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Prevalence and Predictors of Poor Iodine Nutrition in Rural South Odisha: A Comparative Study between Coastal and Hilly Districts

Jaya Singh Kshatri[1], Nivedita Karmee[2], Radha M Tripathy[3]

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Author's Affiliation:
[1]Resident; [2]Associate prof; [3]Professor & Head, Dept. Of Community Medicine, MKCG Medical College and Hospital, Brahmapur, Odisha

Correspondence:
Dr. Jaya Singh Kshatri
jainvincible@gmail.com

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ABSTRACT

Introduction: Apart from iodine content of the salt consumed, the prevalence of IDDs are influenced by factors like storage of salt, environmental factors, overall nutritional status and socio-economic status. Objectives: The objectives f the study were to estimate the prevalence of iodine deficiency in coastal and hilly villages of south Odisha; and to analyse the predictors for poor iodine nutrition status in the community.

Methodology: This was a cross sectional study in south Odisha. UIE and household salt iodine content was estimated and logistic regression model was applied to determine predictors of poor iodine nutrition.

Results: The median UIE in coastal district was found to be 126.4 mcg/L, whereas it was 73.0 mcg/L in the hilly areas. The household salt iodine level of more than 15 ppm was found in only 62% households. Nearly 50% households did not store their salt in airtight containers. The results of logistic regression revealed that hilly region (OR=10.2), household salt iodine content (OR=2.3), storage of salt in non air tight containers (OR=3.7) and stunting (9.8) were the main determinants of poor iodine nutrition.

Conclusion: Poor iodine nutrition was significantly associated with region, household salt iodine content, salt storage in non airtight containers and malnutrition.

Keywords: Iodine deficiency, nutrition, prevalence, Costal

BACKGROUND

Iodine is a trace element that is naturally present in some foods, added to others, and available as a dietary supplement. Iodine is an essential component of the thyroid hormones thyroxine (T4) and triiodothyronine (T3). Thyroid hormones regulate many important biochemical reactions, including protein synthesis and enzymatic activity, and are critical determinants of metabolic activity. They are also required for proper skeletal and central nervous system development in fetuses and infants.[1,2]

The recommended dietary allowances (RDA) of Iodine is 150 mcg per day in adults and 90-120 mcg per day in children less than 13 years of age. [2]The World Health Organization (WHO), United Nations Children's Fund (UNICEF), and the International Council for the Control of Iodine Deficiency Disorders (ICCIDD) recommend a higher iodine intake for pregnant women of 250 mcg per day. [3,4]The earth's soils contain varying amounts of iodine, which in turn affects the iodine content of crops. In some regions of the world, iodine-deficient soils are common, increasing the risk of iodine deficiency among people who consume foods primarily from those areas.[3]

Iodine deficiency has multiple adverse effects on growth and development, and is the most common cause of preventable mental retardation in the world. [3, 5] Basil Hetzel introduced the term "iodine deficiency disorders" (IDD) in 1983, transforming the world's understanding of the problem from the trivial "endemic Goitre" to a wide range of conditions, with the fetus and young children being especially vulnerable. [6]

As per the surveys conducted by the Directorate General of Health Services, Indian Council of Medical Research, Health institutions and the state health directorates, it has been found that out of 390 districts surveyed in all the 29 states and 7 Union Territories, 333 districts are endemic in India, i.e where the prevalence of IDDs is more than 5%. [7]

Approximately one third of the world's population lives in areas where natural sources of iodine are low, and therefore they require the permanent presence of iodine-supplying interventions. This population at risk of iodine deficiency is unevenly distributed across the world and within countries. [8] Communities from mountainous and hilly regions are at a higher risk of developing IDD due to the inherent nature of iodine cycle. Since 1994, the WHO and UNICEF have recommended universal salt iodization as a safe, cost-effective and sustainable strategy to ensure sufficient intake of iodine by all individuals.[9]

Salt iodization programs have dramatically reduced the prevalence of iodine deficiency worldwide. [3]More than 70 countries, including India, have salt iodization programs. As a result, approximately 70% of households worldwide use iodized salt. [3]

However, iodine content in salt at the consumption level and other factors like storage of salt, environmental factors, overall nutritional status and socio-economic status, also seem to contribute to the prevalence of IDDs. Identification of such predictors of poor iodine nutrition and targeted interventions in these communities can bring about an improvement in the prevalence IDDs and subsequent socio-economic benefits from it.

