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Household Salt Iodisation Level and Urinary Iodine Concentration of Children Attending Public Primary Schools in Zaria, Northwest Nigeria

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Abstract

Iodine deficiency is related to a spectrum of diseases collectively referred to as iodine deficiency disorders. It is a risk factor for the growth and development of up to 2.2 billion people living in iodine deficient environment in 130 countries of the world. This cross sectional study aimed at determining the household salt iodization level and the urinary iodine concentration and prevalence of iodine deficiency in 400 randomly selected pupils (6 - 12 years) attending public primary schools in Zaria, North-western. Approximately 15 g salt (three teaspoons) was collected from each of the 400 students. Casual urine samples were obtained from a sub sample of the students (n -100) using sterile containers in the morning hours. Standard methods were used to determine the concentration of iodine in the salt and urine samples. Results show that all the salt samples contained iodine, 96% were iodized within the recommended level (≥ 15 mg/kg), and only 4% had iodine content that were below the recommendation. Urinary iodine concentration revealed that 78% of the respondents were deficient in Iodine. None was severely deficient while 63%, 15% were mildly and moderately deficient respectively. Also, 1% were at risk of Iodine induced hyperthyroidism, while only 21% had adequate Iodine concentration. The mean and median urinary iodine concentration were 82.08 ± 35.71 μg/L and 72.31 μg/L respectively. The respondents in this study had access to iodised table salt. However, more than half of the population were moderately and mildly iodine deficient.

Keywords: *Salt; Urine; Iodine; Pupils; School*

Introduction

Iodine (atomic weight: 126.9 g/mol) is present in the upper crust of the earth as a trace element. The effects of glaciation, flooding and leaching into soil during the Ice Age have led to the variable geographic distribution of iodine. As a result of these natural forces, iodine accumulation is found mostly in coastal areas, and the most common sources of dietary iodine are seaweed and other sealife [1]. Additional sources of dietary iodine include iodized salt (due to the addition of iodine to table salt as a public health measure), dairy foods (due to the iodophor cleansers of milk cans and teats) and bread dough (due to the use of iodate as bread conditioners) [1,2].

Iodine is an essential micronutrient required for the synthesis of thyroid hormones, the most important of which is thyroxine [3]. It's deficiency is related to a spectrum of diseases collectively referred to as iodine deficiency disorders, IDDs [4]. In the early stages of life, iodine deficiency retards brain development by preventing foetal brain from establishing sufficiently dense cell networks. It leads to low academic test scores, reduced mental capacity and mental retardation later in early life [5,6]. Other effects include abortions, stillbirths, congenital abnormalities, impaired physical development, goitre and endemic cretinism [6,7]. Compared to other population segments, pregnant mothers and school children are the most vulnerable groups for iodine deficiency [8,9].

Iodization of salt has proven to be an effective and sustainable long-term public health measure for the prevention of IDDs [10]. Although, much has been achieved in the area of universal salt iodization [11,12] in the sub-Saharan Africa and Nigeria in particular, iodine deficiency continues to be of public health importance in some communities [13,14]. An earlier study have indicated that northern Nigeria is an area of endemic goiter [15].

Nigeria achieved over 95 percent level of salt-iodisation from 1998 to 2004 [12], however, since Universal Salt Iodisation (USI) certification in 2005 and the formal recognition of the efforts of the Nigerian government in 2007 at the Global Micronutrient Forum, financial support for the program to combat iodine deficiency disorders (IDD) decreased on the part of the government and donors [12]. Hence, the usual monitoring of iodised salt at the factory, wholesale, retail and household levels became irregular and sporadic [16,17].

Added to this, is the inadequate documentation of the iodine status of school age children in Nigeria and specifically children from northern Nigeria with the highest level of undernutrition as recorded in the Nigeria Demographic and Health Survey report [18]. Therefore, against this background was this study conceived to assess the progress been made regarding consumption of iodized salt in households in Zaria, Kaduna state.

