RELATIONSHIP BETWEEN SERUM ZINC LEVELS AND SOCIO-DEMOGRAPHIC FEATURES IN NIGERIAN CHILDREN WITH ACUTE LOWER RESPIRATORY INFECTIONS

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Abstract

Background: Acute Lower Respiratory Infections (ALRI) are a major cause of Paediatric morbidity for which several risk factors have been identified. Among these factors are socio-demographic and nutritional factors including micronutrients such as zinc and Vitamin A. The current study was carried out in Ilorin, Nigeria to determine the relationship between serum zinc levels and some socio-demographic characteristics in children with ALRI.

Method: This was a descriptive cross-sectional study involving children aged two months up to 60 months with ALRI. Socio-demographic and clinical data were obtained via a semi-structured questionnaire. Blood samples were collected for determining the serum zinc level. The serum zinc was analyzed with a Jenway™ spectrophotometer after initial preparation with the QuantiChrom™ zinc assay kit. The data collected was analysed with SPSS 16 software package.

Results: Of the 120 children recruited, 73(60.8%) were males and 47(39.2%) females. The mean (SD) age of the children with ALRI was 20.8(17.6) months. Nine (7.5%) children had bronchiolitis, 16(13.3%) had lobar pneumonia and 95(79.2%) bronchopneumonia. Children from monogamous families had mean (SD) serum zinc level of 19.6(12.2) μg/dl which was significantly higher than the corresponding value of 13.1(7.7) μg/dl recorded in those from polygamous homes, *p*=0.031. After a stepwise linear regression analysis, the family type remained significant with an F value of 4.244; p=0.042; 95%C.I.(-12.4 - -0.3).

Conclusion: Children with ALRI from polygamous homes have low serum zinc levels. The family type is a predictor of serum zinc level in children with ALRI.

KEYWORDS: ZINC, UNDER-FIVES ACUTE LOWER RESPIRATORY INFECTIONS

Abbreviations: EPU- Emergency Paediatric Unit; **UITH**-University of Ilorin Teaching Hospital, **ALRI**- acute lower respiratory infections, **WHO**-World Health Organisation

Introduction

Accounting for between 1.9 million and 2.2 million childhood deaths globally, ALRI remains a major public health challenge.–, In Sub-Saharan Africa, ALRI-related deaths account for 20.0-25.0% of childhood mortality in Nigeria.–1 Zinc is a micronutrient required for various metabolic and immunologic responses in the body.3 Indeed, zinc deficiency decreases the ability of the body to respond to infection,4 and has been shown to be one of the leading causes of morbidities in low-income countries.5 The global average prevalence of zinc deficiency has been estimated to be 31.0%, but this value varies from 4.0-73.0% among the WHO sub-regions.[6] In Nigeria, the national average prevalence of zinc deficiency was identified as 21.0% in under-five children, and a corresponding value of 59.1% in Kwara state.7

Low serum zinc levels have been implicated as putting a child at increased risk of ALRI.8 Indeed, a systematic review of studies evaluating preventive effects of zinc supplementation on the morbidity burden of ALRI foundan overall reduction of 15% in the incidence of ALRI in zinc-supplemented preschool children.9 It is also estimated that zinc deficiency is responsible for approximately 800,000 deaths annually among children under-five years of age; of which 406,000 were pneumonia-related and attributed to inadequate zinc intake.10

Age, gender and the level of maternal education are some socio-demographic features that had earlier been identified as risk factors of ALRI in various studies.,, Also domestic crowding, maternal age/child care experience, breastfeeding practices, malnutrition had each been recognized as important risk factors of ALRI-related morbidity and mortality., Despite the burden of ALRI morbidity and mortality reportedly related to zinc deficiency, there is a dearth of studies on the relationship between identified socio-demographic features which are risk factors of ALRI and serum zinc levels. Thus, the aim of the current study was to determine the relationship between serum zinc levels and some socio-demographic characteristics of children with ALRI.

