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A Study on the Effect of Iodine Content of Salt Samples on the Iodine Nutrition Status of Pregnant, Lactating and Healthy Non-Pregnant, Non-Lactating (NPNL) Women

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Abstract: *The present hospital based study was carried on 511 pregnant, 208 lactating and 120 healthy non-pregnant, non-lactating (NPNL) women belonging to age group 20-45 years with low socio-economic background. The pregnant and the lactating women were taken from the antenatal clinic and the NPNL women were taken from other outpatient departments of the same hospital. The aim of the study was to evaluate the relation between their Iodine Nutrition Status (INS) and iodine content of the cooking salt. Urinary Iodine Excretion (UIE) was used as the biomarker of the INS as it is the best indicator of recent iodine intake and Iodometric Titration was used to measure the iodine content of the salt samples. The result suggested that 34% (175) pregnant women, 22% (45) lactating women and 6% (7) NPNL women had insufficient iodine intake as reflected by their Urinary Iodine Excretion (UIE). Even though 70% of these iodine inadequate subjects admitted use of branded salt samples for cooking it was found that 51% (53) pregnant women, 38 %(17) lactating women and 2 (out of 7) NPNL women consumed salt with <15ppm iodine content . It was also observed that 51-71% of the iodine deficient subjects added salt to their food during the initial stages of cooking. Hence inadequate INS of the studied population could be attributed to inadequately iodised salt along with faulty transportation, storage and cooking practices as recorded.*

Keywords: *Iodine Nutritional Status (INS), Salt, Pregnant, Lactating, NPNL, Urinary Iodine Excretion (UIE).*

1. INTRODUCTION

Iodine is an important component in the synthesis of the two essential thyroid hormones namely thyroxine (T_4) and triiodothyronine (T_3), deficiency of these two thyroid hormones leads to foetal growth retardation and other irreversible complications [1].

Iodine deficiency is the most common cause of mental deficiency in the world today. The term Iodine Deficiency Disorder (IDD) refers to all the ill-effects of iodine deficiency in a population that can be prevented by ensuring that the population has an adequate intake of iodine [2]. It affects all stages of human development- foetus, neonate, child and adults but is more frequent during adolescence and pregnancy. Iodine is vital for all pregnant and lactating mothers because deficiency of Iodine during the critical period of foetal development results in permanent brain damage. Hence correction of iodine deficiency before and during pregnancy can prevent this brain damage [3]. Iodine content of a food item largely depends on the soil in which it has been grown. Over the years the surface soils have become progressively depleted in iodine because of rains, flooding, deforestation and soil erosion [3]. So the amount of iodine found in most natural foods is typically quite small and depends on environmental factors such as the soil concentration of iodine and the use of various fertilizers. In India, no state is free from iodine deficiency and 200 million people are 'at risk' of IDD.

1.1. The Spectrum of IDD Across the Stages of Life [2]

Stages in life	Health Effects
❖ **Pregnancy**	Abortions
	Still births
	Congenital anomalies
	Increased perinatal mortality
	Increased infant mortality
	Neurological cretinism
	Mental deficiency
❖ **Foetus**	Deaf mutism
	Spastic diplegia,
	Squint
	Myxedematous cretinism
	Mental deficiency
	Dwarfism
	Psychomotor defects
❖ **Neonate**	Neonatal goitre
	Neonatal hypothyroidism
❖ **Child & Adolescent**	Goitre
	Juvenile hypothyroidism
	Impaired mental function
	Retarded physical development
❖ **Adult**	Goitre with complications
	Hypothyroidism
	Impaired mental function.

The most urgent reason for stressing on Iodine as a preventive measure is not the goitre itself but the cretinism which is its ultimate sequel in areas severely deficient in iodine. On recommendation by the Central Council of Health, the Government of India decided to iodise the entire edible salt in the country by 1992 [4].

