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Emerging High Iodine Levels Among Primary School Children: The South-East Nigeria Experience

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Abstract
Background: *Iodine is essential for the synthesis of thyroid hormones; its deficiency is a serious public health challenge and the commonest cause of thyroid disorders in Africa. Both insufficient and excessive intake of iodine are associated with thyroid diseases.*
Objective: *The aim of this study was to assess the iodine status of primary school children in Nnewi, South-East Nigeria.*
Materials and Methods: *This was a cross-sectional study involving 346 pupils from 12 primary schools in Nnewi, South East Nigeria using two-staged and simple random sampling methods. Their sociodemographic characteristics were obtained using self-administered questionnaires. Urine iodine concentrations were determined with the Sandell-Kolthoff reaction. Data were analyzed using Statistical Package for Social Sciences (IBM SPSS Statistics) version 21. Level of significance for tests of association was set at 5%.*
Result: *There were 158 males and 188 females giving a male to female ratio of 1:1.2. Subjects aged six to nine years constituted 58.4% of the study population. The median urinary iodine concentration of the pupils was 138µg/L and this was adequate. Prevalence of high urinary iodine concentration (UIC) was 28.3% while that of iodine deficiency was 1.7%. Pupils attending private schools had high UIC.*
Conclusion: *There is a double burden of high UIC and iodine deficiency in the study region. There is need for a nationwide survey on the median urinary iodine concentrations of school children and iodine concentrations of their household salt and food items. Also, fight against iodine deficiency should continue.*
Keywords: *Iodine status, school age children, iodine deficiency, high urinary iodine concentration.*

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I. Introduction

Iodine is vital for synthesis of thyroid hormones.[1] Fetal neurodevelopment relies on optimal level of maternal thyroxine.[2,3]Iodine deficiency is a huge public health problem and the commonest cause of thyroid disorders in Africa.[4] It impairs cognition and physical development in school age children (SAC).[5] Conversely, excessive iodine intake is associated with iodine-induced hypothyroidism, iodine-induced hyperthyroidism and autoimmune thyroid disorders.[6] Despite the inauguration of Universal Salt Iodization(USI) program as many as 25 countries are iodine-deficient while 14 countries have iodine excess.[7]

The need for this study arose because studies in previously goiter-endemic regions of Nigeria now report excess UIC. [8,9] Nnewi is not known to be in the goiter belt but it still participates in the USI program. Its inhabitants may be inadvertently exposed to excess iodine as there are no published data on their iodine status. The latest national survey on Median Urinary Iodine Concentration (MUIC) of SAC in Nigeria was in 2004 with a MUIC of 130µg/L which might not be the true picture now.[10] Nigeria has also failed to cover for IDDs in its budget. [11,12] SAC were chosen because the adverse effects of Iodine Deficiency Disorders (IDDs) and iodine excess if detected early in them could be amenable. [13–15] Measurement of UIC is a reliable means of assessing current iodine status because iodine is excreted mostly via urine and MUIC of SAC represents that of their community. [16–18]

The aim of this study was to assess the iodine status of primary school children in Nnewi, South-East Nigeria and its relationship with some sociodemographic factors. This study identified children who were iodine-deficient and those with elevated UIC and appropriate interventions were initiated.

II. Materials And Methods

Study Design: This was a cross-sectional study carried out in Nnewi, South-East Nigeria.

Study Location Nnewi is the biggest industrial city in Anambra State and it has four large quarters: Otolo, Uruagu, Nnewi-ichi and Umudim.[19] It has two seasons; rainy season from March to October and dry season from November to February. With a high annual rainfall, some areas suffer from the effects of leaching and erosion.[19] Nnewi was selected for this study because there was no data on the iodine status of its population before or after the inauguration of the USI program.

The inclusion criteria were;

1. Children aged 6-12 years as at their last birthday.
2. Children that have lived in Nnewi for at least 5 year.
3. Children whose parents gave consent.

The exclusion criterion:

Children with dehydration signs were excluded because dehydration erroneously increases the concentration of iodine in urine.

