

URINARY IODINE LEVELS OF PRIMARY SCHOOL CHILDREN IN ILORIN, NIGERIA

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Abstract: Background: Iodine deficiency is one of the commonest micronutrient deficiencies. Globally, it is the commonest cause of preventable mental retardation and also associated with impaired physical growth. The current iodine nutrition of school children in Ilorin, North-Central Nigeria is not known.

Objective: The study aimed to determine the urinary iodine levels (UIL) of school children in Ilorin and explored the relationship with socio-demographic variables.

Methods: This cross-sectional study was carried out among primary schools children in Ilorin, Nigeria. We recruited school children aged 6-12 years through a multi-staged sampling method. Relevant data including socio-demographic variables were obtained with a pretested study proforma. The recruited school children had urinary iodine determined using the Sandell-Kolthoff method. Data analysis was with Statistical Package for Social Sciences version 20.0.

Results: The median with interquartile range (IQR) of urinary iodine level was 117.2 (99.6-148.6) µg/L. Of the 480 recruited children, 336 (70.0%) had normal urinary iodine levels while 144 (25%) had mild iodine deficiency and two (0.4%) had excess urinary iodine levels. Pupils with iodine deficiency was higher among public schools than those in private schools (33.3% vs 23.6%, $\chi^2 = 150.149$, $p < 0.022$). The median UIL of the age-group 6-9 years was higher than the 10-12 year age group ($p = 0.026$). However, the median UIL values were comparable across gender, socioeconomic strata and mother's educational level.

Conclusions: This study showed that a quarter of the children still had mild iodine deficiency despite salt

iodisation policy adopted by the country. Also, the iodine levels were not influenced by socio-demographics.

Key words: Urinary iodine, Primary school children, Ilorin, Nigeria.

INTRODUCTION

Malnutrition remains an important public health concern in the developing countries with micronutrient deficiency accounting for 7% of the global disease burden (1). Globally, iodine deficiency is one of the commonest micronutrient deficiencies (2). Severe iodine deficiency causes stunted physical growth and it is the commonest cause of preventable mental retardation (3, 4).

Globally, about two billion people, most of whom are domiciled in the Sub-Saharan Africa and South Asia have inadequate iodine intake (3, 5). One third of these are school-aged children; and nearly half of these children live in West Africa (3, 5). Iodine deficiency has been previously reported in different parts of Nigeria, including Ilorin, Kwara State, the present study site (6, 7, 8).

The World Health Organisation (WHO) introduced the universal salt iodisation to curb this menace, and recommends that the iodine nutrition of a population be monitored at least once every ten years using the urinary iodine levels (UIL) of school-aged children in that population as an indicator (5, 9). This is in order to evaluate the iodisation programme in that population.

Urinary iodine determination is a cheap, easy and effective way of measuring body iodine. About 90% of absorbed iodine is excreted by the kidneys; therefore its urinary level is a sensitive bio-marker of current iodine intake (5). On the other end of the spectrum is exces-

sive iodine nutrition, which may lead to iodine-induced hyperthyroidism(IIIH) (4). This has been reported in some African countries including Nigeria due to consumption of excessively iodised salt (3, 6, 10, 11, 12).

The ongoing salt iodisation program in Nigeria and the WHO recommendation of frequent monitoring of the iodine nutrition of a populace makes its imperative to frequently sample school children for their iodine levels in the developing countries where iodine deficiencies are more prevalent. Furthermore, the earlier study conducted in Ilorin about two decades ago showed a high prevalence of iodine deficiency, and the current status of iodine levels in the school children is unknown. Hence, the need for the generation of more recent data on the iodine levels of school-aged children in Ilorin. This study therefore, aimed to determine the urinary iodine levels of school-aged children in Ilorin, Kwara State, Nigeria, and explore the relationship between UIL and socio-demographics.

METHODS

We carried-out a cross-sectional descriptive study between February 8th 2016 and May 13th 2016 in 16 primary schools; 3 public and 13 private schools (with proportionate representation of public and private schools) in Ilorin West Local Government Area of Ilorin, Kwara State, North-Central region of Nigeria. Ilorin West LGA has 260 registered primary schools: 55 public and 205 private primary schools Ilorin City lies in the Precambrian Basement complex of northern Nigeria and is underlain by rock of metamorphic and igneous type, therefore prone to iodine deficiency (13). The minimum sample size required for the study was estimated using the Cochran's formula; $[n = (z^2 pq) / d^2]$, and used a prevalence of iodine deficiency of 56.3% previously reported in Nigeria (14) at a tolerable margin of error of 5%.