According to Indian Council of Medical Research (ICMR) the Recommended Dietary Allowance (RDA) of Iodine for Indian pregnant and lactating mothers has been suggested to be 200µg per day [5] UNICEF, ICCIDD and WHO [2] recommend that the daily intake of iodine should be 250µg for pregnant and lactating women and150µg for adolescents (above 12 years) and adults.

2. LITERATURE REVIEW

According to studies conducted by Yadav et.al (2010) [6] who reviewed nine studies (Rajasthan, West Bengal, Delhi, Haryana, Uttaranchal, Himachal Pradesh, and Maharashtra) found that India showed a significant iodine deficiency among the studied pregnant women. Lack of iodine can cause life-long brain damage to babies even if they look normal. As they grow, the brain damage can been seen through poor performance in school and less coordinated than healthy children [7]. Experts have suggested that the irreversible situation of brain damage in children could be prevented well in advance only by iodising the salt taken by pregnant mothers as 90% of the human brain development occurs between the third months of pregnancy to third year of life.The

National Family & Health Survey (NFHS)-2 [8] showed that people in the low socio-economic stratum had the least coverage of iodized salt. These people consumed salt produced by small-scale manufacturers who often did not iodize the salt used for cooking adequately. The NFHS-2 study also suggested a lack of awareness among people with regards to the benefits of iodized salt. Verma and Raghuvanshi (2001)[9] suggested iodine loss in cooking could be minimised by addition of salt on cooked food rather than addition of salt while cooking. Similarly study conducted by Rana R et al (2009) [10] concluded that the retention of iodine depended upon type of cooking method and time of addition of salt during cooking. They found that less cooking time had better retention of iodine. There is considerable loss of iodine during transportation and storage under prevailing conditions. The stability of iodized salt may also be adversely affected by moisture, humidity, sunlight, heat, acidity and presence of impurities.

3. AIM

The aim of the study was to evaluate the relation between the Iodine Nutrition Status (INS) of pregnant and lactating women with their iodine intake through cooking salt.

4. METHODOLOGY

a. Selection of Subjects for the Study

This observational hospital based study was approved by the Ethics Committee. The pregnant, lactating & non-pregnant, non-lactating (NPNL) women were randomly selected (without any bias) from different outpatient departments of the hospital and consent was obtained in written from all the subjects who confirmed to participate in the study and were free from any acute or chronic disease or disorder.

b. Collection of Urine Samples and Analysis

Various methods exists for the detection of iodine deficiency in human but the Consultation of WHO/UNICEF/ICCIDD have proposed that the Median Urinary Iodine Concentration (MUIC) to be the best indicator in use for population surveys to assess the iodine nutrition status of pregnant and lactating women [2].The urine samples(50ml) were collected in screw capped plastic bottles provided to them with a label furnishing the required details about the sample (name of the patient, age, trimester, date of urine collection). As the outpatient department for the day concluded, the urine samples of the subjects were carefully taken to the laboratory for its analysis. Urinary Iodine of the urine samples was assessed by using the Ammonium persulphate method as recommended by the World Health Organization (WHO)[2].

c. Collection of Data of the Subjects under Study

After the urine analysis was done and the result was calculated.

The pregnant (n=511), lactating (n=208) and NPNL (n=120) women were categorised into two groups on the basis of their MUIC ie

1) Inadequate Iodine Intake subjects 2) Adequate Iodine Intake subjects.

All the relevant information was recorded for both the group (adequate & inadequate) of subjects and cross checked with the data procured from the record section of the same hospital.

d. Collection of Household Salt Samples

Salt iodine is one of the main sources of our dietary iodine intake apart from the food consumed each day. The subjects under the present study were requested to bring salt samples (4 teaspoons) from their homes normally used for cooking in air tight zip lock plastic pouches provided to them .Necessary information regarding the salt samples and the subjects were carefully recorded. The analysis of iodine content of salt was done by Iodometric Titration method [11].

