INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH & DEVELOPMENT

ISSN 2278 – 0211 (Online)

Correlation of Selenium Deficiency with Anthropometric Parameters among Primary School Children in Southwestern Nigeria

Oladibu Olanike Taye
Lecturer, Department of Paediatrics,
Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo state, Nigeria
Onigbinde Michael Olaniyan
Lecturer, Department of Paediatrics ,
Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo state, Nigeria
Ojuawo Ayodele
Professor of Paediatrics, Department of Paediatrics and Child Health,
University of Ilorin Teaching Hospital, Ilorin, Kwara state, Nigeria
Oloyede Taiwo Wulemot
Consultant Chemical Pathologist, Department of Chemical Pathology,
Federal Medical Centre, Katsina, Katsina state, Nigeria
Alabi Ayobami Oyetunji
Lecturer, Department of Paediatrics,
Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo state, Nigeria
Alatishe Taiwo Adedamola
Lecturer, Department of Psychiatry,
Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo state, Nigeria
Ojedokun Samson Aderemi
Medical Laboratory Technologist, Department of Chemical Pathology, Metabolic Research Laboratory
Ladoke Akintola University of Technology Teaching Hospital, Ogbomoso, Oyo state, Nigeria
Kofoworade Olawumi Olabimpe
Lecturer, Department of Paediatrics,
Bowen University Teaching Hospital, Ogbomoso, Oyo state, Nigeria

Abstract:
Background: Selenium is of fundamental importance to health, being an essential trace element involved in many immunological, endocrine, and antioxidant pathways. Its deficiency is associated with growth failure, poor immune function, cognitive decline and increased risk of morbidity and mortality especially among school aged children.
The study aims at determining the serum level of selenium among primary school pupils in Ogbomoso North Local Government Area and its correlations with their socioeconomic characteristics and the anthropometric indices.
Method: Children aged 6 to 12 years old were recruited from registered public and private primary schools. A semi-structured questionnaire designed for the study was used to obtain relevant data. Serum selenium levels was estimated using Human Selenium Binding Protein. Chi-square test of independence was used to examine the association between selenium levels and each of socio-demographic variables and anthropometric indices while Pearson moment correlation was used to determine the correlation between selenium levels and socio-demographic characteristics and anthropometric indices of the study population.
Results: The mean age of the subjects was 8.35 ± 1.61 years. Majority (86.7%) of the subjects were from middle and high socio-economic classes. The prevalence of stunting, underweight, overweight and obesity was found to be 8.8%, 4.3%, 1.8% and 2.0% respectively. The mean serum selenium concentration was 0.51 ± 0.30ng/ml while mean serum albumin was 40.4 ± 8.13 g/l. Selenium deficiency was 36.5% and low serum protein and albumin was found in 15.1% and 27% of the study population respectively.
Serum selenium level was significantly associated with age, family size and gender. There was a negative correlation between age group, family size and serum selenium levels while a positive correlation exist between socio-economic class and selenium levels. Weight-for age and height-for-age has a positive correlation with selenium levels while stunting and selenium levels were negatively correlated.
Conclusion: Prevalence of selenium deficiency is high among subjects and it is an important public health challenge in the country. Socio-demographic characteristics like age, family size, gender and socio-economic class are significantly associated with selenium status of the school children. Selenium deficiency was significantly related to the nutritional status of the study population.

Keywords: *Selenium, micronutrients, diet, nutrition*

1. Introduction

Micronutrients are essential components of a high-quality diet and have profound impact on health. They are required in minute quantities[1] but are essential building blocks for healthy brains and bones. The deficiency of micronutrients is often referred to as hidden hunger.[2] These deficiencies develop over time and their devastating impacts are usually not seen until irreversible damage is done. Primary school period is a dynamic age of physical growth as well as mental development of the child[3,4] hence poor nutrition, including micronutrient deficiency, at this age will negatively affect the overall development of the child and the community as a whole.