With this background, this study was carried out with the objectives to estimate the prevalence of iodine deficiency in coastal and hilly villages of south Odisha; and to analyse the predictors for poor iodine nutrition status in the community.

MATERIALS AND METHODS

This was a cross sectional study conducted between November 2015 to September 2016 in villages of two districts of South Odisha. The study population were children between 6 to 12 years of age and the heads of their households. Clearance from Institutional Ethical Committee was obtained prior to the start of the study.

Sample size estimation: An open source software, "A-Priori",was used to calculate the required sample size.[10] Assuming a medium strength effect size (0.15), power of 80%, statistically significant probability level at 0.05, and 6 predictors for logistic regression model, minimum needed sample size that was obtained was 97. This was rounded off to 100 from each area under study.

Sampling: One hilly district (Rayagada) and one coastal district (Ganjam) from the southern revenue division were selected by simple random sampling. 10 x 10 cluster sampling method was used for sampling from each district. The primary sampling units, the 10 villages per district, were selected by probability proportional to size. The secondary sampling units, the 10 households per village were selected by systematic random sampling. Households with at least one child aged between 6 to 12 years and a responsible adult willing to give informed consent were included for the study. A random house was selected in the main street/road of the village and every n^{th}house adjacent to this was visited,where "n" was a random number generated using a Smartphone app. Direction of sampling was determined by coin toss. If a house was locked or did not meet the selection criteria, then the adjoining house in the same direction was visited. The villages were visited on working days but timed so as not to coincide with school timings. This was done to ensure that children of the households were available at the time. Thus the final sample was 200 from the 2 districts.

Data collection: Informed consent was obtained from the adult responsible or the head of the household. A pre-designed and pre-tested questionnaire was used to record relevant data. Salt being used in the households was physically verified on site and a 15-20 gram sample was collected and stored in airtight screw capped containers till the time of analysis. Casual on the spot urine sample (5-10 ml) was collected from the children in wide mouthed screw capped plastic bottles containing one/two drops of toluene to act as preservative. The samples were stored in a refrigerator at 4°C until analysis. All samples were labelled adequately after collection. The children were assessed for goitre by inspection and palpation method. Anthropometric measurements were recorded for the studies children.

Laboratory Testing: Laboratory testing of salt samples for iodine content and urine iodine excretion was done in the Public Health laboratory of the Department of Community Medicine, MKCG Medical College. Salt iodine content was estimated by Iodometric titration and expressed as parts per million (ppm). Urinary iodine excretion was estimated by 'Wet Digestion Method (Sandell-Kalthoff)' and expressed in mcg/L of urine. [11]

Data assessment: A cut-off of 100 mcg/L or more was considered adequate for urine iodine excretion and 15 ppm for adequate household salt iodine content. The study population was categorized accordingly. Total goitre rate was estimated as a proportion. Updated BG Prasad's scale with the recent regional consumer price index value was used for determination of socio-economic status.[12,13] Malnutrition was assessed using Height-for-Age (Stunting) which is a good measure of chronic malnutrition.Children with z-scores < -2.00 of the CDC 2000 (Centers for Disease Control and Prevention) standardswere categorized as stunted.[14-16]

Data analysis: Descriptive statistics were obtained and appropriate tests of significance were used for univariate analysis. Median urine iodine was compared within the districts using Kruskal-Wallis test for independent samples.Binary logistic regression models were used for multivariate analysis to estimate strength of association. All tests were done at 95% confidence levels and level of significance was set at 0.05. Analysis was done at the Department of Community Medicine, MKCG Medical College using open source software GNU PSPP ver 0.9.0.