The participants were selected through a multi-staged sampling technique using the school list obtained from the State Ministry of Education. Schools were stratified into public and private. Proportional allocation was used to select the number of public to private schools used based on the calculated ratio of public to private schools in the LGA. i.e 55:205 =1:4. Therefore, 3 public and 13 private schools were selected.

A table of random numbers was then used to select 3 public and 13 private schools sampled based on their serial numbers on the school register from the Ministry of Education. This was done separately for the public and private schools. The number of children selected in each primary school was obtained by dividing the total number of pupils to be recruited (calculated sample size = 411) by the total number of schools (16) to be sampled in Ilorin West LGA. For easy recruitment of subjects, 30 pupils were recruited from each selected pri-

mary school in Ilorin West LGA. In each selected primary school, the pupils were stratified into their classes (basics 1-6) and pupils were recruited from each class. The number of children selected from each class was calculated by dividing the total number of children to be selected from that school by 6 (representing 6 classes from basics 1 to 6). Thus, 5 children were recruited from each class in the selected primary school in Ilorin West LGA. In a situation where there was more than one arm in a class, simple random (by balloting) method was used for the selection of a single arm of the class which formed the sampling frame. In each class, using the class register, the pupils were stratified based on their sex; and the ratio of the boys to girls in the class was determined. Proportional allocation was then used to determine the number of boys and girls to be recruited in the class based on their ratio. Simple random sampling by balloting was used to select the required number of boys and girls to make a total of 5 pupils recruited in each class.

Semi-structured questionnaires were used to obtain relevant history and socio-demographic information from the parents of the participants. A total of 480 primary school pupils were recruited into the study; 90 from public and 390 from private primary schools.

Children aged 6-12 years who were apparently healthy and whose parents gave consent were included in the study, while children with cardiac arrhythmias on amiodarone, an iodine containing drug; children with hyperthyroidism on antithyroid drugs such as propylthiouracil, carbimazole and methimazole; and children whose parents / guardians did not give informed consent were excluded from the study.

Parental educational level and occupation was used to calculate the child's social class using adapted Oyedjeji (15) classification into upper, middle and lower classes. Ten millilitre (10 ml) of Spot urine samples were collected from the pupils into clean universal bottles with the lid tightly screwed and transported in ice-packs to the Chemical Pathology Laboratory of the University of Ilorin Teaching Hospital (UIITH) where they were kept in the refrigerator at 2-8 °C till analysis. Samples were pooled and analysed in batches.

Urinary iodine was tested using the Sandell-Koltkoff method. It is based on the Sand-ell-Kolthoff reaction which measures the rate of colour disappearance of ceric ammonium sulphate in urine that is digested with ammonium persulfate. Ceric ammonium sulfate (which is yellow) was reduced to the cerous form (which was colourless), and the reaction was catalysed by iodide. The rate of colour disappearance, as measured by a spectrophotometer determined the iodine content of urine. A standard curve plotted during the analysis was used to extrapolate the concentration of iodine in the urine samples (9, 16).

Urinary iodine level below 100 µg/L was classified as iodine deficiency, levels between 100 and 199 µg/L as sufficient iodine nutrition, those ranging between 200 and 299 µg/L as more than adequate iodine nutrition while levels above 300 µg/L as excessive iodine nutrition (5, 9).

Ethical consideration

Ethical clearance (with reference number UITH/CAT/189/19A/342) was obtained from the Ethics and Research Committee of the University of Ilorin Teaching Hospital. Approval was sought from the Kwara State Ministry of Education and Head Teachers of the selected schools. Parental consent was sought from the parents of the selected pupils and the informed consent form was signed by them. In addition, assent was sought from children 10 years and older.

Data analysis

Data collected on the study pro forma was analyzed using the IBM Statistical Package for Social Sciences (SPSS)[™] version 20.0 for windows. Frequency distribution tables were generated. Urinary iodine level (UIL) was not normally distributed and was therefore represented as median with interquartile range (IQR). Mann-Whitney-U test was used to compare me-

dian values of UIL and Kruskal-Wallis test was used when comparing more than two sets of median UIL. Student t-test was used to compare means of normally distributed continuous variables. Differences between proportions of categorical variables were evaluated using the Chi-square test or the Yates continuity corrected Chi square. The confidence level was set at 95% and level of significance at $p < 0.05$.