5. RESULT & DISCUSSION

Table 1. *Percentage distribution of Iodine Nutrition Status (INS) of Pregnant Women according to their different trimesters of pregnancy*

URINARY IODINE EXCRETION (UIE µg/l)								
		Iodine insufficient pregnant women group 0 to < 150 µg/l					Adequate iodine intake group	Above requirement iodine intake group
Trimesters of pregnancy	No. & % of pregnant women	0-19 µg/l	20-49 µg/l	50-99 µg/l	100-149 µg/l	Total no. & % of subjects with iodine deficiency in each trimester	150-249 µg/l	250-499 µg/l
First Trimester	261 (51%)	9 (3%)	10 (4%)	25 (9.5%)	78 (30%)	*Total =122 (47%)*	101 (39%)	38 (14.5%)
Second Trimester	235 (46%)	3 (1%)	8 (3%)	14 (6%)	23 (10%)	*Total =48 (20%)*	115 (49%)	72 (31%)
Third Trimester	15 (3%)	-	1 (7%)	2 (13%)	2 (13%)	*Total =5 (33%)*	7 (47%)	3 (20%)
Total	511	12 (2%)	19 (4%)	41 (8%)	103 (20%)	*N=175 (34%)*	223 (44%)	113 (22%)
							N=336 (66%)	

Observations from Table 1 suggested that out of 511 pregnant subjects maximum subjects belonged to the first trimester ie 51% (n=261) followed by the second trimester ie 46% (n=235) & least subjects in the third trimester ie 3% (n=15) respectively. Of these subjects 47% (n=122), 20% (n=48) & 33% (n=5) pregnant women who belonged to 1st,2nd & 3rd trimesters of pregnancy respectively had insufficient iodine intake as their median urinary iodine concentration (MUIC) was found to be 109µg/l which was <150µg/l.

The deficiency of iodine was found to be greatest among the first trimester pregnant subjects. If the mother is iodine deficient during conception or early months of pregnancy it would lead to various complications like irreversible damage to the brain of the growing foetus and its overall well being.

As the p-value was found to be significant (<0.05), it was concluded that the UIE and trimesters of pregnancy of the subjects (n=511) were dependent.

Table: 2(a) *Median Urinary Iodine Concentration (MUIC) of Pregnant Women*

MUIC (µg/l)	No.& % of Pregnant Women		Iodine Nutrition Status of the Pregnant Women
<150	*175 (34 %)*		*Insufficient Iodine Intake*
150-249	223 (44%)	66%	Adequate Iodine Intake
250-449	113 (22%)		Above requirement iodine intake
N=	511		

Out of 511 pregnant subjects 34% (n=175) subjects demonstrated Insufficient Iodine intake as their MUIC was 109µg/l (<150µg/l) and the remaining 66% (n=336) subjects had Adequate and above requirement iodine intake with MUIC of 219µg/l (>150µg/l).

Table: 2(b) *Median Urinary Iodine Concentration (MUIC) of Lactating Women*

MUIC (µg/l)	No.& % of Lactating Women	Iodine Nutrition Status of Lactating Women
<100	*45 (22%)*	*Insufficient Iodine Intake*
≥ 100	163 (78%)	Adequate Iodine Intake
N=	208	

Out of 208 lactating women 22% (n=45) subjects demonstrated Insufficient Iodine intake as their MUIC was 86µg/l (<100µg/l) and the remaining 78% (n=163) subjects had Adequate Iodine nutrition with MUIC of 185µg/l (≥ 100µg/l). The iodine concentration of the human milk varies widely due to maternal iodine intake so an iodine deficient lactating women would fail to furnish the necessary mineral to her newborn which would lead to various ill effects of iodine deficiency.