Materials and Methods

Study area

The study was conducted in the ancient city of Zaria (11°04'N 7°42'E), comprising two local government Areas of the 23 in the state.

Sample size

The sample size was obtained using the formula outlined by FAO [19].

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

q = 1 – p

p = Anticipated prevalence (50%)

d = Desired precision = 0.05

z = Value for standard normal deviate = 1.96

n = Sample size.

Ethical consideration and informed consent

Ethical clearance was obtained from the ethical board of Ahmadu Bello University Zaria. Written permission was collected from the Zonal Education Board and State Ministry of Education in Zaria. Permission of the School Principals of selected schools was obtained. Informed consent from the parents/guardian of the children was sorted before being enlisted in the research.

Sampling

The list of all the public primary schools in Zaria was obtained from the Ministry of Education Zonal office, they were stratified into wards, four wards were randomly selected and four schools were also randomly selected from the list of schools in the wards. 400 children aged 6 – 12 years were then randomly selected from the list of registered students in the schools.

Sample collection

Approximately 15g salt (three teaspoons) was collected from each of the 400 students. Casual urine samples were obtained from a sub sample of the students (n - 100) using sterile containers in the morning hours. The Salts and the urine samples were then transported to the Food and Nutrition Laboratory, Dept. of Biochemistry, ABU Zaria in an iodine-free container, which was tightly sealed by means of a plastic zip and placed in a thick paper envelope for laboratory analysis. Urine samples were kept at 4°C in a refrigerator until analysis.

Determination of iodine concentration in salt samples

Salts samples were analyzed for Iodine by Iodometric titration procedure of Mannar and Dunn [20].

The method involved the use of sulphuric acid to liberate iodine from the iodated salt and potassium iodate to solubilize the free iodine. The salt solution was titrated with freshly prepared standardized sodium thiosulphate solution where starch solution was used as end-point indicator. After analysis, the salt samples were classified according to their iodine levels [21].

Determination of iodine concentration in urine samples of respondents

Urinary Iodine Concentration was determined using the Sandell - Kolthoff Ammonium persulfate digestion procedure of Dunn., *et al.* [22].

It involves the spectrophotometric measurement of iodine. Iodine catalyses the reduction of yellow ceric (IV) ions to colourless cerous (III) ions by arsenic (III). The colour change that occurs during the reaction is used to determine Iodine concentration. The course of the reaction is followed by the disappearance of the yellow colour of cerium (IV) as it is reduced. With all other reactants held constant, the rate of reaction is directly proportional to the amount of Iodide catalyzing the reaction.

Classification of respondents urinary iodine concentration

The urinary iodine concentration of the respondents were classified using reference ranges of WHO, UNICEF, ICCIDD [23].

Median Urinary Iodine (μg/L)	Iodine intake	Iodine nutrition
< 20	Insufficient	Severe iodine deficiency
20 - 49	Insufficient	Moderate iodine deficiency
50 - 99	Insufficient	Mild iodine deficiency
100 - 199	Adequate	Optimal iodine nutrition
200 - 299	More than adequate	Risk of iodine-induced hyperthyroidism within 5 - 10 years following introduction of iodized salt in susceptible groups
≥ 300	Excessive	Risk of adverse health consequences (iodine induced hyperthyroidism, auto-immune thyroid diseases)

Statistical analysis

Data was analyzed using SPSS version 20. Results are presented in percentages except where otherwise stated.

Results

Iodization level of salts used in households of pupils attending public primary schools in Zaria, Kaduna State

The level of iodization of the salts used in the various households of the respondents is shown in figure 1. The result indicates that all the salt samples contained iodine, 96% of the samples were iodized within the recommended level (≥ 15mg/kg), and only 4% had iodine content that were below the recommendation.

