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A COMPARATIVE ANALYSIS OF THE RELATIONSHIP BETWEEN THE CONCENTRATION OF IODINE IN HOUSEHOLD SALT AND IODINE DEFICIENCY AMONG PREGNANT WOMEN IN A TERTIARY INSTITUTION IN SOUTHERN NIGERIA

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ABSTRACT

Introduction: *Iodine is required for the synthesis of thyroid hormones and is mostly absorbed through the diet. Pregnant and lactating mothers, women of reproductive age and children under the age of two are the populations most vulnerable to iodine deficiency disorders.*

Material and Methods: *This was a hospital-based comparative study that assessed the efficacy and coverage of the Universal Salt Iodization Program by measuring salt iodine concentration and urinary iodine concentrations in pregnant women and non-pregnant women of reproductive age by using structured questionnaires as well as testing urine and salt samples for iodine concentration. Data were analyzed using the statistical package for social sciences version 25.0.*

Results: *In both arms of the study, the prevalence of iodine deficiency was 100%. None of the salt samples analyzed contained adequate iodine (15-40 ppm). The mean, median, and modal salt iodine level among pregnant and non-pregnant respondents was 0.48ppm (Range 0.044-0.052ppm).Mild iodine deficiency was observed in 57.1% of non-*

pregnant participants and 34.4% of pregnant participants. The median urinary iodine concentration (UIC) in pregnant women was 42.87ug/l, while it was 52.33ug/l in non-pregnant women.

Conclusion: *None of the salt analyzed contained adequate iodine levels; however, pregnant women who had the knowledge and consumed iodized salt had higher UICs. Iodine levels in salt samples were unrelated to the respondents' iodine status.*

Keywords: *Iodine, Pregnancy, Deficiency, Port Harcourt, Nigeria*

INTRODUCTION

Iodine is essential for the synthesis of thyroid hormones and it is mainly absorbed from the diet.[1] The daily requirement of iodine in an average adult is 150ug,[2] this increases by more than 50% in pregnancy (250ug).[3] Iodine was the first micronutrient found to be essential to man and it is relevant to health at all stages of life..[1,4] However, one-third of the world's population still suffers from iodine deficiency.[5,6] Pregnant women and lactating mothers are most susceptible to the effects of iodine deficiency and this may be passed on to the babies with dire consequences.[6] Iodine deficiency is of public health importance, as it is the leading cause of preventable neurodevelopmental impairment in children globally.[5,7,8] The population most susceptible to iodine deficiency disorders are pregnant and lactating mothers, women of reproductive age, as well as children under 2 years of age..[6,7,9] Iodine deficiency appears to be higher in Rivers State than in some other states in Nigeria.[10,11] However, the neurodevelopment abnormalities caused by iodine deficiency in pregnancy can be corrected by the administration of supplemental iodine in the first or second trimester of pregnancy.

The hormonal changes and metabolic demands of pregnancy place a burden on the thyroid gland. To meet these demands, the thyroid gland modifies its biochemistry to increase its hormonal output, thereby increasing its demand for iodine. Thyrotropin receptors are stimulated by human chorionic gonadotrophin, resulting in an exponential release of thyroid-stimulating hormone (TSH).[12,13] This combined with an increase in estrogen levels during early pregnancy, causes an increase in thyroxine-binding globulin levels, increasing maternal thyroid hormone production. As a result, the thyroid gland's demand for iodine increases.[12,13] This increased hormonal output persists till term.

In recent years, there has been much interest in the need for iodine-containing multi-nutrient supplements in pregnancy in both developed and developing countries and in iodine-replete and iodine-deficient regions. The WHO recommends iodine supplementation during pregnancy only in countries with inadequate universal salt iodization (USI) coverage.[14] Between 2003 and 2011, the number of iodine-deficient countries reduced from 54 to 32 and the number of iodine-replete countries increased from 67 to 105.[15] Nearly 150 countries with different degrees of iodine deficiency are implementing universal salt iodization to eliminate iodine deficiency disorders (IDD). As a result, many countries have achieved or are on the brink of achieving IDD elimination.[8,16,17]

