Original Article

Iodine nutritional status and prevalence of goitre among school going children: a cross-sectional study to assess progress towards universal salt iodization in Tikamgarh district of Madhya Pradesh

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Background and Objectives: Iodine deficiency disorders (IDD) has been a major public health challenge for the Indian subcontinent over many years. Our study was conducted in Tikamgarh district of Madhya Pradesh, an iodine deficiency disorders-endemic district, with the objective to estimate total goitre rate and iodine nutrition status. **Methods and Study Design:** A cross-sectional study with 30 cluster sampling was conducted between June to July 2016 among school-going children in the age group of 6-12 years. Ninety children from each school (30x90=2700) were selected for the assessment of Goitre. Total 540 salt samples and 270 urine samples were collected to estimate salt iodine content from their house-hold and urine iodine excretion (UIE) respectively. A total of 150 households and 30 shopkeepers were interviewed to understand the awareness level for salt iodization. **Results:** Goitre rate in Tikamgarh district was 1.9% with prevalence of grade I & II was 1.7% and 0.2% respectively. The median UIE level was 200 mcg/L. The 20% the population had iodine deficiency, 28.9% population had adequate iodine nutrition and 51.1% population had either more than adequate level of iodine. The 72.4% of the population consume adequately iodized salt (≥15 ppm). **Conclusions:** Our study concludes that Tikamgarh district is non-endemic for IDDs against the earlier classification as an IDD-endemic district. About 20% population has 'iodine deficiency' and approximately 51.1% population has 'more than adequate iodine intake'. We recommend stringent programme monitoring, undertake periodic assessment of IDD and explore manifestations of excess iodine intake (≥300 mcg/L) such as Iodine-induced hyperthyroidism in future.

Key Words: iodine deficiency disorders, urinary iodine excretion, hyperthyroidism, iodine toxicity, cluster sampling

INTRODUCTION

Globally, iodine deficiency disorder (IDD) is the most common yet preventable cause of brain damage and mental retardation.[1] Conditions like cretinism, stillbirth, and miscarriage as well as an increase in infant mortality are some of the severe manifestation of IDD.[2] Iodine deficiency in its mild form can even cause a significant loss of cognitive ability and show symptoms like the goitre.[3] Approximately 38 million newborns remain unprotected from the lifelong consequences of brain damage associated with IDD every year in developing countries.[4]

IDD has been a major public health challenge over many years for the Indian subcontinent and its entire population is prone to disorders related to iodine deficiency.[5] Approximately 350 million population of Indian subcontinent are at risk of IDD.[5] A sample survey data published by Ministry of Health and Family Welfare (MoHFW) in 2006 showed that out of 325 districts surveyed in India, 263 districts are endemic for IDD with prevalence of above 10 per cent.[6]

The National Iodine Deficiency Disorder Control Programme (NIDDCP) under Ministry of Health and Family Welfare recognized universal salt iodization (USI) as the key strategy to eliminate IDD in the country. The national programme also aims to conduct periodic surveys to assess the magnitude of the IDD at an interval of five years, the supply of iodate salt, conduct laboratory monitoring of iodized salt and assess urinary iodine excretion. According to NIDDCP, district level surveys are to be conducted using three indicators, viz. Total goitre rate (TGR), Urinary Iodine Excretion (UIE) and household level adequately iodized salt consumption. Various studies across the country in past decade have reported TGR from 2.4% to as high as 38.2% and UIE from 70 to 225 μg/L.[7-14] Several studies have reported higher TGR among female than in the male.[11,12]

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The survey data published by MoHFW in 2006 showed that all 14 sampled districts surveyed in Madhya Pradesh were IDD-endemic which included Tikamgarh district.6 There have been several concentrated efforts under the umbrella of NIDDCP to reduce IDD prevalence among the population over a period of time since then. However, there have been few district level surveys that intended to assess the progress of NIDDCP and USI in the state of Madhya Pradesh since 2006. It is still assumed that prevalence of IDD is still high in the state. Studies undertaken in few districts of Madhya Pradesh in a different period of time have shown the TGR ranges from 2.4 to 21.3%, median UIE 109 µg/L, 21% household with adequately Iodized salt and 8% salt samples were reported without Iodine.[7,12,15]

