – 6 days/week	66 (51.6)	62 (48.4)	128		
1 – 3 days/week	52 (55.3)	42 (44.7)	94	3.15¥	0.37
None	2 (33.3)	4 (66.7)	6		
Total	160 (48.5)	170 (51.5)	330		

¥ Likelihood ratio

ASSOCIATION BETWEEN CORD SERUM ZINC AND SOME OBSTETRIC FACTORS

Table VII shows no significant association between parity, maternal age, mode of delivery, Antenatal Care (ANC) visits and gestational age and cord serum zinc level p-values 0.85, 0.51, 0.57, 0.11, and 0.21 respectively.

Table VII Association between some obstetric Factors and Cord Serum Zinc Level

Obstetric Factors	Cord Serum Zinc (n/%)		Total	$\chi 2$	p-value
	Low	Normal			
Parity					
Primipara	54 (46.6)	62 (53.4)	116		
2 – 4 children	88 (50.6)	86 (49.4)	174	0.336	0.85
>5 children	18 (45.0)	22 (55.0)	40		
Total	160 (48.5)	170 (51.5)	330		
Maternal Age(years)					
19 – 35	136 (49.6)	138 (50.4)	274		
> 35	12 (42.9)	16 (57.1)	56	0.43	0.51
Total	160 (48.5)	170 (51.5)	330		
Mode of delivery					
SVD	142 (49.3)	146 (50.7)	288		
CS	14 (38.9)	22 (61.1)	36	1.11¥	0.57
Vacuum	4 (66.7)	2 (33.3)	6		
Total	160 (48.5)	170 (51.5)	330		
ANC Visits					
<4	8 (28.6)	20 (71.4)	28	2.58	0.11
≥4	150 (51.0	142 (49.0)	294		
Total	158 (49.1)	164 (50.9)	322		
Gestational Age					
Below 37 weeks	10 (55.6)	8 (44.4)	9		
37 – 42 Weeks	146 (47.4)	162 (52.6)	302	3.15¥	0.21
Above 42 weeks	2 (100)	0	2		
Total	160 (48.5)	170 (51.5)	330		

Likelihood Ratio

CORRELATION BETWEEN OCCIPITOFRONTAL CIRCUMFERENCE, BIRTH LENGTH AND CORD SERUM ZINC LEVEL

This shows a weak negative correlation between birth length, OFC and cord serum zinc level though this is not Statistically Significant p-values 0.60, 0.50. As the cord serum zinc increased, the birth length and OFC of the neonates decreased.

Table VIII Correlation between occipitofrontal circumference, birth length and cord serum zinc level.

Variable(N=330)		Cord Serum Zinc	Length	OFC
Cord Serum Zinc	R	1	-0.041	-0.053
	p-value		0.60	0.50
Length	R		1	0.68
	p-value			<0.001**
OFC	R			1
	p-value			

** Significant to level of 0.001

DISCUSSION

The cord serum zinc of neonates delivered at FMC Owerri was found to be low in 48.5% of cases while the mean cord blood serum zinc level in neonates was 65.29±25.7µg/dl. The prevalence of zinc deficiency reported by investigators in Iran, Ghana, Abuja Nigeria, Brazil and Kenya ranged from 6% to 56.6% while the mean cord serum zinc ranged from 60µg/dl to 108.7µg/dl [27,28,29,30]. The prevalence of low cord serum zinc level of 39.6% found by [31] in South West Nigeria was lower than that found in the present

study.This could be explained by the fact that Bolaji et al did not recruit preterms who are more likely to have lower serum zinc than term neonates.[22]However, the mean serum zinc measured by [29] was 60µg/dl which is lower than that found in this study and this can be explained by the fact that these studies were carried out in different geographical regions with different soil and water zinc content from that in the present study. [10] in Iran documented a lower prevalence of 11.9% and a higher mean plasma zinc of 108.57±33µg/dl and these findings can be explained by the fact that this Iranian study excluded anaemic women in their study. Agroup of investigators from Jordan have found a statistically significant relationship between anemia and low serum zinc in pregnant mothers [32]. The index study found that there was no significant association between cord blood serum zinc and gender indicating that gender is not a significant risk factor for low cord serum zinc. This finding is in tandem with other studies like that by [33]. However, [34] reported that more females were zinc deficient and this might have arisen because they alsostudied older children (under-fives); however in New Zealand,male gender was found to predispose to zinc deficiency in neonates [35]. The finding of the index study was that cord serum zinc was lower among neonates whose parents were from low socioeconomic class although this relationship was not statistically significant.The findings of the index studyare corroborated by Demirtuk et al[85] in Turkey. In contrast, a group of Nigerian investigators found a statistically significant relationship between cord blood serum zinc and socioeconomic class [36]. This finding may have arisen from the fact that these investigators recruited their subjects from two different venues (a tertiary hospital and a rural hospital) while the index study recruited subjects only from a tertiary centre. [37] in Egypt also found a statistically significant relationship between socioeconomic class and cord serum zinc but this may have arisen because these investigators excluded neonates who had need for admission as against the present study. The index study found a significant positive relationship between cord serum zinc and The prevalence of zinc deficiency in the index study was lower in neonates whose mothers ingested red meat, dairy products and sea foods daily compared to those whose mothers took these items less than three days in a week, though the relationship was not statistically significant [38]. In contrast [39] showed through a 60-day dietary recall that mothers who were on zinc-rich diets had a higher maternal and cord blood serum zinc when compared to those who took diets that are poor in zinc content and the relationship was statistically significant. This can be explained by the fact that this study was carried out in a country with geographical indices which are different from that in the index study. In New Zealand it was documented that vegetarian mothers or mothers who stopped ingesting red meat in pregnancy gave birth to neonates with low serum zinc [40]. This study found no significant association between cord blood serum zinc and maternal age and is supported by [10,28]. To the extent of the researcher's search, no studies documented a statistically significant relationship between cord serum zinc and maternal age. The index study found that mode of delivery did not significantly affect the cord serum zinc level. This findingis similar to that documented by [29] in America.However, [30] in Iraq found that there was a decrease in cord blood serum zinc for neonates delivered by caesarean section when compared to those delivered vaginally. The index study found no significant association between cord serum zinc and the frequency of maternal antenatal care visits. This is similar to the findings of [30] in Ibadan Nigeria. To the extent of the researcher's search, no studies have documented a statistically significant relationship between cord serum zinc and the frequency ofmaternal antenatal care. The relationship between gestational age and cord serum zinc as documented in the index study was not statistically significant.

CONCLUSION

1. The study on cord blood serum zinc in neonates delivered at FMC Owerri founda prevalence of hypozincaemia of 48.5% which is high.
2. Maternal serum zinc level is a strong factor influencing neonatal serum zinc level.
3. Low cord serum zinc level is commoner among neonates with low birth weight, female gender, and low socioeconomic status.
4. Low cord serum zinc level tended to occur more in neonates whose mothers took red meat, dairy products and seafoods three times or less in aweek.

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