There is a paucity of data on iodine deficiency and the need for supplementation, especially in high-risk populations such as pregnant women, lactating mothers, women of reproductive age, and children under the age of two.[18–20] Most of the data used as a representation of the entire population comes from studies done in school-age children, whose daily iodine requirement is much lower than that of these high-risk populations (90-120ug compared to 150-249ug in pregnant women and 290ug in lactating women), and assessment of iodine deficiency is made in these populations from a median urinary iodine concentration of less than 100ug/l, while less than 150ug/l signifies iodine deficiency in pregnancy.[15,21]

Rivers State is of particular interest because its biosphere has been ravaged by oil exploration activities in the state, resulting in the destruction of biological life in farmlands and the marine environment. Hence, the study aimed to assess the degree of salt iodization in household salt and also the prevalence, pattern, and severity of iodine deficiency amongst women in the reproductive age group and pregnant women in this region. This is to evaluate the need for the supplementation of iodine in pregnant women attending antenatal clinics at the University of Port Harcourt Teaching Hospital.

MATERIALS AND METHOD

Study Area

This study was carried out at the Obstetrics and Gynaecology Department of the University of Port Harcourt Teaching Hospital (UPTH). The University of Port Harcourt Teaching Hospital is an 884-bed hospital located at Alakahia in Obio Akpor Local Government Area of Rivers State, South-South Nigeria. UPTH is a tertiary health institution that renders all levels of health care services for Rivers, Bayelsa, Delta, Imo, Abia, Akwa-Ibom states and beyond.

Study Population

The concentration of iodine in a household salt and urinary iodine concentration was measured in two subgroups of the population: pregnant women and non-pregnant women of reproductive age at the University of Port Harcourt Teaching Hospital in Rivers State.

The coverage of the Universal salt iodization program and the proportion of these populations consuming adequately iodized salt were used to determine their iodine exposure. The iodine content of household salt in the study population was measured to assess the adequacy of salt iodization.

This study included all pregnant women in all trimesters of pregnancy, as well as all non-pregnant women of reproductive age who lived in communities within the state for more than a year and gave consent for the study, while pregnant or non-pregnant women with previously diagnosed thyroid disease or visibly enlarged thyroid glands, or on iodine-containing medication or anti-thyroid medications, pregnant or non-pregnant women who have lived outside Rivers state for more than a year, pregnant or non-pregnant women with obstetric, gynaecological, renal, hepatic, or metabolic medical illnesses that may affect iodine status or thyroid function, and those who refused to give consent were all excluded from the study.

Sample Size and Sampling Method

The minimum sample size for this study was calculated using the formula for measuring significant differences in proportions between two groups,[22]

$$n = (u+v)^2(p1(100-p1) + p2(100-p2)) / (p1-p2)^2$$

where;

n = Sample size for each group.

p_1 = Proportion in first study group

p_2 = Proportion in second study group

v = percentage point on the normal distribution corresponding two-sided significance level. (It is 5%, therefore, v = 1.96).

u = the one-sided percentage point on the normal distribution curve corresponding to

100% - the power of the study. (The power of the study is 90%, therefore u = 1.28).

The prevalence of iodine deficiency among pregnant women in a similar hospital-based study in Imo State, South-East, Nigeria by Ujowundu et al was 14%,[23] (using UIC of less than 100ug/l as iodine deficiency). Therefore, p_1 is 14%.

The prevalence of iodine deficiency in the general Nigerian population estimated from a study in 2012, was 40.4%[16] (using UIC less than 100ug/l as iodine deficiency) Therefore, p_2 is 40.4%.

$n = (1.28+1.96)^2 (14(100-14) + 40.4 (100-40.4)) / (14-40.4)^2 = 54.4$

Therefore, the minimum sample size required for each group of this study was 55.

Allowing for an attrition rate of 10% (which is an addition of approximately 6 persons to each group) the sample size may be rounded up to 61 persons. The total sample size for both study populations with a ratio of 1:1 will be 122.

Using WinPepi version 11.65 statistical software the sample size was:

Required Sample: Total 120 (60 in A, 60 in B)

Continuity-corrected: Total 134 (67 in A, 67 in B)

Expected Precision: Approximately 95% CI for the difference between proportions (D)

= D - 0.174 to D + 0.174

Therefore, a total sample size of 134 with 67 persons in each arm of the study was used and the samples collected over two months for analysis.