Ethical approval was obtained from the Research Ethics Committee of Nnamdi Azikiwe University Teaching Hospital, Nnewi (Ref No: NAUTH/CS/66/VOL.10/25/2017/032). Permission was also obtained from the Anambra state Commissioner for Education and Nnewi North Local Government Education Authority before the commencement of the study (Ref No: MOE/ESD/ASUBEB/VOL.1/7).

Sample size: 360 Pupils

Sample size calculation: The sample size of 360 was obtained after calculation, accepting 0.78 as the proportion of children with subnormal urine iodine levels obtained from a similar study, margin of error of 5%, confidence interval of 95% and adjustment for non-response rate of 33.4%. [20–22]

Study duration: Between October and December, 2017, 360 participants were selected using two-staged and simple random sampling techniques.

Subjects & selection method:

The most recent population data of primary school children was obtained from the Planning, Research and Statistics Department of the Nnewi North Zonal offices of the Anambra State's Ministry of Health and the State Primary Education Board. It showed that there were 42,670 pupils in Nnewi, of which 29,869 pupils were in private schools and 12,801 pupils were in public schools. There were 115 private and 48 public primary schools registered in Nnewi, a ratio of approximately 2:1. Therefore, one public school and two private schools were selected from each of the four villages in Nnewi for a total of 12 schools.

Stage 1: Selection of participating schools; Primary Schools in Nnewi were stratified into government-owned and private-owned primary schools. Three schools (one government-owned and two private-owned) were selected by balloting from each of the four large villages in Nnewi. Twelve schools were selected (four government-owned and eight private-owned).

Stage 2: Selection of the participants for the study; the total number of primary school pupils in the 12 schools selected was 2,873, the sample size of 360 pupils represented 12.5% of this population. To give each child equal opportunity of being recruited, 12.5% of each school's population (Ne) was enrolled. To determine the number of pupils to be taken from each class in a particular school, the total number of pupils to be enrolled (Ne) per school was divided by 6 and the end result Np was the number pupils recruited from each class. For those classes with subclasses such as primary 1A,1B etcetera, a simple random sampling technique was used to select the participating class. The total number of students in a class was divided by Np to obtain the sampling interval (K). The first participant was selected randomly while the remaining participants were chosen systematically by selecting every Kth name after the first participant using the class register.

Data collection: Information on socio-demographics was obtained from the parents using self-administered questionnaires. Socioeconomic class was determined by using the Oyedeji's social classification indices which is based on parents' occupation and highest level of education.[23] Spot urine samples were obtained from those pupils whose parents signed the informed consent form. A brief physical examination was carried out looking out for features of iodine deficiency or excess such as (dry skin, periorbital edema, goiter) and dehydration signs. Thyroid size was determined using the traditional method of inspection and palpation. Goiter classification was done according to the WHO grading for goiter.[18]

Urine iodine testing: Spot urine samples were obtained from the pupils using labeled, clean plastic containers with snug-fitted lids under the supervision with a chaperone if need be. The containers were placed on ice packs immediately and sent to the laboratory where they were refrigerated. Samples were analyzed within 24 hours. Method A (Sandell-Kolthoff reaction) for measuring urinary iodine using ammonium persulfate was employed as recommended by WHO/UNICEF/ICCIDD.[18] The WHO cut-off points for UIC were used to interpret the results.

Data entry and analysis:

Fourteen pupils who could not provide urine samples were excluded from the study leaving 346 participants. Data was analyzed using the IBM Statistical Package for the Social Sciences (SPSS®) software version 21.0 for Windows.Descriptive statistics was used to identify the median, interquartile range and standard deviation of continuous variables such as urine iodine concentrations. One-sample Kolmogorov-Smirnov test was used to test for the normality of the distribution of urine iodine concentrations. Data was stratified by level of UIC, age, sex and socio-economic class to search for influencing factors. Categorical variables (age group, sex, socioeconomic class, type of school, place of residence) were tested for association with iodine status using Chi-Square test and Fisher's exact test where applicable. After bivariate analysis, logistic regression analysis was carried out to identify factors associated with iodine excess.