Deficiencies of some trace elements like zinc, selenium and iodine, are important public health challenge in developing countries like Nigeria[1] due to inadequate nutritional supply or inefficient utilization as a result of parasitic infestation.[5] Excessive intake of these trace elements is uncommon except in environmental exposure or supplement overuse.[1]Both zinc and selenium are potent antioxidants involved in cellular defense against free radicals.[6] Their deficiencies can affect all age groups, but young children are most at risk, particularly in the developing world,[7]resulting in disease states like diarrhea, pneumonia and malaria.

Children are especially susceptible to deficiency states because rapid growth creates an increase demand for these elements. Some vital organs, like the brain, are more vulnerable to sustain permanent damage due to micronutrients deficiency during childhood.[1] Also, in developing countries, children are more prone to gastrointestinal disorders that may cause malabsorption of these elements.

Selenium is an essential trace element with an antioxidant activity. It acts as a catalyst for the production of active thyroid hormone. It is needed for the proper functioning of the immune system.[8,9] It is incorporated into amino acids to form selenoproteins,[10] and it is important in maintaining the cellular membrane integrity.[10] Low selenium status has been associated with increased risk of mortality,[11] poor immune function[15] and cognitive decline.[9,12]

Many children suffer from stunted growth, cognitive delays, weakened immune system and diseases as a result of these deficiencies. There has been increasing evidence over the years that the prevalence of zinc and selenium deficiencies is on the increase in both adults and schoolchildren.[13-15]

Studies on this trace metal are very rare in this environment therefore this study was aimed to determine the serum level of selenium among primary school pupils and its correlations with socioeconomic characteristics and the anthropometric indices of this group of people.

2. Materials and Methods

2.1. Study Setting and Design

The study was conducted among apparently healthy primary school children aged 6 – 12 years in Ogbomoso North Local Government area between September 2018 to December 2018. There are 88 registered private and public primary schools in Ogbomoso North Local Government Area with 61 of them being private primary schools and 27 public primary schools in a ratio of 2:1.

The study adopted a descriptive cross-sectional study design.

2.2. Sampling Techniques

Multi-stage sampling method was used

2.3. Sample Size

The sample size for the study was calculated using the formula.

$$n = \frac{Z^2 pq}{d^2}$$

Where;

n = minimum sample size when the population is greater than 10,000

z = the standard normal deviate usually set at 1.96, which correspond to the 95% confidence level

p = the proportion in the target population estimated to selenium deficiency.

Prevalence rate of 62% was used,[9] Selenium deficiency from a similar study in Africa was 62%

q = 1 – p = (1 – 0.62)

d = degree of accuracy desired, set at the 0.05 level. (Standard error of 5%)

Thus,

$$n = \frac{1.96^2 \ X \ 0.62 \ X \ (1 - 0.62)}{0.05^2} = 362$$

2.4. Sampling Procedure

2.4.1. Stage 1

The lists of all registered public and private primary schools in Ogbomoso North Local Government were obtained from the Local Inspector for Education (LIE).

2.4.2. Stage 2

Selection of Schools

Ten percent (10%) each of the total schools in both private and public schools were selected in order to have a good representation and reasonable number of respondents from each school. Therefore, six (6) private schools and three (3) public schools were proportionately selected.

The schools were then arranged in alphabetical order, the total number of schools in private schools was divided by 6 while those in public schools was divided by 3and the n^{th} school was selected.

2.4.3. Stage 3

Selection of Pupils in the Selected Primary Schools

- The desired sample size was selected by proportional allocation of respondents from different classes in the selected public and private schools (Primary 1 to 5 in private and 1 to 6 in public).
- Respondents were selected from 9schools =>400 divided by 9 schools = 44.

Forty-four (44) respondents were proportionally allocated to the different classes of each of the selected schools. This was done by dividing the total number of pupils in the class by the total number in the school and multiplying this by the desired number of the respondents in that school (i.e. 44) as shown below;

$$\frac{\text{Numbers of pupils in the class X} \quad \text{desired number of pupils in that school}}{\text{Total number of pupils in the school}}$$

- Equal numbers of both male and female was selected, (with the sampling fraction determined based on the number of male / female pupils in the class and the number of respondents to be selected) using the teacher's class register

2.5. Inclusion and Exclusion Criteria

Apparently healthy children aged 6-12 years in Primary (public and private) schools, in Ogbomoso North Local Government with availability of parental informed consent and pupil's assent (7years and above) were included in the study while children on selenium supplementations such as synovit, selenium aspartate capsule, multivitamins, aminopep were excluded. Children with chronic conditions such as Sickle cell anemia, renal diseases and children who refused to participate were also excluded from the study.