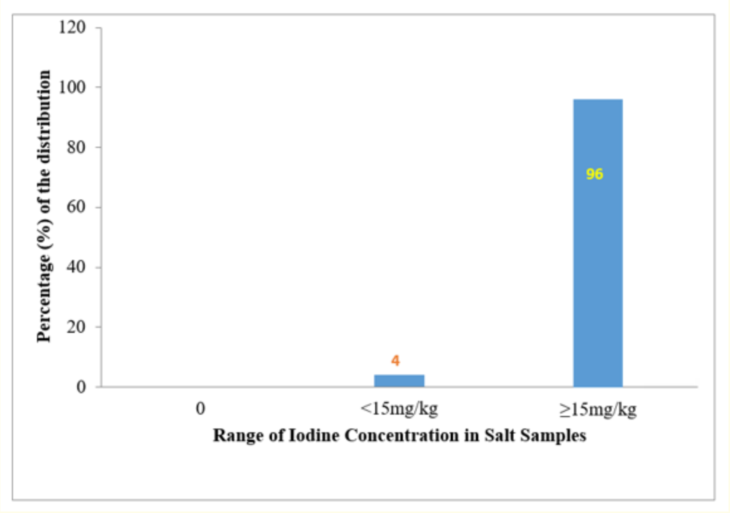

Figure 1

Iodine status of pupils attending public primary schools in Zaria, Kaduna State

The Iodine status (based on urinary Iodine concentration) of the respondents is presented in figure 2. The result clearly shows that 78% of the respondents were deficient in Iodine. None was severely deficient while 63%, 15% were mildly and moderately deficient respectively. Also, 1% were at risk of Iodine induced hyperthyroidism, while only 21% had adequate Iodine concentration.

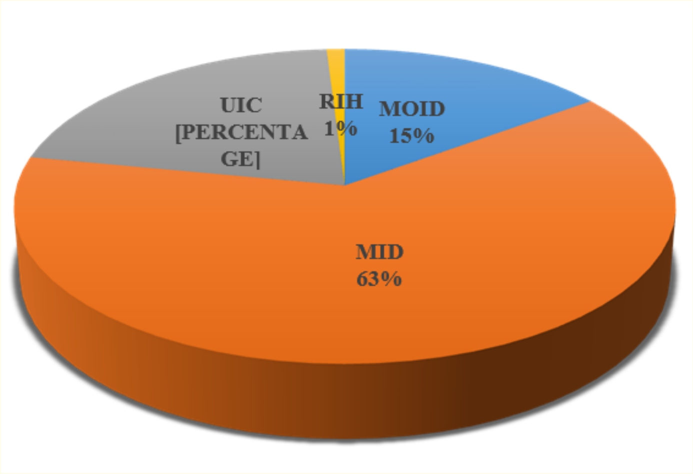

Figure 2: *Distribution of Respondents by Iodine Status.*

MID: Moderate Iodine Deficiency; MLD: Mild Iodine Deficiency; OIC: Optimal Iodine Concentration;

RIH: Risk of Iodine-induced Hyperthyroidism in Susceptible Group.

Mean and median urinary iodine concentration of pupils attending public primary schools in Zaria

The mean and median urinary Iodine concentration of the respondents is presented in table 1. The results indicates 82.08 ± 35.71 μg/L and 72.31 μg/L as the mean and median concentrations.

Parameter	Value
Mean Urinary Iodine Concentration	82.08 ± 35.71 μg/L
Median Urinary Iodine Concentration	72.31 μg/L

Table 1: *Mean and median urinary iodine concentration of pupils attending public primary schools in zaria. Value for first parameter is mean ± standard deviation.*