RESULTS

Socio-demographic characteristics of the study participants

A total of four hundred and eighty (480) children were enrolled from sixteen primary schools in Ilorin West LGA. The mean \pm standard deviation (SD) age of the study participants was 8.6 ± 1.8 years. Two hundred and thirty-eight (49.6%) of the children were males and 242 (50.4%) were females, with a male: female (M:F) ratio of 1:1. Regarding the highest educational qualification, 76% of the subjects had mothers with at least a Senior School Certificate (SSCE); only 6.9% of the subjects had mothers with no formal education. The other socio-demographic parameters are as shown in Table 1.

Among the pupils recruited in this study, 7.9% were from households that bought salt from unpackaged and

Table 1. Socio-demographic characteristics of the pupils

Variable	Frequency (N = 480)	Percentage	Cumulative percent
Age group (years)			
6-9	319	66.5	66.5
10-12	161	33.5	100.0
Sex			
Male	238	49.6	49.6
Female	242	50.4	100.0
Educational Status of Father			
Post-secondary	198	41.3	41.3
Secondary	203	42.3	83.6
Primary	61	12.7	96.2
No Formal Education	18	3.7	100.0
Educational Status of Mother			
Post-secondary	130	27.0	27.0
Secondary	235	49.0	76.0
Primary	82	17.1	93.1
No Formal Education	33	6.9	100.0
Ethnicity			
Yoruba	417	86.9	86.9
Igbo	28	5.8	92.7
Hausa	4	0.8	93.5
Others	31	6.5	100.0
Social class			
High (class I & II)	269	56.0	56.0
Middle (class III)	165	34.4	90.4
Low (class IV & V)	46	9.6	100.0

Table 2. Characteristics of salt consumed by study participants

Variable	Frequency (N = 480)	Percentage
Salt Packaging		
Sealed Nylon	436	90.8
Loose in bowls	38	7.9
In Jute/woven sacks	6	1.3
Storage of salt		
Nylon	65	13.5
Tightly closed container	393	81.9
Open container	17	3.5
Sacks	5	1.1
Awareness about salt iodization		
Yes	358	74.6
No	122	25.4
Utilisation of iodized salt (n = 358)		
Yes	261	72.9
No	97	27.1
Look out for iodine in ingredient list		
Yes	210	43.8
No	270	56.2

Table 3. Urinary iodine status of study participants

Iodine level	Frequency (N = 480)	Percent
Mild deficiency	122	25.4
Normal	334	69.6
Above normal	22	4.6
Excess urinary iodine	2	0.4

Severe iodine deficiency: UIL = 0-19 µg/L, Moderate iodine deficiency: UIL = 20-49 µg/L, Mild deficiency: UIL = 50-99 µg/L, Normal iodine level: UIL = 100-199 µg/L, Above normal iodine level: UIL = 200-299 µg/L, Excess urinary iodine: UIL: >300 µg/L

Table 4. Comparison of iodine nutrition across the public and private schools

Variable	Total N=480	Private n = 390	Public n = 90	U or χ^2	p value
UIL (Fg/L)					
Median	117.2	117.2	116.8	16734.000 ^U	0.392
Inter-quartile range	99.6-148.6	101.4 – 149.3	88.4 – 147.3		
UIL group					
Mild deficiency	122 (25.4)	92 (23.6)	30 (33.3)	8.244 ^y	0.041
Normal	334 (69.6)	283 (72.6)	51 (56.7)		
Above normal	22 (4.6)	14 (3.5)	8 (8.9)		
Excess	2 (0.4)	1 (0.3)	1 (1.1)		

U: Mann Whitney U test; y: Yates corrected chi square; UIL: Urinary iodine level

Table 5. Relationship between the median urinary iodine level of participants and their socio-demographic features