III. Results

Three hundred and forty-six pupils participated, there were158 (45.7%) males and 188 (54.3%) females with a male to female ratio of 1:1.2. Adolescents (aged between 10 and 12 years) constituted 41.6% of the enrolled participants. Majority of the participants were from the middle socioeconomic class (54.9%). The private school participants were 228 (65.9%), while public school participants were 118 (34.1%) in number, giving a ratio of private school participants to public school participants of 1.9:1. Otolo residents had the highest number of participants (34.7%), while Nnewichi had the least number of participants (16.2%) (Table 1).

Table 1: Iodine status and its relationship with some selected sociodemographic variables

VARIABLES	FREQ (%) N= 346	Urinary Iodine Concentration (%)			P_d	P_h	X^2_d	X^2_h
		Deficient <100µg/dl	Adequate 100-199µg/dl	High >199µg/dl				
Gender								
Males	158 (45.7)	3(1.9)	105(66.5)	50(31.6)	1.000†	0.201	-	1.638
Females	188 (54.3)	3(1.6)	137(72.9)	48(25.5)				
Age group								
6-9 years (younger children)	202 (58.4)	2(1)	134(66.3)	66(32.7)	0.414†	0.042□	-	4.130
10-12 years (adolescents)	144 (41.6)	4(2.8)	108(75)	32(22.2)				
Place of residence								
Otolo	120 (34.7)	3(2.5)	87(72.5)	30(25)	0.833†	<0.01□	1.225	27.280
Umudim	97 (28.0)	2(2.0)	83(85.6)	12(12.4)				
Uruagu	73 (21.1)	0(0)	39(53.4)	34(46.6)				
Nnewichi	56 (16.2)	1(1.8)	33(58.9)	22(39.3)				
Socioeconomic class								
Upper class	103 (29.8)	2(1.9)	66(64.1)	35(34)	0.729†	0.238	0.693	2.865
Middle class	190 (54.9)	4(2.1)	139(73.2)	47(24.7)				
Lower class	54 (15.3)	0(0)	37(68.5)	16(31.5)				
Type of school								
Private	228 (65.9)	2(0.9)	143(62.70	83(36.4)	0.237†	<0.01□†	-	20.516
Public	118 (34.1)	4(3.4)	99(83.9)	15(12.7)				

* =statistically significant; X^2_d =chi-sq value for iodine deficiency; X^2_h =chi-sq value for high IUC
P_d = P-value for iodine deficiency; P_h =P-value for high IUC; †= *p*-value for Fisher's exact test.

The general prevalence of iodine deficiency was 1.7% while 28.3% had high UIC. Urine iodine concentrations were not normally distributed, with a range of 75µg/L to 300µg/L and a MUIC of 138.0µg/L.Among the iodine-deficient children, the minimum MUIC was 75µg/L, the maximum MUIC was 95µg/L and the MUIC was 83µg/L. Among pupils with high UIC was a minimum UIC of 200µg/L, a maximum UIC of 300µg/L and a MUIC of 230µg/L. (Table 2)One child had a visible goiter thus giving a Total Goiter Rate (TGR i.e., percentage of school age children with palpable or visible goiter) of 0.3%.

Table 2:Overview of iodine status of the subjects

Iodine status	Frequency	Percentage	UIC (µg/L)		
			Minimum	Maximum	Median (IQR)
Deficient	6	1.7	75	95	83 (78.8, 89.8)
Adequate	242	69.9	100	199	128 (120.0, 142.5)
High	98	28.3	200	300	230 (210.0, 250.0)

IQR = Interquartile range (25th, 75th percentile)

Younger children had a significantly higher prevalence of high UIC (32.7%) than the older children (22.2%). {x^2=4.130, p= 0.042} (Table 1)The differences in the prevalence of iodine deficiency observed across some sociodemographic variables particularly; SEC, type of school and place of residence, were not statistically significant unlike the differences observed among those that had high UIC.Pupils attending private schools had a higher prevalence of high UIC (36.4%) than those in public schools (12.7%) and this difference was statistically significant (x^2=20.516, p<0.01).