Discussion

In 1992, Standard Organization of Nigeria (SON) mandated that all food grade salt be iodized with 50 ppm potassium iodide at packaging stage, and revised with inclusion of 30 ppm at distributor and retail levels, and > 15 ppm iodine at household level [24,25]. Report show that Nigeria achieved this mandate within a few years [26-28]. This present study carried out more than two decades after the initiation of universal salt iodization in Nigeria has revealed that monitoring of compliance to this mandate is still ongoing as 96% of the salt samples were iodized at 15 mg/kg and greater. None of the samples were devoid of iodine and the 4% samples with less than 15 mg/kg could have been due to the storage method practiced by the households, as iodine in salt is usually lost when exposed to air. Furthermore, all the households in this study had access to iodized salt, this could be attributed to the awareness campaign still ongoing about the need for consumption of iodized salt. This result is in agreement with the report of Kulwa., *et al.* [6] who determined the iodine status of school age children in Tanzania. It however contrasted with the report of Madukwe., *et al.* [29] who reported that only 58.30% and 70% of household salts were iodized at ≥15 μg/ L in a study carried out in two commercial towns in Enugu State, Nigeria.

Urinary iodine concentration is a marker of very recent dietary intake [6,30]. School children in addition to being a vulnerable group, are representatives of the current state of iodine deficiency in an area and are a major priority for prompt correction of iodine deficiency [31,32]. In this study, 78% of the school children are iodine deficient (mild deficiency: 63%, moderate deficiency: 15%) thus indicating that the children in this study area are at risk of developing iodine deficiency disorders. Mild iodine deficiency impairs cognition in children, and moderate to severe iodine deficiency in a population reduces intelligent quotient (IQ) by 10 - 15 points [33,34].

Furthermore, data from other studies indicate that children from iodine-deficient areas have poorer school performance and lower intelligence quotients than children from non-iodine - deficient populations [32,35]. Although, most of the respondents are from households with access to salts iodized at recommended levels, this observed deficiencies in iodine nutrition could be attributed possibly to the consumption of goitrogen containing foods that are known inhibitors of iodine absorption. Foods like sweet patatoe, millet, sorghum and cabbage are predominantly grown in Northern Nigeria, these foods are also rich in goitrogens. Also, a number of the respondents with this deficiency could be from the households whose salt samples contained iodine that were less than the recommendation (< 15 μg/ L). Additionally, it is possible that the school children in this study area are also deficient in other micronutrients like iron. Studies show that high prevalence of iron deficiency among children in areas of endemic goitre may reduce the effectiveness of iodized salt programs [36-38]. Deficiencies of iron and iodine often co-exist in children in regions of West and North Africa [39]. The result obtained in this study agrees with the reports of Kulwa., *et al.* [6] where 90% of the school children who participated in their study in Tanzania had iodine deficiency (mild deficiency: 40%, moderate deficiency: 42%, severe deficiency: 8%). Umenwanne and Akinyele [32] also reported that 90% of the children in their study in Enugu State, Nigeria, had severe to moderate forms of iodine deficiency, and 10% had mild deficiency.

A few of the respondents (1%) were at risk of developing iodine-induced hyperthyroidism, as their iodine level were more than optimal this could probably be attributed to excess intake of iodized salt added to consumption of iodine from other dietary sources, or use of some medications. Only 21% of the respondents had optimal iodine concentration, this could be attributed to the cooking practices, storage method of salt, quantity and frequency of consumption of foods prepared with iodized salt, and the state of well-being of the respondents.

Median urinary iodine concentration (UIC) has been widely applied as an indicator of the iodine status of a given population [40]. The median Iodine concentration from this study (72.31 μg/L) indicated that the study population were mildly iodine deficient when compared to the reference range; UIC 50 - 99 μg/L [23]. This reveals that even though severe deficiency was absent, mild deficiency accounted for more than half of the deficiencies recorded (63%), with moderate deficiency at 15%, this points to the fact that beyond the advocacy for consumption of iodized salts, the need to determine other underlying factors that could interfere with elimination of iodine deficiency in this population group and devise strategies/policies on how to combat them is paramount.

Conclusion

Households in this study area has access to iodized salt, however, there was a high prevalence of iodine deficiency as more than half of the respondents (78%) were mildly and moderately deficient.

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Conflict of Interest

The authors declare no conflict of interest.

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