Subjects, Materials and Method

This descriptive cross-sectional study was conducted in the Emergency Paediatric Unit (EPU) and the Paediatric Medical Ward at the University of Ilorin Teaching Hospital (UITH), Kwara State. Children aged between two months and less than 60 months with an admission diagnosis of either pneumonia or bronchiolitis were enrolled as subjects over a period of four months. Using the age-related values for tachypnea to categorize the children, children aged two months and above were recruited as subjects while those aged less than two months were excluded as the EPU admits children aged above one month.

Using the formula (z^2pq/d^2)and a prevalence of 15.8 % from a previous study,15a minimum sample size of 102 was calculated, however 120 subjects were enrolled.

The diagnosis of pneumonia was based on the presence of cough, fever, breathlessness, age-related tachypnoea and auscultatory findings of one or more of reduced breath sound intensity, bronchial breath sounds and crepitations.16 Bronchiolitis was diagnosed based on the presence of cough, fever, wheezing and dyspnoea, associated with bilateral polyphonic expiratory rhonchi, inspiratory crepitations and clinical/radiographic features of hyperinflation.16 Excluded from the study were children who had severe form of malnutrition (marasmus, kwashiorkor and marasmic-kwashiorkor), diarrhoea in the preceding one month, or who had taken zinc supplements in the past one month. Ethical approval was granted by the *Ethics and Research Committee* of the UITH.

Subjects that satisfied the recruitment criteria for the study had a full clinical evaluation. A semi–structured questionnaire was administered to obtain the socio-demographic and clinical data from each care-giver after obtaining an informed written consent. Socio-economic index scores were awarded to the occupations and educational attainments of their parents or caregivers using the Oyedeji socio-economic classification scheme.17 Other relevant data collected include the maternal age, birth order, number of siblings, family type of the subject and anthropometric measurements. The number of sibling was divided based on the maximum of four children per family into two groups. The weight was measured using a bassinet weighing scale (*Surgifriend Medicals, London, England*) in infants, and a beam balance weighing scale (*Marsdens*, *London, England*) for older children able to stand unsupported. The standing height was measured to an accuracy of 0.1cm using a standard stadiometer attached to the weighing scale, while measurement of the length was carried out using a modified infantometer in infants.

Using strict aseptic techniques, two millilitres of blood was collected via venepunture, and immediately emtied into a plain bottle, and then allowed to clot. Serum samples were obtained by centrifuging the clotted blood sample at 3000rpm for five minutes in a bench-top centrifuge. The sera obtained were transferred into sterile plastic tubes and stored immediately at -20°C, till it was ready to be analyzed when the sera were thawed followed by batch analysis. The serum zinc analysis was done with a Jenway™ spectrophotometer 6300 model (*Jenway Limited, Dunmow, Essex, United Kingdom*) for measuring optical density at 425nm, after an earlier preparation with the QuantiChrom™ Zinc colorimetric assay kit (*Bioassay Systems, Hayward, California, USA*).

The Zn^{2+} Standard (10µM), 50µl of water, Sample and Sample Blank (50µL sample + 2µL EDTA) were transferred into wells of a clear bottom 96-well plate.18 Subsequently 200µL of the working reagent was added to each well and then mixed by tapping the plate lightly. The resulting solution was allowed to incubate for 30 minutes at room temperature.18 The optical density (OD) was read at 420-426nm (peak absorbance at 425 nm).18

Data generated was analyzed with the SPSS 16 software package. A nutritional anthropometry program, *NutriStat*® of Epi-info version 3.5.1(2008) was used to determine the percentage and *z*-score for age of each child based on the WHO Growth Reference dataset. Frequencies, proportion, means and standard deviations were calculated. The *Chi-square* and *Student's t-tests* were used to identify significant differences for categorical and continuous variables respectively. The analysis of variance (ANOVA) test was used to compare the means of more than two groups. The Pearson correlation coefficient was determined in quantitative variables while Spearman's rank correlation test was used for categorical variables. A linear regression model was built using a stepwise method. A p value of <0.05 was considered significant.