Variable	UIL		
	Median (IQR)	U or K	p value
Age group (years)			
6–9	117.2 (101.4–153.6)	22490.500 ^U	0.026
10 -12	115.7 (94.2 – 138.2)		
Sex			
Male	122.0 (101.4 – 150.4)	26759.500 ^U	0.180
Female	117.2 (97.9– 144.7)		
Educational Status of Father			
Post-secondary	117.2(100.9-152.7)	2.012 ^K	0.570
Secondary	117.2(99.6-148.6)		
Primary	117.2(101.4-137.7)		
No formal Education	114.2(83.5.9-139.5)		
Educational Status of Mother			
Post-secondary	117.2(97.9-155.4)	0.612 ^K	0.894
Secondary	117.2(102.2-138.1)		
Primary	117.2(99.6-147.3)		
No formal Education	124.2(100.5-150.5)		
Ethnicity			
Yoruba	117.2(99.6-149.3)	1.196 ^K	0.754
Igbo	115.6(104.4-130.1)		
Hausa	106.9(91.6-146.7)		
Others	117.2(94.2-153.6)		
Social class			
High (class I & II)	115.7 (94.2 – 153.6)	0.591 ^K	0.744
Middle (class III)	122.0 (102.2 – 141.6)		
Low (class IV&V)	123.7 (102.2 – 148.6)		

IQR: Inter-quartile range; U: Mann Whitney U test; K: Kruskal Wallis test; UIL: Urinary iodine level

loose in bowls while 1.3% bought salt in jute sacks. Three hundred and ninety-three (81.9%) pupils belonged to households that stored their salt in tightly closed containers, while 3.5% left them in open containers. Three hundred and fifty-eight (74.6%) of the participants had parents that had heard about salt iodisation, and of these, only 72.9% use iodised salt. This is as shown in Table 2.

The median (inter-quartile range) urinary iodine level of the study population was 117.2 (99.6-148.6) µg/L. Three hundred and thirty-four (69.6%) of the total population screened had normal urine iodine level (UIL) while 122 (25.4%) children had mild iodine deficiency as shown in Table 3. None of the pupils had moderate or severe iodine deficiency.

Although the median UIL of both school populations were comparable, significantly higher number of pupils in the public schools had mild iodine deficiency than those in the private schools (33.3% VS 23.6% $\chi^2 = 150.149$, OR 1.8, 95% CI 1.088 to 3.009, $p = 0.022$). Other details are shown in Table 4.

Comparing the median urinary iodine level of the school children across the different age groups, there was a significant difference between age and urinary iodine level as shown in Table 5. The median UIL of the age-group 6-9 years was statistically higher than the 10-12-year age group ($p = 0.026$). The median UIL values were comparable across the socio-economic strata, ethnicity and the different levels of father's and mother's education.

DISCUSSION

Twenty five percent of the study participants had iodine deficiency (mild -UIL between 50 and 99 µg/l). The 25.4% prevalence of iodine deficiency in this study is similar to the findings during the year 2001 national study that reported a prevalence of iodine deficiency as 28% in the State of the present study (8). This may mean that the iodine nutrition has not changed over the years in the State despite the country's iodisation policy. Also, it may be due to the fact that some of

the study participants were from households that still bought salt in loose, unpackaged forms and large porous woven sacks which are much cheaper. Iodine is very volatile and may evaporate from iodised salt especially when exposed to heat and moisture or stored in porous or open containers (9). Furthermore, the current UNICEF data on salt iodisation estimates that only 3 out of 4 households in the world used iodised salt (17). The above factors may have contributed to the mild iodine deficiency seen among the children in this present study.

This study also showed the number of children with mild iodine deficiency was higher among children that attended public schools. This probably reflects the fact that the children in private schools are better nourished than those in public schools. Also, the children from public schools are more likely to come from poorer homes that consume non-iodised salt or salt sold in unpackaged loose forms.

The median UIL (of 117 $\mu\text{g/l}$) in this study was much different from the findings in Saki which recorded 285 $\mu\text{g/l}$, a value that is within the 'above normal UIL' range; but similar to the 124 $\mu\text{g/l}$ recently reported in Nsukka, South-East, Nigeria (6, 18). Furthermore, the 69.6% prevalence of adequate UIL in this study was much higher than the 8.3% and 41% previously reported by Nwaramah et al (14) in Enugu and Augustine (6) in Saki, from South-Eastern and South-Western parts of Nigeria respectively. The difference in prevalence recorded in this study may be because Ilorin, unlike Enugu and Saki, is not in the goitre belt of Nigeria (19).

This study also found that less than 1% of the children had urinary iodine level above 300 $\mu\text{g/l}$. This is suggestive of excess iodine nutrition. The prevalence of excessive iodine level in this study is very much lower than the 50% and 67% reported in South-west Nigeria (6, 12). This suggests that Ilorin populace is not presently at risk of IIH but regular monitoring the UIL of the populace is pertinent to prevent IIH. The low prevalence of excess UIL in this study may also be because Ilorin populace is not in the goitre belt of Nigeria; IIH occurs in populations which previously had chronic iodine deficiency (9).