With respect to the place of residence, those that reside at Uruagu had the highest prevalence of high UIC (46.6%) whereas, Umudim residents had the least prevalence (12.4%). These observations were statistically significant {x^2=27.280, p<0.05}.

Although the upper SEC had the highest prevalence of high UIC when compared to other SEC classes this was not statistically significant (p>0.05) (Table 1).

On multivariate analysis, significant factors with high odds for high UIC were the type of school {OR = 3.540, p< 0.05} and the place of residence {for Uruagu, OR = 2.427, p< 0.05; for Umudim, OR = 0.374, p< 0.05}.Private school pupils were approximately four times more likely to have high UIC than their public-school counterparts. Also, pupils living in Uruagu were approximately two times more likely to have high UIC than those living in Otolo, whereas pupils living in Umudim were less likely to have high UIC compared to those living in Otolo.The odds of having high UIC were not significantly higher among the younger children (6-9 years), males or pupils living in Nnewichi (Table 3).

Table 3:Adjusted odds ratio for high UIC and some sociodemographic variables.

Variables		Odds ratio	OR CI	*P* value
Age group	6 - 9 years	1.298	0.750 - 2.246	0.352
	10 - 12 years (R)	1	-	-
Gender	Male	1.153	0.690 - 1.928	0.588
	Female (R)	1	-	-
Type of school	Private	3.540	1.832 - 6.840	< 0.01*
	Public (R)	1	-	-
Place of residence	Uruagu	2.427	1.260 - 4.673	0.008*
	Nnewichi	1.266	0.616 - 2.602	0.522
	Umudim	0.374	0.175 - 0.798	0.011*
	Otolo (R)	1	-	-

R = Reference category, OR = Odds ratio, CI = Confidence interval; * = statistically significant

IV. Discussion

This study showed that MUIC of pupils in Nnewi, Southeast Nigeria was 138µg/L, there was no data concerning the iodine status of this community prior to this study. Prevalence of iodine deficiency was 1.7% while TGR was 0.3%. The fact that as many as 28.3% of the pupils had high UIC is of public health concern.

There are varying levels of MUIC in different parts of Nigeria, MUIC in this study was lower than that reported in Akwa Ibom (187.5µg/L) by Alozie *et al*, [24] but higher than the MUIC reported by Nwamarah *et al*,[25] in Okpuje, Nsukka LGA, Enugu state (124.7µg/L). These differences in MUIC may be because of varying iodine levels in household salt/food consumed by the pupils. Prevalence of severe iodine deficiency in Nnewi was zero, the same result was reported in Nsukka LGA of Enugu state [25] and Urue Offong/Oruko LGA of Akwa Ibom state,[24] this indeed is a remarkable feat for Nigeria. However, a study by Abua *et al*,[26] reported that 75% of the SAC in Boki and Ikom LGAs of Cross River State were iodine deficient with up to 23% of the study population being severely iodine deficient, with a MUIC of 65µg/L, which differs with this study and others.[24,25] This difference in the former is probably due to poor household iodized salt coverage (72 to 75.5%) identified unlike the studies at Enugu and Akwa Ibom with household iodized salt coverage of 94.4% and 96.1% respectively.[24,25]

Remarkably, three out of ten pupils (28.3%) had UICs exceeding the optimal range of 100-199µg/L indicating that they could be at risk of hyperthyroidism, autoimmune thyroiditis, hypothyroidism and goiter.[27] This finding is consistent with some studies done in Nigeria which also reported high prevalence of excess or above adequate UIC.[8,9,28] High prevalence of excess UIC was also noted in a Somalian study however, this was linked to high iodine levels in ground water because household salt iodization coverage in Somalia was remarkably low.[29] In Korea, very high prevalence of excess UIC (66%), though in pre-SAC, was linked to sea weed consumption.[30]

There was no significant difference in iodine status with respect to age. Anyiam *et al*[28] in Kaduna also reported that age had no influence on the UIC. However, Als *et al*[31] observed that Swiss adolescents had a significantly higher prevalence of moderate to severe iodine deficiency compared to younger children, this was attributed to the higher intake of milk and its products by the younger children compared to the adolescents. Most studies in Nigeria did not search for age-related influence on iodine status.[8,9,21,25]