2.6. Blood Sample Collection, Storage and Laboratory Analysis

Five milliliter of venous blood was collected from the cubital fossa of each child for serum selenium analysis. The samples were immediately transported in a sample rack to chemical pathology department of LAUTECH Teaching Hospital (LTH), Ogbomoso where they were spun for 15minutes at 2200 revolutions/min to separate the serum. The sera were then kept at a temperature of -20^{0}C until all sample collection was completed. Sera from the participants were analyzed in batches using standards and level 2 and 3 controls for the selenium assay. Human Selenium Binding Protein 1(SELENBP1) ELISA Kit with REF number UM-S1502 and LOT number 20180913 by Span Biotech Limited was used to assay the selenium binding protein 1(SELENBP1) in the sample of subject's serum.

2.7. Data Analysis

The data obtained were analyzed using Statistical Package for Social Sciences (SPSS) version 21 (International Business Machine Corporation (IBM) licensed SPSS). Data collected on the questionnaire were entered using numerical codes.

The WHO growth charts and BMI-for-age charts were used to compute Z-score (weight-for-age, height-for-age and BMI-for-age) according to WHO reference standard (WHO, 2007).[17] These charts were used to convert raw anthropometric data (weight, height and age of the children) into anthropometric Z-score used to classify them into levels of nutritional status (stunting, underweight, overweight and obesity). Stunting and underweight were calculated as height-for-age and weight-for-age Z-score below -2 Z-score respectively, while overweight was BMI-for-age>2 Z-score and obesity was BMI-for-age >3 Z-score (5-19years).

Summary statistics entailed the use of frequency, percentages, and graphical representation in analysis of categorical variables such as sex, religion, ethnicity, family type etc. while mean and standard deviation of continuous variables were obtained.

Distribution of selenium in participants were checked using box plot. The distribution of selenium in the study population was not normally distributed. Log transformation of selenium values were taken to impose normality. Student t-test and F test were used where suitable in comparison of selenium concentration across categorical variables. Chi square test of independence was used to examine the association between level of selenium and each of socio-demographic variables and anthropometric parameters. Pearson moment correlation was used to examine the relationship between concentration of selenium and each of the socio-demographic variables and anthropometric parameters. Cut-off value for selenium deficiency was 2ng/ml. All decisions were made at 95% level of confidence and level of significance of p set at < 0.05.

2.8. Ethical Clearance

Ethical clearances were obtained from the ethical review committee of Ladoke Akintola University of Technology Teaching Hospital, Oyo State Ministry of Education and the Headmasters/ Headmistresses of the selected schools.

2.9. Conflict of Interest

Author declared no conflict of interest

2.10. Funding

This research work was self-sponsored.
No public or private fund or grant received from any organization.

3. Results

A total of 400 primary school children aged 6 to 12 years were recruited with a mean age of 8.35 ± 1.61 years as shown in Table 1. There was a female preponderance with a male to female ratio of 1:1.3.

Three hundred and seventeen (79.3%) children were from monogamous families, 15.2% from polygamous families and 5.5% had single parents. Forty-seven percent were from a family size with fewer than 4 persons, 39.8% with 4 to 6 persons, while 12.8% had a family size of 7 and above (Table I). One hundred and seventy-one (42.8%) children belong to high socio-economic class, 44% were in middle socio-economic class, and 13.3% were in low socio-economic class.