RESULTS

A total of 200 households were visited for the study and 120 males (60%) and 80 females (40%) were interviewed. The mean age of the interviewed adults was 34.5 years. The distribution was similar between the districts under study. The socio demographic characteristics of the households included in the study is given in table-01.

Urine samples were collected from 200 children. The mean age of the sampled children was 8.8 years (SD=1.4 years). The distribution was similar in both the districts. The total goitre rate was calculated to be 8.5%. TGR was significantly higher in the hilly district (15%) as compared to the coastal (2%). The urine iodine excretion ranged from 15.8 mcg/L to 181.2 mcg/L. The median UIE was 110.3 mcg/L. The UIE of the hilly district (Median=73.0 mcg/L) was significantly lower than the coastal district (Median= 126.4 mcg/L) (Independent samples Mann-Whitney U test; p<0.01). The mean household salt iodine content was 13.07 ppm. This was significantly lower in the hilly district (t-test; p<0.01).The prevalence of stunting was 19.5%. The hilly district had a significantly greater proportion of stunted children (26%) as compared to the coastal district (13%) (Chi sq=5.3; df=1; p=0.02). The distribution is given in table-02.

Among the respondents, 18% had knowledge about iodine deficiency disorders (IDD) and iodized salt.

Table-01: Socio-demographic characteristics of the study population

Socio-demographic characteristic	Coastal	Hilly	Total (%)
Religion			
Hindu	95	78	173 (86.5)
Muslim	2	0	2 (1.0)
Christian	3	22	25 (12.5)
Type of family			
Nuclear	55	63	118 (59.0)
Joint	11	8	19 (9.5)
3-Generation	34	29	63 (31.5)
Caste			
General/OBC	78	30	108 (54.0)
SC	17	5	22 (11.0)
ST	5	65	70 (35.0)
Occupation			
Agriculture	33	23	56 (28.0)
Labourer	36	40	76 (38.0)
Housewife/Unemployed	18	12	30 (15.0)
Dangara (forest gathering)	0	16	16 (8.0)
Other Skilled	13	9	22 (11.0)
Education of the head of household			
Illiterate	28	30	58 (29.0)
Primary	40	46	86 (43.0)
Secondary	15	7	22 (11.0)
Higher	17	17	34 (17.0)
Socio-economic status			
Upper	11	9	20 (10.0)
Middle	30	25	55 (27.5)
Lower	59	66	125 (62.5)

Table 2: Characteristics of the studied children

Characteristics	Coastal	Hilly	Total (%)
Gender			
Male	58	53	111 (55.5)
Female	42	47	89 (44.5)
Age group			
6-8 Years	31	41	72 (36.0)
8-10 Years	47	41	88 (44.0)
10-12 Years	22	18	40 (20.0)
Goitre			
Grade-01	2	6	8 (4.0)
Grade-02	0	9	9 (4.5)
TGR	2%	15%	8.5
UIE			
0-19.9 mcg/L	0	6	6 (3)
20-49.9 mcg/L	3	21	24 (12)
50-99.9 mcg/L	6	37	43 (21.5)
≥ 100 mcg/L	91	36	127 (63.5)
Median UIE (mcg/L)	126.4	73.0	110.3
Household salt Iodine			
<15 ppm	43	33	76 (38)
≥15 ppm	57	67	124 (62)
Mean (ppm)	14.91	11.23	13.07
SD (ppm)	±2.37	±3.98	±3.75
Stunting			
Yes	13	26	39 (19.5)
No	87	74	161 (80.5)

Upon inspection of salt storage in kitchen, 52.5% households stored their salt in airtight containers. UIE was less than 100 mcg/L in 36.5% (n=73) of the children. Salt iodine content was 15 ppm or above in 62% of the households.

Univariate analysis with chi-square test was performed between UIE adequacy and 6 variables categorized as given in table-03.Binary logistic regression model was created for the dependent variable UIE with cut-off at 100 mcg/L and 6 co-variates as given in table-03.