The probability sampling method was used to select the study participants for both arms of the study. While a simple random sampling technique was used to select non-pregnant women of reproductive age for one arm of the study, a stratified sampling technique was used to select pregnant women for the other arm of the study.

Sample Processing

The patients were given a marked sterile Universal bottle for a specimen of their household salt, the amount of salt they were required to submit for the study (approximately 10 grams of salt, equivalent to 2 tablespoons of salt) was determined by a mark on the specimen bottle. The salt sample was retrieved at their next clinic appointment and sent to the research laboratory where the iodine content of the salt sample was determined using the Sandell-Kolthoff reaction (validated by re-running the tests using a non-radioactive ELISA kit and spectrophotometer reader) and the iodine content in salt was measured using the titration method for determining salt iodate and salt iodide content.

A casual urine sample of about 10ml was collected from participants. The urine sample was transported to the chemical pathology research laboratory of the University of Port Harcourt Teaching Hospital where the urinary iodine concentration was measured using the Sandell-Kolthoff test and validated with an ELISA kit, read on a spectrophotometer.25

Data Analysis

The data was entered into a spreadsheet and analyzed using the statistical package for Social Sciences version 25.0. The Mann-Whitney U test was used for comparisons between medians, the Chi-square test was used to compare categorical variables and the Student 't' test was used to compare continuous variables between the pregnant and non-pregnant subgroups of women. The results were presented in frequency tables. A p-value of <0.05 was considered significant at a 95% confidence level.

RESULTS

There were significant differences between the study groups in age distribution and marital status. The mean age for the pregnant study group was 32.15±5.2, and the median and modal age was 31 years, with a range of 23 to 43 years. Table 1 shows the socio-demographic data of the patients in the two arms of the study (pregnant and non-pregnant women of reproductive age). Most of the patients (51.5%) were nulliparous and in their first trimester of pregnancy. Figure 1 depicts the gestational age distribution in the pregnant population at the time of the study. The non-pregnant study group's mean age was 32.147.5 years, the median age was 33 years, and the modal age was 38 years, with a range of 20 to 52 years. They were predominantly nulliparous (76.2%). The majority of patients in both arms of the study had a tertiary level of education, with 85.5% of pregnant respondents and 83.6% of non-pregnant respondents having a tertiary level of education.

Of the 129 participants in the study, only 80 (62.0%) provided household salt for analysis. None of the salt samples analyzed contained adequate iodine (15-40 ppm). The mean, median, and modal salt iodine level among pregnant and non-pregnant respondents was

0.48ppm (Range 0.044-0.052ppm). There was no significant relationship between levels of iodine in salt consumed and the severity of iodine deficiency in the two groups. However, the use of iodized salt was associated with statistically higher UIC among pregnant respondents when compared with those who did not use iodized salts. (U (UICuse iodized salt 45.22ug/l, UICdoes do not use iodized salt 26.67ug/l) =101, z= -2.574, p≤ 0.001). In addition, there was a significant relationship between pregnant women with low iodine levels and a previous history of unexplained stillbirths (32.22ug/l, p-value- 0.004).

The median urinary iodine concentration (Median UIC) among pregnant women was 42.87ug/l, while the median UIC among non-pregnant women was 52.33ug/l. A Mann-Whitney U test indicated that this difference was statistically significant, U (NPregnant=66, Nnon-pregnant =63) =1234.5, z= -3.98, p≤ 0.001. The mean UIC among pregnant women was 42.14±1.23ug/l, with a range of 14.05ug/l-62.44ug/l, while the mean UIC among non-pregnant respondents was 49.82±7.6ug/l with a range of 31.5ug/l-60.56ug/l. This is shown in Table 2.

All participants had some degree of iodine deficiency. Mild iodine deficiency was seen in 57.1% of the non-pregnant respondents and 34.4% of the pregnant respondents. Moderate iodine deficiency was seen in 42.9% of non-pregnant respondents and 56.2% of pregnant respondents. Severe Iodine deficiency was observed only among the pregnant respondents (9.4%). Table 3 shows the WHO Classification of Iodine Deficiency published in 2007, while table 4 shows the pattern of iodine deficiency among the non-pregnant and pregnant population.