Variables	No of Children	Percentage (%)
Age (years)		
< 8	124	31.0
8 - 10	232	58.0
> 10	44	11.0
Mean (SD)	8.35 (1.61)	
Sex		
Male	188	47.0
Female	212	53.0
Religion		
Christianity	225	56.3
Islam	171	42.8
Traditional	2	0.5
Others	2	0.5
Ethnicity		
Yoruba	375	93.8
Igbo	12	3.0
Hausa	10	2.5
Others	3	0.8
Family type		
Monogamy	317	79.3
Polygamy	61	15.2
Single parents	22	5.5
Family size		
< 4	190	47.5
4 to 6	159	39.8
7 and above	51	12.8
Socio-economic class		
High	171	42.8
Middle	176	44.0
Low	53	13.3

Table 1: Socio-Demographic Characteristics of the Study Population

3.1. Feeding Practices and Intake of Supplements by the Participants

On a daily basis, 95% of the children feed 3 to 4 times, 3% feed 5 times or more, whilst 2% do not feed up to 3 times. Sixty eight percent of these children eat in between meals.

Over 91% of the study population consumes milk, fish, meat and green leafy vegetables. Of the 91.8% that consumes milk, about half of them consume it sparingly. Seventy seven percent consume meat and fish frequently whilst 58.3% often eat green leafy vegetables. Further, only 4% of the children were on haematinics (Table 2).

Practices	No of Children	Percentage (%)
No of meals per day		
< 3 times	8	2
3 – 4 times	380	95
5 times and above	12	3
Consumption of milk		
Yes	367	91.8
No	33	8.3
Frequency of milk consumption		
Always (More than once/day)	25	6.8
Often (daily)	143	39
Sometimes (2 – 3 times per week)	134	36.5
Seldom	65	17.7
Consumption of meat/fish		
Yes	395	98.8
No	5	1.3
Frequency of meat/fish consumption		
Always (More than once/day)	76	19.2
Often (Daily)	229	58
Sometimes (2 – 3 times per week)	66	16.7
Seldom	24	6.1
Consumption of green leafy vegetables/fruit		
Yes		
No	395	98.8
Frequency of green leafy vegetables/fruit	5	1.2
Always (More than once / day)		
Often (Daily)	39	9.9
Sometimes (2 – 3 times per week)	191	48.4
Seldom	100	25.3
In-between meals	65	16.4
Yes		
No	271	67.8
Child on blood supplementation	124	31
Yes		
No	16	4
	384	96

Table 2: Feeding Practices and Intake of Supplements among the Children Studied

3.2. Anthropometric Indices of the Study Population

The mean weight was 25.71 ± 6.61kg, (range of 13.10 to 53.0kg) whilst the mean height was 125.88 ± 11.22cm (range 95.0cm to 149.0cm). Eighty-six percent (86.8%) of the children had normal height, 8.8% were stunted and 4.5% had height above +2 Z - score. Three hundred and sixty-eight (92%) children had normal weight, 4.3% were underweight, 2% were obese and 1.8% were overweight (Table 3).

Parameters	No of Children	Percentage (%)
Height-for-Age (n = 400)		
Stunting	35	8.8
Normal	347	86.8
Above +2 Z-score	18	4.5
BMI-for-Age (n = 400)		
Underweight	17	4.3
Normal	368	92.0
Overweight	7	1.8
Obese	8	2.0

Table 3: Anthropometric Indices of the Study Subjects

The mean serum selenium level was 0.51 ± 0.30ng/ml, also higher in males than in females and not statistically significant.

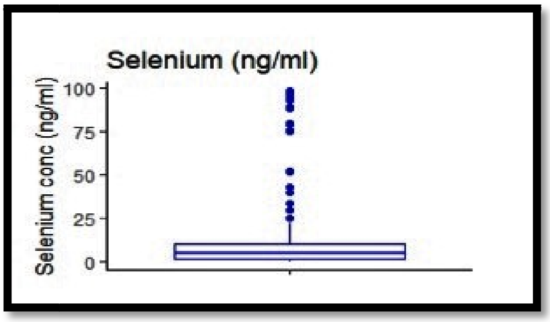

Figure 1: Distribution of Selenium Concentration among Children in the Study Population