Tikamgarh district was one among 14 IDD-endemic districts of Madhya Pradesh enlisted in revised policy guideline of NIDDCP of MoHFW, 2006.[6] However, Even after a period of 10 years, there has been no survey to assess the current status of IDD prevalence in the district. It is important to gauge the iodine adequacy status (UIE 100-199 µg/L) in the population and identify the level of iodine under nutrition as well as over-nutrition for potential toxicity threat[16].

Therefore, our study was conducted with an aim to assess the prevalence of IDD, urinary iodine excretion level among 6-12 years children. The second objective of the study was to determine the prevalence of household consuming adequate iodine in salt samples at the consumer level in 2016.

METHODS

Ethics approval

Ethics approval was obtained from the Institutional Ethics Committee, AIIMS Bhopal (IHEC-LOP/2016/EF0025) dated 15 Feb 2016. The written consent was obtained from children and ascent from their legal guardians after explaining them the purpose of a study.

Study site

Study was conducted in Tikamgarh district of Madhya Pradesh which is predominating caters rural population. It is located approximately at distance of 220 km north-east of state capital Bhopal. The district covers an area of 5048 km². It is one among 250 most backward district of India as per Ministry of Panchayati Raj. It is divided into 6 administrative blocks and has a total of 963 villages.[17] The population of the district is 1,445,166 with the literacy rate of 61.43%.[17] The percentage of boys and girls aged 6-17 years attending schools are 96.5% and 97.4% respectively. The literacy rate is 61%.[18]

Study population and period of study

The study was conducted from June to July 2016 among school-going children aged 6-12 years, in Tikamgarh district of Madhya Pradesh.

Study design

It was a cross-sectional study.

Sampling method and sample size

Clinical goitre survey

A sample of 30 schools was selected from the district by cluster sampling technique, using the method of 'probability proportionate to size' sampling in each school. A sample of 90 children (45 boys and 45 girls) of age group 6-12 years was selected from each school. Thus a total of 2700 (90X30) children were examined for goitre in the district. The children identified from respective schools were clinically examined for goitre by technical staffs, who are Medical Social Worker cum Laboratory technician under the supervision of Family Physician. The primary job of technical staff was community mobilization and obtaining blood and urine samples as per the Standard operating procedures under the project.[19]

The technical staff undergone the two week specialized training before the start of project to recognize the stages of Goitre in children. Salt samples: Every 5th child, selected from the sample of 90 children in the earlier steps for goitre survey, was covered for the collection of the salt sample by visiting their corresponding houses. Therefore, 18 salt samples were collected from each cluster. A total of 540 (18X30) salt samples were collected for estimation of iodine level in the district. These salt samples were tested qualitatively on spot with MBI kit and iodine concentration was recorded.

Urine samples

On the spot urine samples were collected from every alternate child out of those 18 selected children in the previous step. Total nine urine samples were henceforth collected for estimation of UIE level from each school. A total of 270 (9X30) urine samples were collected for estimation of UIE in the district. Urinary iodine estimation was estimated by the wet ashing method based on the Sandell–Koltoff reaction, using the perchloric acid vanadate system, originally used by Zak and Baginski, for serum protein bound iodine.[19]

Total 150 households & 30 shopkeepers were interviewed with the help of pre-designed semi-structured interview guide to understand the knowledge and practices on iodized salt during house visit to collect the salt samples.

Data collection and variables

Data collection was done a through structured, pretested questionnaire in local language i.e. Hindi. The information about independent was obtained by interview of the child by visiting the selected schools. The information was validated during the house-holds visit and during an interview with shopkeepers regarding USI. The assessment of goitre and their grade was done through clinical examination by technical persons specially trained for the survey. On the spot urine sample was collected from selected child at school for assessment of UIE. The sample of salt was obtained for biochemical estimation of iodine by visiting the corresponding house of selected child.