Table-03: Relationship between UIE and factors influencing it

Variables	Urine Iodine		P value	aOR (95% CI)	p-value for OR
	<100 mcg/L (n=73)(%)	≥ 100 mcg/L (n=127)(%)			
Region					
Coastal	9 (12.3)	91 (71.7)	<0.01**	1 (Ref)	<0.01**
Hilly	64 (87.7)	36 (28.3)		10.2 (2.8-36.6)	
Literacy					
Illiterate	29 (39.7)	27 (21.3)	<0.01**	2.25 (0.6-8.6)	0.23
Literate	44 (60.3)	100 (78.7)		1 (Ref)	
SES					
Upper	9 (12.3)	11 (8.7)	0.7	1 (Ref)	-
Middle	21 (28.8)	39 (30.7)		6.2 (0.47-83.7)	0.16
Low	43 (58.9)	77 (60.6)		9.6 (0.78-117.5)	0.07
Household salt iodine					
≥ 15 ppm	68 (93.2)	56 (44.1)	<0.01**	2.4 (1.7-3.3)	<0.01**
<15 ppm	5 (6.8)	71 (55.9)			
Storage Container					
Airtight	32 (43.8)	90 (70.9)	<0.01**	1 (Ref)	-
Not airtight	41 (56.2)	37 (29.1)		3.7 (1.0-13.8)	0.04*
Stunting					
Yes	25 (34.2)	14 (11)	<0.01**	9.8 (1.7-56.6)	-
No	48 (65.8)	113 (89)		1 (Ref)	0.01*

*Significant at p<.0.05; **Significant at p<.0.05; aOR=Adjusted OR

DISCUSSION

The present study was conducted to to estimate the prevalence of iodine deficiency in coastal and hilly districts of south Odisha and to analyse the predictors for poor iodine nutrition status in the community.

The TGR was found to be 8.5%.Goitre is a reflection of chronic iodine deficiency and can be used as a baseline assessment of a region's iodine status and as a sensitive long-term indicator for the success of an iodine program.[3]TGR was higher in the hilly district (15%) compared to coastal district (2%), which indicates mild iodine deficiency. According to NIDDCP, a district is declared as endemic if the TGR is above 5% in children of 6-12 years. Goitre prevalence rates between 5% and 10% may be associated with a range of abnormalities, including inadequate urinary iodine excretion and/or subnormal levels of TSH among adults, children and neonates.[17] Chudasama et al in a study in Saurashtra observed that Goiter prevalence ranged from 1% to 35%, and the overall prevalence was 8.8%. [18] In another study conducted by Sethy et al TGR was found to be 23.6%. In Odisha, TGR varied from 10.8 in Bargarh to 31.2% in tribal Kandhamal.[19]

The median UIE in coastal district was found to be 126.4 mcg/L, whereas it was 73.0 mcg/L in the hilly areas. Even though the iodine intake among children in coastal areas was adequate mild iodine deficiency was noted among children from hilly areas. The median is preferred as a measure of central tendency here as UIE in the populations is not normally distributed. The urinary iodine level is used as a valuable indicator for measuring the iodine nutritional status and for the assessment of IDD in an individual, because 90% of body iodine is excreted through urine. In children and non-pregnant women, median urinary iodine concentrations of between 100 mcg/L and 299 mcg/L define a population which has no iodine deficiency. In addition, not more than 20% of samples should be below 50 mcg/L.[3]In populations, median urinary iodine concentrations of 100-200 mcg/L indicate adequate iodine intake and optimal iodine nutrition.[20] Currently in India, there are no national data on the iodine status of the population based on UIE, although a number of small-scale surveys have been carried out in the past. A recent estimate pooled from such sub-national surveys indicated that the median UIE of the population was 154 mcg/L andthat 34% of Indians had UIE<100 mcg/L, indicating insufficient iodine intake.[21] However in another study by Kapil et al in the National capital region, the median UIE in children was found to be 200 µg/L. [22]A study by Moorty et al. in Odisha has shown that the range of UIE varied from 15.4 mcg/L to 204.4 mcg/L, with a median UIE of 85.4 mcg/L. Almost one third of the samples were having a UIE of less than 50 mcg/L and 60% had a UIE of less than 100 mcg/L.[23]

