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Is Salt Purchased And Consumed By Indian Pregnant Women Adequately or Inadequately Iodized? A Pilot Study from a Tertiary Care Centre in South India

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Abstract

Background: The most sustainable cost-effective intervention to counter iodine deficiency disorders (IDD) is universal salt iodization program. Periodic monitoring and surveillance of salt iodization is essential in most vulnerable pregnant women. Both iodine content in salt and Spot Urinary Iodine Concentration (SUIC) serve as useful process and impact indicators to assess iodinestatus.
Methods: A pilot study was conducted in pregnant women in third trimester to estimate prevailing iodine levels and for prevalence of iodine deficiency disorders. Spot UIC, maternal serum TSH, neonatal capillary blood TSH and iodine content in salt with rapid test kits were done**.**
Study design: Descriptive cross-sectional study.
Inclusion criteria: Normal pregnant women with singleton pregnancies and gestational age 34 to 36 weeks.
Exclusion criteria: Women with thyroid disorders, multiple gestation.
Study number: 105 maternal and neonatal pairs.
Results: Descriptive and non-parametric tests were used. Analysis was done as group 1 with pregnant women who consumed salt with 0 iodine, group 2 used iodine up to 15 parts per million and group3 iodine was above 15 up to 30 ppm. Unbranded and branded salt users were 22.85% and 77.14 %. Spot UIC was below 150 µ /L in 59 participants. TSH was above 4.2 µIU/L in 13 pregnant women.
Discussion: This study was part of PhD research conducted in the Tamil Nadu Dr MGRMedical University Chennai in a government hospital. Prevalence of iodine deficiency was 56.2% inadequately iodized salt was purchased by 35.24% of participants. Iodine deficiency was detectedin 37.5%of unbranded salt users and 61.73% of branded salt users. Maternal subclinical hypothyroidism was diagnosed in 12.38% population. Neonatal TSH was above 5µIU/L in 8 neonates suggestive of maternal iodine deficiency.
Conclusion: This pilot study highlights need to monitor iodine content in fortified salt with may not be adequate in pregnancy and stress the need for larger sampled regional studies throughout country to monitor salt iodization program adequacy and sustainability to further plan public health strategies.

Keywords: Pregnancy iodine status; Spot urinary iodine concentration; Salt iodization; Maternal hypothyroidism; Neonatal TSH; Salt fortification; Branded salt, Unbranded crystal salt; Rock salt

Introduction

Demand for Iodine in Pregnancy

Pregnancy is a physiological state of relative iodine deficiency due to additive effects of three major factors maternal, placental and fetal components all of which increase iodine metabolism and its utility for thyroid hormones synthesis. Increased glomerular filtration rate and increased renal clearance of iodine cause obligatory iodine losses in urine which further leads to iodine deficiency. Maternal iodine deprivation also occurs due to iodine transfer through placenta into fetal circulation. Fetus is totally dependent on mother's iodine reserve and her thyroid hormones further depleting maternal stores. The net impact of these physiological hormonal and metabolic challenges unique in pregnant women is a complex "internal milieu" which when left unchecked steps into pathophysiological cascade of events referred to as Iodine Deficiency Disorders (IDD) [1]. Pregnant women and neonates are physiologically more vulnerable for IDD. The health outcomes of both mother and developing fetus depends upon the ultimate impact of iodine deficiency which may be synergistic or antagonistic and cause transient or permanent thyroid gland dysfunctions at any time during gestation or in the perinatal period accordingly [2,3].

Magnitude of problem of IDD in India and rationale to assess iodine status in pregnancy

Worldwide research studies document definitive roles for ethnicity and geographical factors as major determinants of iodine bioavailability and thyroid hormones synthesis. IDD is a public health problem in all States and union territories in India [4] and every year nine million pregnant women and eight million newborns are at risk of IDD. Resurgence of iodine deficiency is a matter of concern warranting further evaluation for correcting deficiency status and imbalances accordingly. Indian studies report up to 38 % iodine deficiency in pregnant women populations in North, East and West Indian states. State level iodine estimation surveys were done in South India in State of Tamil Nadu from 2000 to 2006 in 6-12 years age group of children and household adult non-pregnant women [5]. This was a sub national level of IDD survey in India that included three indicators of iodized salt coverage. Process indicator included iodine content of consumed salt in households. Outcome indicators were urinary iodine concentration (UIC) and thyroglobulin levels respectively. Survey provided vital data in that in State of Tamil Nadu only 18.2% consumed adequately iodized salt defined by WHO as salt with iodine above 15ppm at time of consumption of salt as against recommended criteria at 90 % by WHO. Total goitre rate (TGR) was 13.5% and median UIC was 89.5µg /l. Among surveyed children 17.7 % had less than 100 µg/L. It is now accepted that schoolchildren studies cannot be considered representative of pregnant women [6] and WHO has revised cut-off criteria for iodine deficiency as 150 µg/L in pregnancy as against 100 µg/L for schoolchildren from 6 to 12 years. Study results have indicated the need to monitor current iodine fortification levels above 30 parts per million and serves to highlight a vital observation that the same salt when consumed during pregnancy will definitely be inadequate even with consumption of costlier dairy products and fish food as pregnant women require at least 250 µg/L per day and salt is the main source of iodine providing at least 47 to 51 % of overall daily requirement [7].