Analysis and statistics

Data was collected through paper-based proforma then entered in Microsoft office excel 2010 and quantitative analysis was done using software package SPSS. The key

Table 1. Block level prevalence of goitre, Tikamgarh district

Sl. No	Blocks	Prevalence (%)		TGR (%)
		Grade I	Grade II	
1.	Baldevgarh	1.38	0	1.38
2.	Jatara	1.94	0	1.94
3.	Niwari	2.5	0.5	3.0
4.	Palera	1.66	0	1.66
5.	Prithvipur	1.66	0.55	2.21
6.	Tikamgarh	3.88	0.27	4.15

TGR: Total Goitre Rate.

Table 2. Socio-demographic determinants of children with goitre in Tikamgarh district

Variable		Goitre		OR[¶] (95% CI)	*p*-value
		Present	Absent		
Age (in years)	6-9	37	1691	1.39 (0.76-2.55)	0.28
	10-12	15	957	Ref[††]	
Sex	Male	28	1322	1.17 (0.67-2.03)	0.57
	Female	24	1326	Ref[††]	
Religion	Hindu	51	2550	3.22 (0.44-23.58)	0.248
	Muslim	1	98	Ref[††]	
Caste	OBC[†]	36	1714	2.56 (0.35-18.34)	0.35
	SC[‡]	14	709	2.4 (0.31-18.48)	0.39
	ST[§,]	1	103	1.18 (0.07-19.17)	0.90
	General	1	122	Ref[††]	
Block	Baldevgarh	5	355	Ref [††]	
	Jatara	7	353	1.4 (0.44-4.47)	0.56
	Niwari	11	349	2.23 (0.76-6.5)	0.14
	Palera	6	354	1.2 (0.36-3.97)	0.76
	Prithvipur	8	352	1.61 (0.52-4.98)	0.4
	Tikamgarh	15	345	3.08 (1.1-8.58)	0.03

OBC: Other backward caste; SC: Schedule Caste; ST: Schedule Tribe.
[†]Other backward caste, [‡]Schedule Caste, [§]Schedule Tribe, [¶]Odds ratio [††]Reference.

analytic outputs were the presence of goitre (grade I and II), the household with 'inadequate iodized salt' and child with 'insufficient UIE'. The UIE <100 µg/L was considered as 'insufficient UIE and <15 ppm of iodine in household salt was considered as household with 'inadequate iodized salt'.[6,16] The STROBE guideline was used for reporting the quantitative component of the study.[20]

RESULTS

A total of 2700 primary school children aged 6-12 years from 30 different clusters were examined for TGR. The total goitre prevalence rate was found to be 1.9% with the prevalence of grade I & II was 1.7% and 0.2% respectively. No significant difference was found in TGR amongst the male (2.1%) and female (1.78%). Out of six blocks in the district, Tikamgarh block (4.15%) had highest TGR while Balderdash block (1.38%) had lowest TGR. The highest prevalence of grade-I Goitre was in Tikamgarh block and grade-II was in Prithvipur block (Table 1).

The study found that odds of children developing goitre in Tikamagarh block are 3.08 time higher than in Balvedgarh block (OR=3.08 [1.1-8.58], *p*-value=0.03). However, our study could not find any other statistical association between the presence of goitre (Grade I & II) and socio-demographic factors like age, sex, religion, Caste (Table 2).

Out of total analyzed 270 urine samples of the children studied, the median UIE level was 200 µg/L. On UIE level, 28.9% of the children had adequate urine iodine concentration (100-199 (µg/L), 20% children had sub-optimal urine iodine concentration (<100 µg/L), while 51.1% children had excess urine iodine concentration (≥200 µg/L). Out of 51.1% children with more than adequate urine iodine concentration, 29.6% of children had UIE ≥300 µg/L (Figure 1).

Total 24.1% households were consuming inadequate Iodised salt i.e. iodine content <15 ppm. Out study found that households of Niwari block had higher odds of consuming inadequate Iodised salt when compared with Balderdash block (OR=2.28 [1.10-4.72, *p*=0.02] (Table III). Similarly, the odds of household consuming inadequate Iodised salt is higher in Prithvipur block when compared with Balderdash block (OR=2.48 [1.16-5.28], *p*=0.01).