Gender had no significant influence on urine iodine status in this study, though males were noted to have a higher prevalence of both iodine deficiency and excess. Nwamarah *et al*[25] in Enugu and Anyiam *et al*[28] in Kaduna had similar reports. However, Wiersinga *et al*[32] and Gur *etal*[33]reported a higher prevalence of iodine deficiency among females in the Netherlands and Istanbul respectively. In the Netherlands it was attributed to differences in their dietary habits (males consumed more bread and milk than females). Earlier onset of puberty in the females and the attendant increase in metabolic demand, may also be contributory to the higher prevalence of iodine deficiency observed among the females.

Iodine status of the subjects was observed to differ with respect to place of residence, this difference was particularly significant for children with high UIC. Pupils that reside in Uruagu had the highest prevalence and were two times more likely to have high UIC compared to those living in Otolo, whereas Umudim residents were less likely to have high UIC compared to Otolo residents. These findings could be due to differences in iodine content of ground water or crops grown in those areas. This finding is consistent with that of Nwamarah *et al*[25] in Nsukka, Enugu State where Ibagwa community had a higher prevalence of iodine deficiency compared to Orba community, this was not due to differences in salt iodine content obtained from these communities because the proportion of households consuming adequately iodized salt was unexpectedly higher in Ibagwa than in Orba.[34] The findings by Gur *et al*[33] in Turkey is also in accord with the above finding because the rate of iodine deficiency was higher in children living on the European side of Istanbul than those on the Anatolian side of Istanbul, this result may have been due to the low iodine content of water and/or crops in the European side of Istanbul as the study also showed that use of iodized salt had no significant effect on the prevalence of iodine deficiency. However, a Swiss study by Al *et al*[31] reported that place of residence (rural/urban) had no influence in UIC and they attributed it to the fact that the study was conducted in an industrialized area, a similar finding may not be obtained in a developing country.

The type of school a child attended was a significant factor that influenced the iodine status of the child, private school pupils were four times more likely to have highUIC than their public-school counterparts. Public school pupils had a higher prevalence of iodine deficiency though this association was not significant. Children that attend private schools are more likely to eat balanced meals than those that attend public schools.[35] This finding was in keeping with the study by Hynes *et al*[36] where it was also demonstrated that private school pupils had higher UICs compared to public school pupils.

Surprisingly, socioeconomic class had no significant association with iodine status of the pupils. Hynes *et al*[36] and Skeaff *et al*[37] also made similar observations in Tasmania and New Zealand respectively, the former considered parental literacy level and occupation as indices for the SEC while the latter did not show details on how the SEC was derived. Gur *et al*[33] reported that maternal literacy level (one of the determinants of the SEC by Oyedeji[23]), monthly family income and number of persons per household were significantly associated with iodine status. The SEC indices used in the current study did not factor in monthly family income, a factor that may determine the family's capacity to assess adequate nutrition.

This study established that although Nnewi, Southeast Nigeria is an iodine-sufficient population, there is a double burden of both high UIC and iodine deficiency. While some are at risk of the deleterious effects of iodine excess, few may have subtle negative impact on their cognition and development because of iodine deficiency.

V. Conclusion

This study showed that there were more children with UIC above the normal range. Three out of ten pupils had high UIC and are therefore at risk of developing thyroid disorders and/or malignancies, this is of public health concern. Therefore, it is imperative that the Nigerian government conducts a nationwide survey on MUIC of its citizens because the last nationwide survey was conducted more than a decade ago. Iodine levels in household salt should also be determined to ensure that it does not exceed WHO recommendations. Meanwhile, the fight against IDDs should continue because some children were still iodine deficient albeit mild.

Conflict of interest
All authors declare no conflict of interest.

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Authorship
All authors contributed significantly to this work and fulfilled the criteria for authorship as stipulated by the journal. All authors contributed substantially to the concept and design of the work, analyses, interpretation of results, critical manuscript revision for intellectual content and approval of final version. CMA acquired data and analyzed. CMA, JCE, IE, JCE and UVC contributed to conceptualization and design, data clean up and manuscript development.