The mean household salt iodine content in the present study was significantly lower in the hilly district. The iodine level of more than 15 ppm was found in only 62% households. The Iodized Salt Coverage Study 2010 shows that the availability of adequately iodized salt at the household in Orissa has almost doubled from 32.4% in NFHS 3 in 2005-06 to 59% in 2010.[24] Consumption of iodised salt has increased but it is still way behind the USI target of 90% households consuming adequately iodised salt. In a study by Srivastava et al two-third (65.2%) of the households were consuming adequately iodized salt, while about one-fifth (21.5%) of the households were consuming inadequately iodized salt.[25] However Chudasama et al observed that the iodine level of more than 15 ppm was found in 81% of salt samples tested at the household level and in another study in the National capital region, the salt samples collected from study subjects revealed that 87% of salt samples had stipulated level of iodine of 15 ppm and more.[18, 22] It has been recommended by WHO/UNICEF/ ICCIDD that 90% of the household should get iodized salt at the level of 15 ppm for sustainable elimination of IDD as a public health problem.[3]

The knowledge about iodised salt was very low. The higher the knowledge / awareness about iodized salt, the greater is the presence of iodized salt in the household. The awareness is at the level of the head of the household.[24]

Upon inspection of salt storage in kitchen, nearly 50% households did not store their salt in airtight containers. A study by Roy et al observed that in rural areas, 87% stored the salt in closed containers. Improper storage of salt has a significant negative effect on it iodine content.[26]

Univariate analysis showed that there was statistically significant association between region, literacy status, household salt iodine, storage container and urinary iodine excretion.The results of logistic regression revealed that hilly region, household salt iodine content, storage of salt in non air tight containers andstunting were the main determinants of poor iodine nutrition.

It is an established fact that mountainous and hilly regions are prone to depleted iodine in the soil and subsequently in the crops produced resulting in a greater IDD prevalence. The "Goitre Belt" of the sub-Himalayan region is an example of this phenomenon. In such geographies, iodine supplementation with salt remains an effective source to prevent IDDs. Hence there may be a strong correlation between household salt iodine content and UIE.

Illiterates were at a greater risk of poor iodine nutrition. Literacy improves the awareness of the individual and family towards the identification and benefits of use of iodized salt and improves knowledge regarding IDDs and their prevention. Low SES households were at a greater risk of having poor UIE with an OR of 9.6 (95% CI: 0.78-117.5). This however, was not statistically significant. An overview of findings from the eight states reveals that, in fact, 64.7% of households in the richest wealth quintile have access to adequately iodized salt, whereas only 36.2% of those in the lowest wealth quintile have access. This data is evidence that the poorest households continue to be the most disadvantaged in terms of access to adequately iodized salt.[27]

Moisture plays a critical role in the stability of iodine. In particular, when salt is stored at a temperature characteristic of storage and distribution conditions in many developing countries, moisture absorbed by hygroscopic impurities is the major contributor to the rapid loss of iodine.[28]Stunting is a good measure of chronic malnourishment. Children born to iodine deficient pregnant women often results in stunted growth.[29] When fetal and neonatal hypo-thyroxinaemia occur after the first phase of maximal brain growth velocity, the long-term clinical consequence is severe thyroid insufficiency with stunted growth.[30]

CONCLUSION

A TGR of 15 % in the hilly region along with median UIE less than 100 mgc/L and household salt content less than 15 ppm indicates insufficient iodine intake and is associated with a risk of developing IDDs . Poor iodine nutrition was significantly associated with region, household salt iodine content, salt storage in non airtight containers and malnutrition.

A well-defined and compelling strategy is necessary in order to reach the last 30% of households that are likely to be least accessible and most socioeconomically disadvantaged.[20] Ensuring availability of adequately iodized salt, strengthening the monitoring system and intensive IEC activities, especially in the targeted population, are needed to eliminate IDDs.

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