Current iodine status among pregnant women in State of Tamil Nadu

As there is paucity of iodine related studies in pregnant women belonging to South India particularly in State of Tamil Nadu it is justified to conduct population studies initially to assess current prevailing iodine status. This pilot study is designed to estimate current urinary iodine levels and thyroid functions in pregnant women with their paired neonates and to screen adequacy of iodine content as parts per million (ppm) in salt purchased. Study will provide vital data on prevailing iodine status and thyroid functions of pregnant women and their newborns and serve as baseline assessment on adequacy and sustainability of salt iodization program to further design larger population research programs for public health protection strategies.

Factors affecting salt iodine content

Globally iodized salt is considered an artificial product [8]. Sea salt has virtually no iodine and is considered pure and natural product. Organic salt and pink salt crystals are used liberally worldwide with a fixed idea that excess iodine is harmful and salt rich in minerals is healthier. Several factors are attributed to influence the ultimate iodine content present in both purchased and consumed salt. Major contributors are moisture content of salt, packaging in loose jute bags, impurities in salt during transport and storage for longer periods in metal containers and beyond salt shelf lives may increase iodine losses up to 80%. At level of consumption at least 15-20% of iodine is lost in cooking practices especially in South Indian recipes followed by generations of people where deep frying and addition of salt before boiling has set in as a tradition. Using crystal type of salt may further increase iodine loss as iodine is heat labile. Studies done by Pandav et al in State of Tamil Nadu [4,5] have further revealed utility of salt as crystalline form in most districts which is inadequately iodized. Losses during boiling, roasting, deep frying and microwave cooking are reported as 40.23%, 10.57%, 10.40% and 27.13% respectively [9]. The loss of iodine depends upon type of cooking method and time of addition of salt during cooking. The loss of iodine in cooking practices ranges from 30-70%. The iodine content of regional diets in India ranges from 170-300 mcg/day. Vegetarians avoid animal products and processed foods [10].

Methods and Materials

Ethical Committee approval was obtained and study was registered in CTRI registration number CTRI/2018/02/012252. A detailed informed and written consent were obtained from all participants. Spot urinary iodine concentration was estimated by ammonium per sulphate wet digestion method based on Sandell

Kolthoff reaction [11]. Maternal TSH was estimated by chemiluminescence and neonatal TSH was done by fluoro-immunometric assay DELFIA method and stringent quality control measures were maintained both as internal and external quality standards with ensuring quality of urinary iodine program (EQUIP) and new born screening NSQAP at CDC Atlanta [12,13]. Adequacy of iodine in consumed salt was tested with UNICEF rapid salt testing kits as a semi quantitative test [14-16].

Study Characteristics

Study design

Study was descriptive cross–sectional study conducted from 2018 to 2020.

Inclusion criteria

Pregnant women at 34 to 36 weeks of gestation attending antenatal clinic at study sites with singleton pregnancies.

Exclusion criteria

Mothers with known thyroid disorders multiple gestation and refusal of consent. Study Population Pregnant women at 34 to 36 weeks of gestation and their babies as mother baby dyads (pairs).

Study site

This study is a part of ongoing PhD research program conducted in India within State of Tamil Nadu among pregnant women and their neonates in government tertiary care centre affiliated to The Tamil Nadu Dr MGR Medical University, Chennai. Standardized maternal urinary iodine reference values were not available for comparison and this study with mother newborn dyads is first of its kind in State of Tamil Nadu. It was therefore decided to calculate sample size based on a study done by Pandav et al [5] in school children within the State in which expected prevalence of IDD is 20 percent based on consumption of adequately iodized salt at 18.2%. A pilot study was designed with 10% of estimated main sample size and is presented in this article. Study number105 pairs with mothers and their neonates as participants Statistical method Descriptive analysis for normally distributed data and nonparametric analysis for urinary iodine concentrations as median value as data was not distributed normally.