Table 2(c) *Median Urinary Iodine Concentration (MUIC) of Non-Pregnant, Non-Lactating (NPNL) women*

MUIC (µg/l)	No.& %of NPNL women	Iodine Nutrition Status
<100	*7 (6%)*	*Insufficient Iodine Intake*
≥ 100	113 (94%)	Adequate Iodine Intake
N=	120	

Out of 120 NPNL women 6% (n=7) subjects demonstrated Insufficient Iodine intake as their MUIC was 87µg/l (<100µg/l) where as 94% (n=113) NPNL women had Adequate Iodine nutrition as reflected by their urinary iodine concentration which was 227µg/l (≥ 100µg/l).

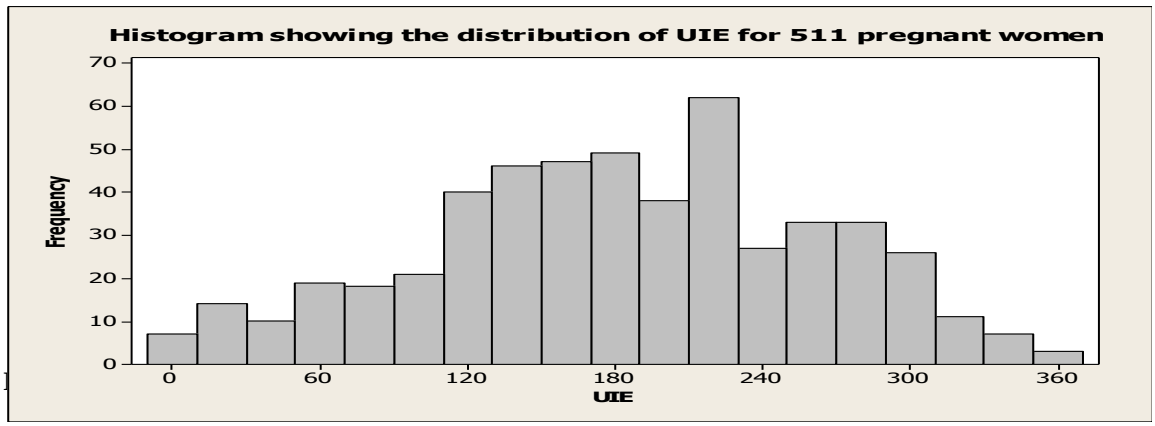

Figure 1

Note: In this histogram the x-axis represents the Urinary iodine excretion (UIE in µg/l) of the Pregnant women (n=511) and the y-axis represents the frequency of pregnant subjects.

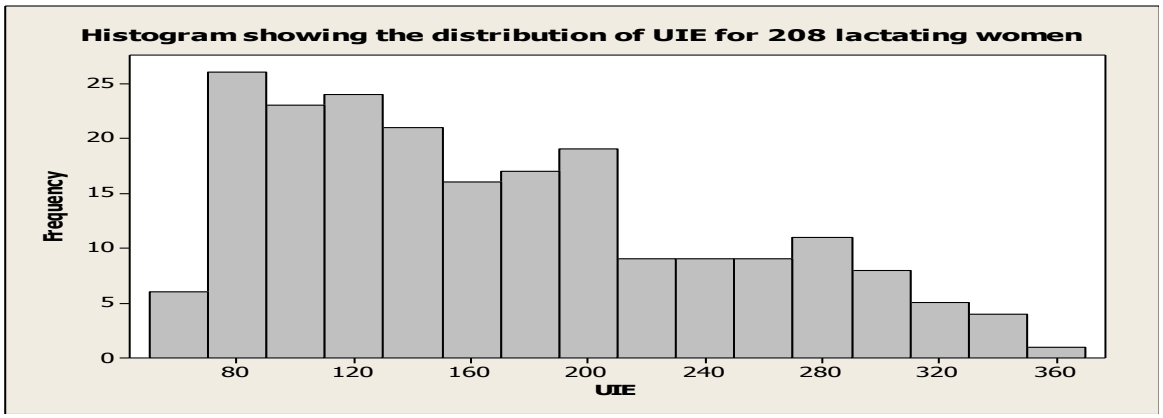

Figure 2

Note: In this histogram the x-axis represents the Urinary iodine excretion (UIE in µg/l) of the lactating women (n=208) and the y-axis represents the frequency of the lactating subjects.