References

[1]. LaFranchi S, Huang S. A. Thyroid development and physiology. In: Kliegman R, Stanton B, St.Gene J, et al. (eds) Nelson Textbook of Paediatrics. Philadelphia: Elsevier Inc., 2016, pp. 2663–4.
[2]. de Escobar G, Obregon M, del Rey F. Maternal thyroid hormones early in pregnancy and fetal brain development. Best Pr Res Clin Endocrinol Metab. 2004; 18(2): 225–248.
[3]. Williams G. Neurodevelopmental and neurophysiological actions of thyroid hormone. J Neuroendocr. 2008; 20(6): 784–94.
[4]. Tsegaye B, Ergete W. Histopathologic pattern of thyroid disease. East Afr Med J. 2003; 80(10): 525–8.
[5]. de Benoist B, Burrow G, Delange F, et al. Introduction. In: de Benoist B, Burrow G, Schultink W (eds) Assessment of Iodine Deficiency Disorders and Monitoring their Elimination. Geneva: WHO press, 2007, pp. 1–5.
[6]. Laurberg P, Pedersen IB, Carle A, et al. The u-shaped curve of iodine intake and thyroid Disorders. In: Preedy VR, Burrow GN, Watson RR (eds) Comprehensive Handbook of Iodine: Nutritional, Biochemical, Pathological and Therapeutic Aspects. San Diego: Elsevier, 2009, pp. 449–55.
[7]. Iodine Global Network. Global scorecard of iodine nutrition in 2019 in the general population based on school-age children (SAC), https://www.ign.org/cm_data/Global_Scorecard_2019_SAC.pdf (2019).
[8]. Onyeaghala A, Anetor J, Nurudeen A, et al. Assessment of urinary iodine status of primary school children in Saki, in South Western Nigeria. Bull Environ Pharmacol Life Sci. 2012; 1(5): 05–09.
[9]. Onyeaghala A, Anetor J, Nurudeen A, et al. High urinary iodine content among primary school children in Ibadan, Nigeria, a public health concern. J Toxicol Env Health Sci. 2010; 2(7): 93–96.
[10]. Iodine global network. Global scorecard of iodine nutrition. *IGN* 2016; 1–4.
[11]. Senator Udoma Udo Udoma. Overview of the 2016 budget and the strategic implementation plan for 2016 budget of change. Federal Republic of Nigeria. 2016; 1–19.
[12]. de Benoist B, Burrow G, Delange F, et al. Indicators of sustainable elimination of IDD. In: de Benoist B, Burrow G, Schultink W (eds) Assessment of Iodine Deficiency Disorders and Monitoring their Elimination. Geneva: WHO Press, 2007, pp. 52–54.
[13]. Zimmermann M, Connolly K, Bozo M, et al. Iodine supplementation improves cognition in iodine-deficient school children in Albania; a randomized, controlled, double-blind study. Am J Clin Nutr. 2006; 83(1): 108–14.
[14]. Van den Briel T, West C, Bleichrodt N, et al. Improved iodine status is associated with improved mental performance of school children in Benin. Am J Clin Nutr. 2000; 72(5): 1179–85.
[15]. Gordon R, Rose M, Skeaff S, et al. Iodine supplementation improves cognition in mildly iodine-deficient children. Am J Clin Nutr. 2009; 90(5): 1264–71.
[16]. Gibson R. Assessment of iodine and selenium. In: Gibson R (ed) Principles of Nutritional Assessment. New York: Oxford University Press, 2005, pp. 749–796.
[17]. DeMaeyer E, Lowenstein F, Thilly C. The control of endemic goiter, http://apps.who.int/iris/bitsream/10665/40085/1/9241560606 eng.pdf (1979, accessed 24 May 2016).
[18]. de Benoist B, Burrow G, Delange F, et al. Indicators of impact. In: de Benoist B, Burrow G, Schultink W (eds) Assessment of Iodine Deficiency Disorders and Monitoring their Elimination. Geneva: WHO Press, 2007, pp. 28–43.
[19]. Nnewi North, http://en.wikipedia.org/wiki/Nnewinorth (accessed 28 October 2016).
[20]. Charan J, Biswas T. How to calculate sample size for different study designs in medical research. Indian J Psychol Med. 2013; 35(2): 121–126.
[21]. Nwamarah J, Okereke E. A pilot study of iodine and anthropometric status of primary school children in Obukpa, a rural Nigerian community. J Public Health Epidemiol. 2012; 4(9): 246–252.
[22]. Kurth B, Kamtsiuris P, Holling H, et al. The challenge of comprehensively mapping children's health in a nation-wide health survey: design of the German KiGG-Study. BMC Public Health. 2008; 4(8): 196.
[23]. Oyedeji G. Socio-economic and cultural background of hospitalized children in Ilesha. Nig J Paediatr. 1985; 12(4): 111–7.