Results and Analysis

A total of 105 mothers and their neonates were analyzed in groups by descriptive and non- parametric tests. Salt samples were tested and correlated with variables accordingly.

Prevalence of iodine deficiency in the study population was 56.2%. Iodine content ranged from 0 ppm to 30 ppm. Group 1 included salt samples with nil iodine at 0 ppm. Group 2 samples had iodine above 0 up to 15 ppm and Group 3 with iodine above 15 up to 30 ppm respectively. It was observed in group1 SUIC was below 150 µg/L in 42.9 % participants and 62.9 % in both groups 2 and 3 participants. Unbranded salt users were 22.85 %. Branded salt was purchased by 77 %. Iodine was significantly absent at 0 ppm with no colour changes with UNICEF rapid salt test kits (both test and stock solutions) in unbranded whole sale loosely packed crystal salt, rock salt and organic salt types. When branded pink salt was tested with test solution first there was no colour change initially but when stock solution was added a very pale blue colour appeared indicating iodine present up to 15ppm. Another brand developed blue colour instantly consistent with 15 ppm iodine content. Only 3 brands available in local market had iodine fortified at 30 ppm at site of production and package. Among brands with both crystal and powder types in crystal salt blue colour was less intense and slowly achieved.

Serum TSH was above 4.2 µIU/L in 13 pregnant women. A vital finding was that in those pregnant women with urinary iodine concentration below 100 µg/L TSH was high with a negative correlation between TSH and UIC. Maternal free thyroxine (Ft4) was low in 1 participant. None of neonates had TSH above 10 µ IU/L. But an important observation noted was that neonatal TSH was above 5µ IU/L in 6.86% of neonates.

Discussion

This study was a part of PhD research program conducted in The Tamil Nadu Dr MGR Medical University in India in a government hospital. Prevalence of iodine deficiency was 56.2 %. Maternal subclinical hypothyroidism was detected in 12.38 % population. Free thyroxine level was low in 1 pregnant woman (0.9 %) and it was observed that she purchased and used unbranded salt with no iodine content.

Iodine content in purchased salt versus consumed salt

Inadequately iodized salt was purchased by 66.6 % of participants in which 33 % purchased and consumed salt with nil iodine. It was noted that in all 3 groups among branded salt users 61.73 % developed iodine deficiency and 37.5 % of unbranded salt users had iodine deficiency. This raises a vital question regarding whether costlier and well packed branded salt is also not fortified and or inadequately iodized similar to cheaper loosely available unbranded salt.

Iodized salt is the main source of iodine besides dairy products and fish foods which is not affordable by all particularly in India in view of low socio- economic status. Amount of iodine fortified as ppm may be inadequate for vulnerable pregnant women. Study results further revealed that salt at time of consumption must have become even lower after cooking. WHO has released reports stating that iodine intake is significantly influenced by ethnic, cultural and social unawareness and cooking practices [4,5,9]. This is particularly true in Indian population especially in South Indian cooking which includes boiling, deep frying and reheating practices all of which could have further reduced iodine content to critically low levels and affect both maternal and neonatal outcomes.

Basic research question and most probable answer

The basic research question is that if salt iodine concentrations are deficient for normal adults' men and women then definitely the salt consumed by pregnant women and young children will be deficient in iodine if same ppm of iodine is fortified at manufacture site. The probable reason for Indian neonates to have a higher prevalence of Congenital hypothyroidism at "1 in 1132" and at "1 in 722 " in South India as reported by ICMR study [17] may be maternal consumption of less iodized salt and other micronutrients deficiency especially iron in addition to iodine .This observation is strengthened by the fact that " dyshormonogenesis " is the most common etiology for Congenital hypothyroidism in India while in Western countries dysgenesis or genetic causes are more common. Perhaps an extensive baseline study on current maternal urinary iodine concentration and its correlation with both maternal and neonatal thyroid function and outcomes will answer research question.

The utility of neonatal TSH by heel prick dried blood spot method as published by WHO has reported that neonatal TSH Values of more than 5µIU/L in term neonates and after 72 hours of birth more than 3% of entire population indicates iodine deficiency in that paired mothers .As per WHO criteria when neonatal TSH values are above 5µIU/L in more than 3% in the study population indicates iodine deficiency in that population. In this study neonatal TSH above 5µIU/L was 6.86 % suggestive of mild iodine deficiency in maternal population [18].