Results

A total of 120 children were recruited and enrolled for the study. Nine (7.5%) children had bronchiolitis, 16(13.3%) had lobar pneumonia and 95(79.2%) bronchopneumonia. The mean (SD) age of the children with ALRI was 20.8(17.6) months and a range of two to 59 months while the mean (SD) maternal age was 29(5.5) years with a range of 19 to 40 years. Table 1 shows the distribution across age, gender and social class of each child.

Table 1: Socio-demographic characteristics of children with ALRI

Parameter	Frequency	Percentage
Age group (months)		
2 - <12	47	39.2
12- <24	30	25.0
24 - <36	26	21.7
36 - <48	3	2.5
48-<60	14	11.6
Gender		
Male	73	60.8
Female	47	39.2
Socio-economic class		
I	10	8.3
II	47	39.2
III	33	27.5
IV	28	23.3
V	2	1.7

The overall mean(SD) serum zinc level in the children with ALRI was 18.7(11.8) µg/dl. One hundred and eighteen (98.3%) children had low serum zinc status while two(1.7%) had normal zinc status. Table 2 shows that the mean (SD) serum zinc level in infants was higher compared to the corresponding value in the age group beyond infancy (***p*=0.007**). The mean (SD) serum zinc level in children from a monogamous family was higher than the corresponding value recorded in those from a polygamous family (***p*=0.031**). Also, the mean serum zinc level in children with ALRI who had three or less siblings was higher than the corresponding value recorded in children with more than three siblings (***p*=0.037**).

Table 2: Some socio-demographic features and serum zinc levels in children with ALRI

Socio-demographic feature	No. of cases (%)	Zinc level in ALRI (µg/dl) Mean(SD)		*p*-value
Age group (months)				
2-<12	47(37.5)	22.0(16.4)	2.737#	**0.007**
12 -<60	73 (62.5)	16.0(7.3)		
Gender				
Male	73(60.8)	17.9(14.2)	0.907#	0.366
Female	47(39.2)	19.9(6.4)		
Social class of child				
High (I,II, III)	90(75.0)	19.6(12.5)	1.538#	0.127
Low (IV, V)	30(25.0)	15.8(8.9)		
Maternal age group (years)				
[illegible]	6(5.0)	14.9(3.2)		
21-34	93(77.5)	18.9(10.2)	0.322*	0.725
[illegible]	21(17.5)	18.8(18.5)		
Level of maternal education				
≥Secondary	86(71.7)	19.5(12.7)		
Primary	21(17.5)	16.2(6.7)	0.724*	0.487
None	13(10.8)	17.3(12.4)		
Family type				
Monogamous	102(85.0)	19.6(12.2)	2.181#	**0.031**
Polygamous	18(15.0)	13.1(7.7)		
Number of siblings				
≤3	100 (83.3)	19.7(12.2)	2.104#	**0.037**
>3	20(16.7)	13.6 (8.5)		

* = F value # = t value

Table 3 shows significant correlations between the serum zinc levels and the age of the children, the number of siblings and the type of family of the children with ALRI (each *p*=0.013, 0.031 and 0.037 respectively).

Table 3: Correlation of socio-demographic features and serum zinc levels in children with ALRI

Socio-demographic feature	Correlation coefficient *(r)*	*p*-value
Age (months)	-0.226	**0.013**
Social class	-0.139	0.131
Maternal age (years)	0.033	0.722
Maternal educational level	-0.079	0.389
Family type	-0.198	**0.031**
Number of siblings	-0.190	**0.037**

The type of family was a significant finding after a stepwise linear regression analysis (Table 4). The goodness of fit model gave an F value of 4.244; df =1, p=0.042; 95%C.I.(-12.4 - -0.3) and accounting for a 3.5% effect on serum zinc levels.