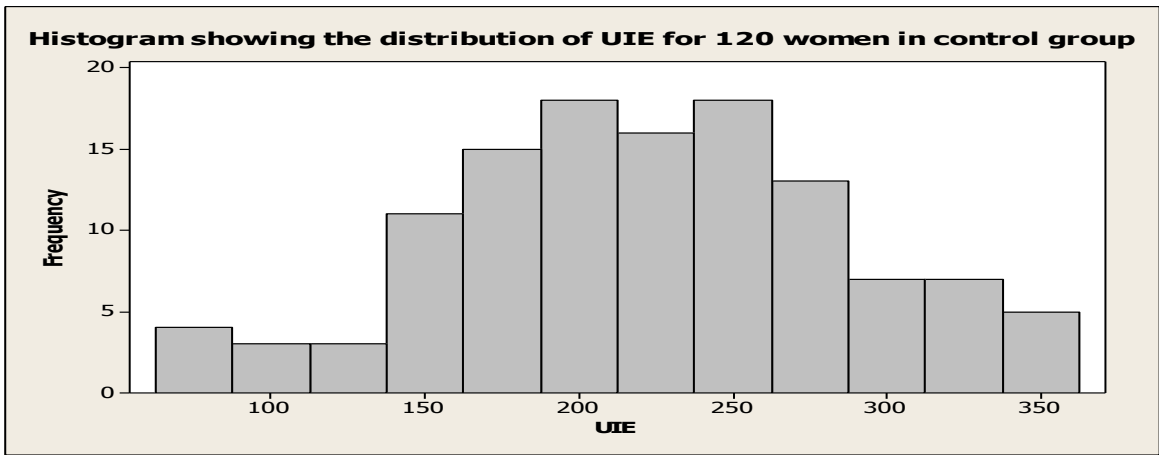

Figure 3

Note: In this histogram the x-axis represents the Urinary iodine excretion (UIE in µg/l) of the NPNL women (n=120) and the y-axis represents the frequency of NPNL subjects (control group).

Table: 3(a) *Estimation of Iodine Content in household salt samples of the Pregnant, Lactating & NPNL women:*

Groups under study	No. of subjects	Iodine Content of Salt Samples Used by Subjects				
		10- 15 ppm	15-20 ppm	20-25 ppm	25-30 ppm	> 30 ppm
Group 1: *Insufficient Iodine Intake Pregnant woman*	103	*53* *(51%)*	25 (24%)	14 (14%)	11 (11%)	-
Group 2: Adequate Iodine Intake Pregnant woman	153	7 (5%)	93 (61%)	22 (14%)	25 (16%)	6 (4%)
Group 3: *Insufficient Iodine Intake Lactating woman*	45	*17* *(38%)*	22 (49%)	5 (11%)	1 (2%)	-
Group 4: Adequate Iodine Intake Lactating woman	163	9 (6%)	22 (13%)	62 (38%)	42 (26%)	28 (17%)

Group 5: *Insufficient Iodine Intake NPNL women*	7	*2 (29%)*	4 (58%)	1 (13%)	-	-
Group 6 : Adequate Iodine Intake NPNL women	113	2 (2%)	12 (11%)	36 (32%)	45 (40%)	18 (15%)

Note: The iodine content of salt samples in the range of 10-15ppm represents inadequately iodised salt as per the Prevention of Food Adulteration Act (PFA act) 1954 (presently known as Food Safety & Standards Act ,2011)[12] .