Table 1: Socio-demographic Characteristics

	Groups				P-Value
	Pregnant (N=66)		Non-Pregnant (N=63)		
	N	%	N	%	
Age Group					
20-24	0	0.0%	16	25.4%	
25-29	16	24.2%	13	20.6%	
30-34	31	47.0%	9	14.3%	0.001
35-39	13	19.7%	19	30.2%	
>40	6	9.1%	6	9.5%	
Parity					
Nullipara	34	51.5%	48	76.2%	
Primipara	15	22.7%	6	9.5%	
Multipara	17	25.8%	9	14.3%	0.013
Marital Status					
Single	0	0.0%	25	39.7%	
Married	66	100.0%	38	60.3%	0.001
Patient's Occupation					
Employed	20	35.7%	23	46.0%	
Self Employed	29	51.8%	18	36.0%	0.259
Unemployed	7	12.5%	9	18.0%	
Husband's Occupation					
Employed	36	60.0%	15	46.9%	
Self Employed	24	40.0%	15	46.9%	0.099
Unemployed	0	0.0%	2	6.3%	
Educational Status					

No Formal Education	1	1.6%	0	0.0%	
Primary	0	0.0%	2	3.3%	
Secondary	8	12.9%	8	13.1%	0.387
Tertiary	53	85.5%	51	83.6%	

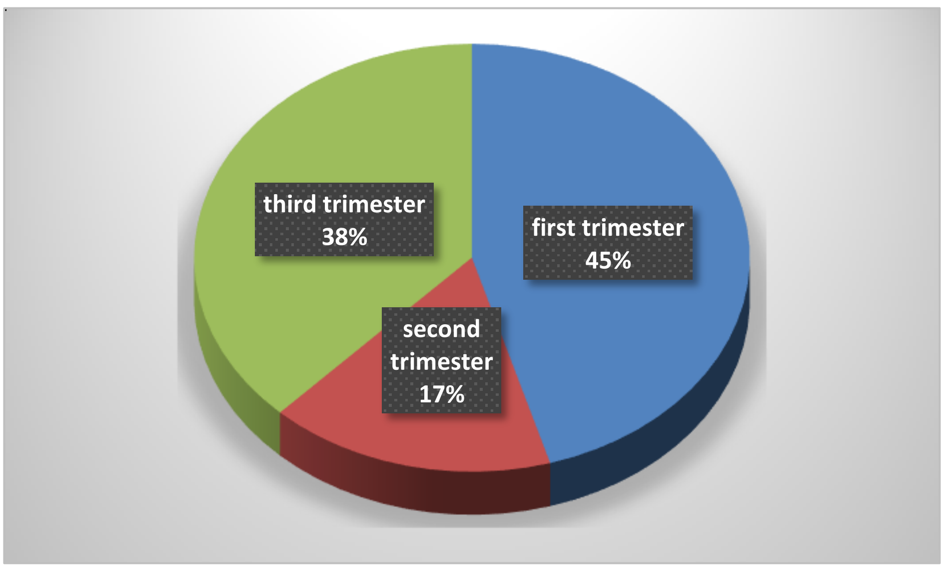

Figure 1: Gestational Age of Pregnant Respondents

Table 2: Median UIC and Salt Iodine Concentration between Pregnant and Non-Pregnant Women.

	Groups						
	Pregnant (N=66)		Non-Pregnant (N=63)				
	Mean Rank	Median	Mean Rank	Median	U Statistics	Z score	p-value
Salt (μg/L)	64.64	48.14	65.38	48.31	2055.00	-0.11	0.911
UIC (μg/L)	52.20	42.87	78.40	52.33	1234.50	-3.98	0.001

Table 3: Criteria for Assessing Iodine Nutrition

Life Stage	Median urinary iodine (μg/l)	Category of iodine status
School-aged children, non-pregnant and non-lactating adults	<20	
	20-49	Severely deficient
	50-99	Moderately deficient
	100-199	Adequate
	200-299	More than Adequate
	≥300	Excessive
Pregnant women	<150	Insufficient
	150-249	Adequate
	250-499	More than adequate
	≥500	No added health benefit expected

Culled from WHO, UNICEF & ICCIDD (2007) Assessment of Iodine-Deficiency Disorders and Monitoring Their Elimination, 3rd. Geneva: World Health Organisation.