[24]. Alozie Y, Assi A, Alozie G. Iodine status of school-aged children in Urue-Ofong/Oruko Local Government Area of Akwa Ibom State. Nig J Nutr Sci. 2012; 33(1): 42–5.
[25]. Nwamarah J, Otitoju O, Emewulu C. Iodine and nutritional status of primary school children in a Nigerian community Okpuje, in Nsukka LGA, Enugu state, Nigeria. Pharm Lett. 2015; 7(7): 271–80.
[26]. Abua S, Ajayi O, Sanusi R. Adequacy of dietary iodine in two local government areas of Cross River state in Nigeria. *Pak J Nutr* 2008; 7(1): 40–3.
[27]. Soriguer F, Guitterez-Repisco C, Gonzalez-Romero S, et al. Iodine concentration in cow's milk and its relationship with urinary iodine concentrations in the population. Clin Nutr. 2011; 30(1): 44–48.
[28]. Anyiam O, Ogurinde G, Raji T, et al. Urinary iodine levels, goiter rates and intelligence quotient in primary school children in Giwa Local Government Area of Kaduna State, Nigeria. J Obes Metab Res. 2015; 2(3): 135–139.
[29]. Kassim I, Moloney G, Busili A, et al. Iodine intake in Somalia is excessive and associated with the source of household drinking water. J Nutr. 2014; 44(3): 375–81.
[30]. Lee J, Kim JH, Lee SY, et al. Iodine status in Korean preschool children as determined by urinary iodine excretion. Eur J Nutr. 2014; 53(2): 683–8.
[31]. Als C, Keller A, Minder C, et al. Age- and gender-dependent urinary iodine concentrations in an area-covering population sample from Bernese region in Switzerland. Eur J Endocrinol. 2000; 143(5): 629–37.
[32]. Wiersinga W, Podoba J, Srbecky M, et al. A survey of iodine intake and thyroid volume in Dutch school children: reference values in an iodine-sufficient area and the effect of puberty. Eur J Endocrinol. 2001; 144(6): 595–603.
[33]. Gur E, Ercan O, Can G, et al. Prevalence and risk factors of iodine deficiency among school children. J Trop Paed. 2003; 49(3): 168–71.
[34]. Madukwe E, Ani P, Maduabuchi A. Iodine content of household salt and urinary iodine of primary school pupils in commercial towns in Nsukka senatorial zone, Enugu state, Nigeria. Pak J Nutr. 2013; 12(6): 587–593.
[35]. Ugochukwu E, Onubogu C, Edokwe E, et al. Nutritional contents of lunch packs of primary school children in Nnewi, Nigeria. Ann Med Health Sci Res. 2014; 4(Suppl2): S108–S114.
[36]. Hynes K, Blizzard C, Venn A, et al. Persistent iodine deficiency in a cohort of Tasmanian school children: associations with socio-economic status, geographical location and dietary factors. Aust N Z J Public Health. 2004; 28(5): 476–80.
[37]. Skeaff S, Thomson C, Wilson N, et al. A comprehensive assessment of urinary iodine concentration and thyroid hormones in New Zealand school children: a cross-sectional study. Nutr J. 2012; 11: 31.

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