Table 4: Linear regression analysis of serum zinc levels and socio-demographic features of children with ALRI

Parameter	Beta co-efficient	*t*	*p*
(Constant)		6.903	0.001
Type of family	-0.186	-2.060	**0.042**
Gender	0.001(a)	.014	0.988
Age (months)	-0.125(a)	-1.375	0.172
Number of sibling	-0.125(a)	-1.205	0.231
Maternal age (years)	0.111(a)	1.068	0.288
Social class group	.035(a)	.347	0.729
Maternal educational level	0.055	0.533	0.595

a Predictors in the Model: (Constant), type of family
b Dependent Variable: Serum zinc levels

Discussion

Among the children with ALRI, the highest serum zinc levels were recorded in the infants, and the serum zinc levels of subjects decreased with increasing age. There was a paucity of data comparing the serum zinc levels across different age groups for comparison in the current study. However, it is postulated that in infants with ALRI the serum zinc is not reduced as much as in the older age group because such infants may still be breastfeeding.19 Studies have shown that breastmilk contains adequate zinc initially with a decline occurring from six months postpartum.20-22 Also complementary feeding, often commenced at the age of six months, are usually with whole grain cereals and legumes which have reduced zinc bioavailability due to their contents of phytates and fibres reported to inhibit zinc absorption.7,[23] In the current study site, maize consumption was reportedly the most frequent followed by sorghum, cassava and rice while the most common legume consumed was groundnut followed by cowpea.7 The higher serum zinc levels in the infant age group may therefore be attributable to the fact that the zinc content of human breast milk is adequate for the first six months of life prior to the commencement of zinc-unfortified, plant-based complementary feeds.

In the current study, higher serum zinc levels were found in female children compared with males with ALRI and though this observation did not reach a significant level, the higher levels of zinc identified in females is in accord with those of previous studies., It has been suggested that males probably have higher requirements for zinc than females because of their higher growth rates.26 Thus, the findings of higher zinc levels in the female child compared to the male may be attributable to the male child having a lower pre-morbid zinc level, possibly as a result of their higher physiological requirement for zinc. This vulnerability may be aggravated by an intercurrent ALRI.

Children from polygamous homes and those who shared the available household resources with several siblings showed significantly lower levels of serum zinc when compared to their peers from monogamous family settings and those with fewer siblings. These findings are not surprising in view of the need to share the meagre family resources (including food intake of zinc-rich animal sources) between a greater number of children (and adult dependents) in the household.27 Clearly, this scenario is likely to contribute to inadequate zinc intake and hence the occurrence of a pre-morbid zinc deficient state, with the attendant impaired immunity which worsens with a concomitant ALRI. Interestingly, both of these adverse household variables associated with low serum zinc levels are also associated with crowding, a domestic variable that had earlier been identified as a significant risk factor for ALRI., As a large sibship is more likely to engender crowding and hence more frequent ALRI in children from such homes, there is the possibility of further zinc depletion with the resultant precipitation and sustenance of a zinc deficient state.
The absence of a significant association in the present study between zinc levels and some selected socio-economic indices in children with ALRI was surprising. Such indices included the social class, maternal age and maternal literacy status which had been identified as important risk factors and prognostic determinants of ALRI in earlier reports.–, Children with a poor socio-economic background are more likely to be malnourished with little access to zinc-rich food sources (such as meat, poultry and dairy products) and this would support the likelihood of an expected low serum zinc level in such children. Furthermore, the appropriate and timely healthcare seeking behaviour, as well as a clear understanding of the available preventive strategies, are less likely to be appreciated by the illiterate mothers.31 In such children with a poor parental background, inadequate family income would hardly support a prompt and appropriate health seeking behaviour in the event of the occurrence of any of the ALRI syndromes.32 A possible consequence of such belated presentations (at the relevant health care facilities) is an aggravation of the pre-existing zinc depletion associated with progression of the ALRI. Hence, a clear explanation would be difficult to proffer for the present findings of lower, but insignificant differences in serum zinc levels of the children with ALRI whose mothers were younger, less literate and their social class adjudged low.

Conclusion: Children with ALRI from polygamous home have lower serum zinc levels compared to those from monogamous families. The family type is a predictor of serum zinc level in children with ALRI. Attending clinicians to children with ALRI from this background should have a high degree of suspicion with regard to low zinc states.

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Participation: RMI conceptualized the study, collected and analyzed the data, and drafted the paper. SAB assisted with all the laboratory analysis, while 'WABJ, AAA and OTA refined study protocol. All authors contributed to the final draft of the paper.

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