Table 4: Pattern of Iodine deficiency among respondents.

Participants Category	Percentage of Iodine Deficiency (%)		
	Mild	Moderate	Severe
Pregnant Respondent	34.3	56.3	9.4
Non-pregnant Respondent	57.1	42.9	0.0

DISCUSSION

This study focused on women of reproductive age who were pregnant and also considered a non-pregnant group. Iodine deficiency was found in both pregnant and non-pregnant women in this study. The iodine deficiency observed in all respondents was exacerbated by the low iodine content of the salt consumed in their homes (median salt iodine concentration; 0.048 ppm). The adequate iodized salt coverage was 0%. It is unclear whether the low iodine content in the salt submitted for analysis is due to non-compliance with the salt iodization rules (40-60ppm) or if iodine, being very volatile, was lost along the supply chain or in their homes due to poor storage or exposure of the salt to sunlight and/or humidity.[24,25]

A multicenter study conducted in Aba in 2011 by Igwe et al [26] observed a median UIC of 58.67ug/l, which was like the median UIC of 42.87ug/l reported in this study among pregnant respondents. Iodine deficiency was found in all pregnant women from the three communities studied. This was attributed to the region's high consumption of cassava, despite the high USI program household coverage. The researchers were left to assume adequate salt iodization and concluded that dietary habits were the cause of the iodine deficiency observed because the household salt consumed by pregnant women in Abia state was not assayed for iodine content as was done in our study.

Severe iodine deficiency was found in 9.4% of pregnant respondents, moderate iodine deficiency in 56.2%, and mild iodine deficiency in 34.4%. This is nearly a reversal of the findings in Abia state, where only mild and moderate iodine deficiencies were found

(64% and 36%, respectively). A similar study in Zaria by Jibril et al[27] found a median UIC of 193ug/l among pregnant women and a 46% prevalence of mild iodine deficiency (UIC150ug/l). Iodine deficiency was found to increase with gestational age, from 36% to 49%. The high consumption of seafood and adequately iodized salt was attributed to the high median UIC.

Because approximately 38% of respondents in our study were in their third trimester, the median UIC may be much lower based on their contribution. This analysis was beyond the scope of this research. This study also observed that the iodine concentration in the salt analyzed did not affect their iodine status. The degree of iodine deficiency observed was unavoidable with pregnancy and the consumption of inadequately iodized salt.

Although iodine deficiency was observed in non-pregnant respondents representing the iodine status of the general population, with a median UIC of 52.33ug/l, the severity of the problem was worse in pregnancy. Because of the high demands of the fetus on maternal iodine stores, pregnancy is a known independent contributor to iodine deficiency.[20] There was also no correlation between the iodine concentration in the salt studied and the iodine levels in non-pregnant respondents.

A similar paradox was observed by Abua et al in Cross River state in 2008,[24] when three-fourths of the children in the study were iodine-deficient despite 72% of the households consuming adequately iodized salts (15ppm). Since there are so many confounding factors affecting the iodine status of the population, the USI program alone may not be enough to meet the iodine needs of the general population; therefore, the high-risk population requires even more attention and care to address their iodine needs.

CONCLUSION

Despite the low iodine content of salt, pregnant women who indicated knowledge and consumption of iodized salt had higher UICs than those who did not indicate knowledge and consumption of iodized salt. Furthermore, Iodine levels in salt samples were unrelated to the respondents' iodine status and/or severity of iodine deficiency. Iodine deficiency was more severe in pregnant women.

Our findings indicate that pregnant women require iodine supplementation. The USI program for the general population must also be expanded.

To further educate our women, knowledge of the importance of dietary iodine, foods containing iodine, goitrogens, and iodized salt should be incorporated into antenatal classes. An iodine supplementation program for pregnant women should be developed, and women should be encouraged to take iodine-containing prenatal vitamins.

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