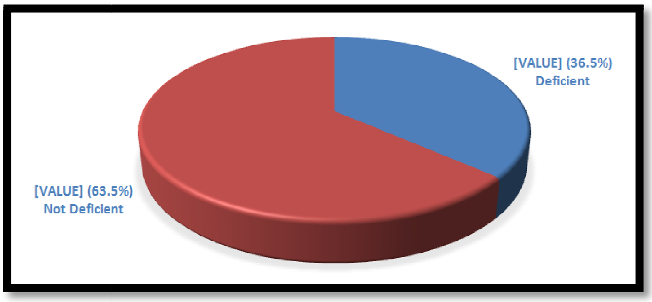

Figure 2: Selenium Deficiency among Children in the Study Population

3.3. Serum Selenium Levels According to Socio Demographic Characteristics of Pupils in the Study Population

Table 4 shows the serum selenium levels across socio-demographic characteristics of the study subjects. The mean serum selenium is significantly higher among male than female children (t = 2.188, p=0.029). There is an association between serum selenium levels and age of children with significant higher levels of serum selenium in the younger age groups than the older age groups. (F = 5.803, p = 0.003).

There is a significant association between serum selenium levels and family size, as serum selenium concentration was higher among children from a smaller family size compared to those from larger family size (F = 4.330, p = 0.014). Further, serum selenium levels did not differ significantly across the family type and socio-economic classes of children in the study population, p > 0.05

Variables	(n = 400)		
	Mean ± SD (ng/ml)	**t / F**	**P**
Sex			
Male	0.728 ± 0.54		
Female	0.844 ± 0.52	t = -2.188	***0.029**
Age groups			
< 8	0.921 ± 0.59		
8 to 10	0.737 ± 0.47		
> 10	0.691 ± 0.56	F = 5.803	***0.003**
Family type			
Monogamy	0.787 ± 0.52		
Polygamy	0.821 ± 0.62		
Single parent	0.923 ± 0.27	F = 0.272	0.762
Family size			
< 4	0.869 ± 0.59		
4 to 6	0.726 ± 0.46		
> 7	0.685 ± 0.48	F = 4.330	***0.014**
Social class			
High	0.854 ± 0.49		
Middle	0.760 ± 0.55		
Low	0.675 ± 0.54	F= 2.787	0.063

Table 4: Serum Selenium Levels across Socio-Demographic Characteristics of the Study Subjects
**< 0.05 Indicates Significance, F: F Statistic, T: T-Statistic*

3.4. Serum Selenium Levels According to Anthropometric Characteristics of Children

Table 5 shows the concentration of serum selenium across anthropometric characteristics. Serum selenium levels was significantly associated with weight for age.

Serum selenium concentration was significantly lower in underweight children (0.648 ± 0.44) compared to normal weight (0.789 ± 0.52) and overweight children (1.146 ± 0.72), F = 5.173, p-value = 0.006.

However, there was no significant association between serum selenium levels and BMI for age of children, p-value > 0.05.

Also, serum selenium concentrations were not significantly associated with height for age, p-value > 0.05.

Variables	(n = 400) Log Selenium (Mean ± SD) (ng/ml)	F	P
Weight for Age			
Underweight	0.648 ± 0.44		
Normal	0.789 ± 0.52		
Overweight	1.146 ± 0.72	5.173	*0.006
BMI for Age			
Underweight	0.791± 0.42		
Normal	0.781 ± 0.53		
Overweight	1.293 ± 0.65	2.234	0.084
Obese	0.699 ± 0.40		
Height for Age			
Stunting	0.654 ± 0.27		
Normal	0.813 ± 0.42		
Above + 2 Z scores	0.815 ± 0.20	2.500	0.083

Table 5: Serum Selenium Levels across Anthropometric Characteristics of Children
F; F-Statistic, P-Value < 0.05 Indicates Significance

4. Discussion

The mean serum selenium level in this study was low, but the concentration was significantly higher in private schools than in public schools. There is no data on the selenium concentration of school age children in Nigeria, but studies from other parts of the world showed higher mean concentration in Ethiopia[7], Vietnam[18] and NE Slovenia.[19]

The prevalence of 36.5% for selenium deficiency in this study population was high which could be a reflection of their diet. Selenium deficiency was more in public schools than private schools. This value is higher than a prevalence rate of 11.4% found in the healthy control group of a comparative hospital-based study in Enugu[20] but lower than 48%[21] and 62%[7] in similar cross-sectional studies in Zimbabwe and Ethiopia respectively. This difference is likely due to the type of study design, study population, geographical location and cut-off points that define selenium deficiency in the various studies. A similar study in primary school children from Northeast Thailand[22] found out that none of the pupils had selenium deficiency, probably due to sufficient selenium in their diet.