Comparing the median UIL across the different age groups, the 6 to 9 year olds had the highest median value, while the 10-12 year olds had the least value. Amor et al (20) in India had earlier documented variation of UIL with age, although contrary to this study, he reported increasing UIL values with age. The possible reason for the decrease in iodine with increasing age recorded in this study may be the increased need for iodine for growth in this age-group, which marks the beginning of the adolescent years and growth spurt.

The findings in this study were consistent with the findings of Alozie et al (7) in Akwa-Ibom, South-south

Nigeria and Skeaff et al (21) in New Zealand who reported no gender variation in UIL of population studied. This is however contrary to the findings from Enugu in South-east and Cross-River state in South-south Nigeria that reported more cases of iodine deficiency in boys than girls (14, 22). The reason for no gender variation with UIL reported in this study is unclear but could possibly be that households that use iodised salt for general cooking do so without prejudice to both genders in the households.

The median UIL in the present study population was comparable across the different socio-economic strata. This might be due to availability and usage of iodised salt by majority (72.9%) of households, in the community this study was carried out. This is in agreement with earlier studies by Skeaff (21) in New Zealand and Volzke (23) in Germany but contrasts Low (24) in Malaysia, who reported variations in UIL in subjects across different socioeconomic classes.

CONCLUSION

This study showed that a quarter of the children still have mild iodine deficiency despite the salt iodisation policy adopted by the country. Iodine deficiency was more marked in public schools than in private schools. Also, the urinary iodine levels were not influenced by socio-demographics.

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AUTHOR CONTRIBUTION

Y.T.O., O.O.A., R.R.O and S.K.E designed research; Y.T.O, E.D.A and S.A.B. conducted research; Y.T.O and A.O analyzed data; and Y.T.O, A.O and R.M.I. wrote the paper. Y.T.O had primary responsibility for final content. All authors read and approved the final manuscript.

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Sažetak

NIVO JODA U URINU KOD DECE OSNOVNIH ŠKOLA U ILORINU, NIGERIJ

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Uvod: Deficit joda je jedna od najčešćih deficita mikronutritijenata. Ovaj deficit je najčešći uzrok preventivne mentalne retardacije, ali je takođe i povezan sa poremećajem fizičkog rasta. Zastupljenost joda u ishrani kod dece u Ilorinu, Severno-centralnoj Nigeriji do sada nije poznata.

Cilj: Studija ima za cilj da utvrdi nivo joda u urinu (UIL) kod dece školskog uzrasta u Ilorinu i ispita vezu sa sociodemografskim varijablama.

Metod: Ova studija je izvedena kod učenika osnovnih škola u Ilorinu, Nigeriji. Uključena su deca uzrasta 6-12 godina, a raspoređena su pomoću multi-stage metode. Relevantni podaci koji su uključivali sociodemografske varijable bili su uzeti sa prethodno sprovedenim pretestom. Metoda Sandell-Kolthoff je korišćena za utvrđivanje nivoa joda u urinu. Analiza podataka sprovedena je koristeći Statistički paket za Društvene Nauke verzija 20.0.

Rezultati: Medijana sa interkvartalnim opsegom (IQR) urinarnog nivoa joda bila je 117.2 (99.6-148.6)

µg/L. Od 480 dece uključene u studiju, 336 (70%) imalo je normalan nivo joda, dok je 144 (25%) imalo osrednju deficijenciju joda, dvoje dece (0.4%) imalo je povišene vrednosti joda u urinu. Nedostatak joda je bio učestaliji kod dece, koja su pohađala državne osnovne škole od dece koja su pohađala privatne osnovne škole (33.3% vs 23.6%, $\chi^2 = 150.149$, $p < 0.022$). Medijana UIL starosne grupe 6-9 godina je bila veća nego kod grupe od 10-12 godina ($p = 0.026$). Bilo kako bilo, medijana UIL vrednosti je bila uporediva između polova, socioekonomskih stratuma, kao i nivoa edukacije majki dece.

Zaključak: Ova studija je pokazala da četvrtina dece i dalje ima osrednji nedostatak joda, uprkos zakonu o obogaćivanju voda i namirnica jodom. Takođe, na vrednosti nivoa joda nisu uticale sociodemografski podaci.

Ključne reči: jod u urinu, deca osnovnih škola, Ilorin, Nigerija.

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