It is estimated that 10-15% of iodine is lost when packed with good moisture barrier such as low density polyethylene .But on the contrary packing with porous package such as gunny bags can result in up to 80% loss of iodine within six months .Therefore storage beyond 6 months is not useful and time should be minimized between iodization and consumption on the table in households to retain iodine content of salt at least at 9-10 ppm per day.

An observation noted in this study was that pregnant women reduced salt intake both as precautionary and therapeutic measures to reduce pregnancy induced hypertension which may be a vital contributory factor for iodine deficiency in predisposed pregnant women particularly in vegetarians and lower socioeconomic populations. Selection of an optimal level of iodization requires an estimation of iodine losses between its addition to salt and its consumption after cooking. Therefore, stringent measures and operations to check iodine content with process and impact indicators such as salt iodine concentration in urine and thyroid profiles will improve salt fortification monitoring accordingly. For a pregnant woman to have a normal median urinary iodine concentration of 150µg /day she should consume at least 250 µg iodine per day. To achieve this consumption of iodine, salt iodization at the manufacture site should be 50 to 60 mg of iodine/ kg salt. Usually 20% of iodine is lost from salt between production and household reach time. Another 20% loss is due to cooking cultural practices and thus average salt intake is 10 grams per person per day in normal adults and non-pregnant adult women. WHO recommendation is salt fortification with iodine should be at minimum of 50-60 ppm at manufacture and packaging stages so that after storage and cooking, at time of consumption of food iodine content is at least on an average 30 ppm which will be just adequate for a pregnant woman. Above all purchase of powdered salt, proper storage and timely consumption is most essential.

The WHO/UNICEF/ICCIDD recommends that iodine concentration in salt at the point of production should be within the range of 20-40 mg of iodine per kg of salt (i.e., 20-40 ppm of iodine) in order to provide 150 µg of iodine per person per day. The iodine should be added as potassium (or sodium) iodate. Under these circumstances median urinary iodine levels will vary from 100-200 µg/l. In view of physiological differences iodine requirements vary among school children, non-pregnant and pregnant and lactating mothers. Iodine fortification levels should be specific and most protective to vulnerable pregnancy population [18]. For pregnant women the salt iodine content at the packaging level must be 50-60 ppm and 20-30 ppm at the retail shops to achieve at least 15 ppm in the household dietary consumption in order to provide 250 µg of iodine per day [19,20].

Challenges

Food fashions, role of goitrogens and market malpractices utilizing non iodized salt particularly crystal salt which is cheaper and rock salt which can be used for longer time periods when compared to the powdered and adequately iodized table salt have led our populations to become imbalanced and or inadequately iodized state. Left unchecked further compromise can lead to increase in thyroid disorders and morbidities in precious maternal population and birth of physically and mentally challenged unhealthy neonates. The situation is alarming and it warrants larger research studies to monitor salt iodization process with public private partnership programs to reach to the ground level of origin and provide public health protective strategies.

Strengths of Study

This study is first of its kind to assess both maternal and neonatal iodine status and thyroid gland functions as pairs. A correlation between type of salt used and amount of iodine content in salt used by our population has thrown light on unawareness about which is the healthiest salt.

Limitations

Rapid salt testing kits is only a semi-quantitative test and estimation of iodine content has to be confirmedwith iodine titration method. Sample size needs to be larger and various ethnic groups have to be evaluated to substantiate our pilot study results. There is no method to assess iodine content of cooked food and assumption is that when salt is purchased without iodine content, it will definitely be deficient after cooking and salt will no longer serve as a source of iodine.

Conclusion

The need to monitor salt iodization program and sustainability has been focused with proof of study results showing high prevalence of iodine deficiency and hypothyroidism in vulnerable pregnant women and neonates which warrants urgent public health protection strategies.

Recommendations

The impact of iodine imbalances affects all stages of life but pregnant women and neonates are the most severely affected as physiological demand is much more in these subgroups. It is therefore most vital to assess iodine content adequacy in the consumed salt and monitor salt iodization program which is the most sustainable and cost effective intervention to counter iodine deficiency disorders .Adequate iodization of salt with atleast 50-60 ppm is necessary so that at the time of food consumption by pregnant women iodine content should be above 15ppm to prevent irreversible brain damage due to iodine deficiency which is the most common endocrine cause of preventable and treatable cause of mental impairment in children and preventable maternal morbidity in pregnancy.

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