No significant correlation exists between sex and serum selenium levels in the study population. This is similar to most studies with no variations in selenium levels correlated with sex.[21,23-25] According to the type of schools, the concentration was found to be significantly higher in girls than boys in private schools. This finding in private school is in consonance with results from Iran[26] and Turkey[27] which also showed that girls had higher serum selenium concentration than boys.

Selenium has been shown to increase with age from several studies.[19,22,23,28] This is in contrast to what was observed in this study where selenium concentration was found to be significantly higher in younger age group. This may be due to preferential feeding of younger children with selenium rich foods like organ meats and dairy products.

Selenium concentration has a negative correlation with family size of the study population. This agrees with findings from other studies where children from small family size have higher serum concentrations of selenium compared with those from large family size.

Serum selenium concentration was positively correlated with socio-economic status (SES) in the study population. Children from higher socio-economic status had higher concentration of selenium.

Serum selenium has a positively correlation with overweight and a negative correlation with stunting. There was a significant positive correlation between serum selenium and weight for age in public and private schools. Serum selenium also increases with an increase in BMI for age. This is similar to findings in Ethiopia[7] who reported a significant association between selenium and anthropometry in the studied population but different from several other studies where there were no significant differences.[18,20,21]

5. Conclusion

The prevalence of selenium deficiency in this study was 36.5% with higher concentration level among private schools than the public schools.

Prevalence of stunting is 8.8% which is higher than other forms of malnutrition.

Socio-demographic factors like age, sex, family type, the family size and socio-economic class significantly affect selenium levels in school age children. There is a negative correlation between age, family size and socio-economic class with selenium level. There is a positive correlation between BMI-for age and serum selenium level and a negative correlation with underweight and stunting.