The findings of the Table 3(a) suggested that 51% (n=53), 38% (n=17) and 29% (n=2) of the Insufficient iodine intake pregnant, lactating and NPNL women belonging to groups 1, 3 & 5 respectively were found to consume inadequately iodised salt which had <15ppm iodine content. Only 2-6% of the adequate iodine intake group subjects consumed salt which was inadequately iodised.

Table:3 (b). Types *of salt purchased by the Pregnant, Lactating & NPNL women for household cooking*

Groups of Subjects	Total no. of subjects	Types of salt purchased by groups under study		
		Open source salt	Branded iodised salt	Unaware of source
Group1 *Insufficient Iodine Intake Pregnant Woman*	103	*23 (22%)*	*74 (72%)*	*6 (6%)*
Group2 Adequate Iodine Intake Pregnant Woman	153	3 (2%)	140 (91%)	10 (7%)
Group 3 *Insufficient Iodine Intake Lactating Woman*	45	*6 (13%)*	*32 (71%)*	*7 (16%)*
Group 4 Adequate Iodine Intake Lactating Woman	163	6 (4%)	145 (89%)	12 (7%)
Group 5 *Insufficient Iodine Intake NPNL Women*	7	*2 (29%)*	*5 (71%)*	-
Group 6 Adequate Iodine Intake NPNL Women	113	8 (7%)	96 (85%)	9 (8%)

Table 3(b) showed that 13-29% of the insufficient iodine intake pregnant, lactating and NPNL women belonging to group 1, 3 and 5 respectively consumed open source ie unpackaged salt samples. Almost 70% of these subjects used salt samples under different brand ie packaged salt samples and 6-16% of the women were unaware of their salt source used in their household.

Table 3(c). *Stages of salt addition by the subjects under study during cooking*:

Group of Subjects	Total no.	% Distribution of subjects under study		
		Initial Stage of cooking	Middle Stage of cooking	Final Stage (after cooking)
Group 1 *Insufficient Iodine Intake Pregnant Woman*	103	*72 (70%)*	31 (30%)	-

Group 2 Adequate Iodine Intake Pregnant Woman	153	145 (95%)	5 (3%)	3 (2%)
Group 3 *Insufficient Iodine Intake Lactating Woman*	45	*23* *(51%)*	22 (49%)	-
Group 4 Adequate Iodine Intake Lactating woman	163	52 (32%)	103 (63%)	8 (5%)
Group 5 *Insufficient Iodine Intake NPNL Women*	7	*5* *(71%)*	2 (29%)	-
Group 6 Adequate Iodine Intake NPNL Women	113	78 (69%)	24 (21%)	11 (10%)

From the table 3c it was observed that 51 -71% of the subjects belonging to the Insufficient Iodine intake group added their salt in the initial stages of cooking and 29-49% of these subjects added in the middle stage of cooking. None of these iodine deficient subjects added their salt after the cooking was completed.

6. Statistical Analysis

The frequency of pregnant, lactating and NPNL subjects and their UIE was represented by histogram using the software Minitab-16 [13].

7. Conclusion

Out of the 511 pregnant, 208 lactating and 120 NPNL women studied 34% pregnant, 22% lactating and 6% NPNL women exhibited inadequate iodine nutrition.

So from the present study the iodine inadequacy among the pregnant and lactating subjects could be attributed to the following reasons : 1) increased requirements of iodine during pregnancy and lactation (250µg/d) than in adults (150µg/d).2) consumption of inadequately iodised salt ie iodine content <15ppm, unpackaged open source salt which is poorly iodised.3) addition of salt in the initial stages of cooking was a common practise along with its improper storage (jars with no lid/ broken lid/ open bowls/in the salt pouch itself).

Though Iodine Deficiency is single most common cause of mental handicap worldwide yet it is totally preventable**.** Regular consumption of adequately iodised salt along with minimizing of iodine loss through faulty cooking techniques and storage would protect the pregnant and lactating women from the ill effects of iodine deficiency.

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