6. References

i. Greenbaum LA. (2007). Micronutrient Mineral deficiencies. In: Kliegman RM. Behrma RE. Stanton BF. Jenson H, editor. (265–266) Nelson Textbook of Pediatrics. 18th ed. Philadelphia: Elsevier Inc.
ii. Unicef. (2009) Micronutrients. Food and Nutrition Bulletin.
iii. Boma GO, Anthony IP, Mukoro DG, Abaiola E, Andrew F, Daniel MD, et al. (2014) Nutritional Status of Children in Rural setting. IOSR J Dent Med Sci.; 13:41–47.
iv. Sunil PC. Malnutrition among primary school children in Hyderabad. (2014) Andhra Pradesh, India. Int J Tech Res Appl.; 2:36–39.
v. Hesham MS, Edariah AB, Norhayati M. (2005) Intestinal parasitic infections and micronutrient deficiency: a review. Med J Malaysia, 59:284–293.
vi. Alfieri MA, Leung FY, Grace DM. (1998) Selenium and zinc levels in surgical patients receiving total parenteral nutrition. Biol Trace Elem Res, 6 :33–39.
vii. Amare B, Moges B, Fantahun B, Tafess K, Woldeyohannes D, Yismaw G, et al. (2012). Micronutrient levels and nutritional status of school children living in Northwest Ethiopia. Nutr J, 11:1–8.
viii. Negm FF, Soliman DR, Ahmed ES, Elmasry RA. (2016). Assessment of serum zinc, selenium, and prolactin concentrations in critically ill children. Pediatr Health Med Ther, 7:17–23.
ix. Rayman MP. (2000). The importance of selenium to human health. Lancet, 356:233–241.
x. Misra S, Kwong RW, Niyogi S. (2012). Transport of selenium across the plasma membrane of primary hepatocytes and enterocytes of rainbow trout. J Exp Biol, 215:1491–1501.
xi. Kupka R, Msamanga GI, Spiegelman D, Rifai N, Hunter DJ, Fawzi W et al. (2005). Selenium levels in relation to morbidity and mortality among children born to HIV-infected mothers. Eur J Clin Nutr, 59:1250–1258.
xii. Rayman MP.(2012). Selenium and human health. Lancet, 379:1256–1268.
xiii. Abah RO, Okolo SN, John C, Ochoga MO. (2015). Prevalence of Zinc Deficiency Among School Children in a Rural Setting in North-Central Nigeria. Int J Public Health Res, 3:214–217.
xiv. Ibeawuchi A, Onyiriuka A, Abiodun P. (2017) High Prevalence of Zinc Deficiency in Rural Nigerian Preschool Children: A Community-Based Cross Sectional Study. Rom J Diabetes Nutr Metab Dis, 24:031–039.
xv. Babalola O, Anetor J, Adeniyi A. (2003)Assessment of Selenium Status of Healthy Adults in South Western Nigeria. ASSET Ser A, 3:111–120.
xvi. https://oyostate.gov.ng/ogbomoso-north-local-government/ Assessed on 16/08/2017.
xvii. De Onis M. (2008) The new WHO child growth standards. Paediatria Croatica Supplement, 2:13–17.
xviii. Nhien NV, Khan NC, Yabutani T, Ninh NX, Chung L, Motonaka J, et al. (2008) Relationship of low serum selenium to anemia among primary school children living in rural Vietnam. J Nutr Sci Vitaminol, 454–459.
xix. Micetić-Turk D, Turk Z, Radolli L. (1996) Serum selenium values in healthy children aged 1-18 years in NE Slovenia. Eur J Clin Nutr, 50:192–194.
xx. Ubesie A, Ibe BC, Emodi IJ, Iloh KK. (2017) Serum selenium status of HIV-infected children on care and treatment in Enugu, Nigeria. South African J Child Health, 11:21.
xxi. Kuona P, Mashavave G, Kandawasvika GQ, Dzangare J, Masanganise M, Chandiwana P, et al. (2014) Serum Selenium Levels and Nutritional Status of School Children from an HIV Prevention Programme in Zimbabwe. J Trop Dis Public Health, 2:134.
xxii. Krittaphol W, Bailey KB, Pongcharoen T, Winichagoon P, Thomson C, Gibson RS. (2006) Primary school children from northeast Thailand are not at risk of selenium deficiency. Asia Pac J Clin Nutr, 15:474–481.
xxiii. Muntau AC, Streiter M, Kappler M, Röschinger W, Schmid I, Rehnert A, et al. (2002) Age-related Reference Values for Serum Selenium Concentrations in Infants and Children. Clin Chem, 48:555–560.
xxiv. Safaralizadeh R, Pourpak Z, Moin M, Zare A, Teimourian S. (2005) Serum concentration of Selenium in healthy individuals living in Tehran. Nutr J, 4.
xxv. Gashu D, Stoecker BJ, Bougma K, Adish A, Haki GD, Marquis GS. (2016). Stunting, selenium deficiency and anemia are associated with poor cognitive performance in preschool children from rural Ethiopia. Nutr J, 15:1–8.
xxvi. Safaralizadeh R, Sirjani M, Pourpak Z, Kardar G, Teimourian S, Shams S et al. (2007) Serum selenium concentration in healthy children living in Tehran. Biofactor, 31:127–131.
xxvii. Mengübaş K, Diab NA, Gökmen IG, Ataman OY, Çavdar A, Cin Ş. (1996). Selenium status of healthy Turkish children. Biol Trace Elem Res, 54:163–172.
xxviii. Rükgauer M, Klein J, Kruse-Jarres JD. (1997). Reference Values for the Trace Elements Copper, Manganese, Selenium, and Zinc in the Serum / Plasma of Children, Adolescents, and Adults. J Trace Elem Med Biol, 11:92–98.