Out of 150 households interviewed for the type of salt consumption, 72.6% (109) households were using packet salt while 27.4% (41) were using loose salt. Further, in 72.7% households, family members were aware of iodized salt whereas, in 27.3 % households, family members were not aware of iodized salt. We interviewed 30 shopkeepers and found that 80% shopkeepers were selling packet salt and 56.7% shopkeepers were aware of iodization salt.

DISCUSSION

As per the data released by MoHFW in revised policy guideline of NIDDCP (2006), Tikamgarh district was

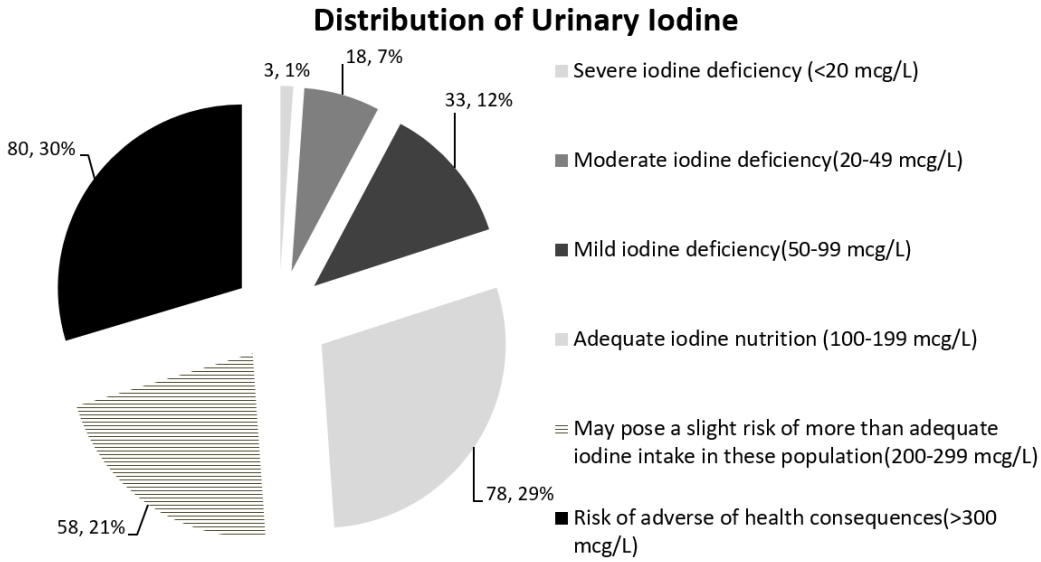

Figure 1. Population distribution of urinary iodine excretion levels in Tikamgarh district (n=270). The graph adopted from urinary iodine concentration for determining iodine status deficiency in population, WHO.[14]

Table 3. Socio-demographic determinants of children with adequate iodized salt intake

Variable		Household with Iodised salt		OR¶ (95% CI)	*p*-value
		Inadequate	Adequate		
Age (in years)	6-9	77	249	0.94 (0.63-1.4)	0.76
	10-12	53	161	Ref††	
Sex	Male	66	198	1.1 (0.74-1.64)	0.62
	Female	64	212	Ref††	
Religion	Hindu	124	394	0.84 (0.32-2.19)	0.72
	Muslim	6	16	Ref††	
Caste	OBC†	91	264	1.8 (0.60-5.41)	0.28
	SC‡	33	111	1.56 (0.50-4.86)	0.44
	ST§,	2	14	0.75 (0.12-4.66)	0.75
	General	4	21	Ref††	
Block	Baldevgarh	14	58	Ref††	
	Jatara	14	94	0.62 (0.27-1.38)	0.24
	Niwari	32	58	2.28 (1.10-4.72)	0.02
	Palera	10	62	0.67 (0.27-1.62)	0.37
	Prithvipur	27	45	2.48 (1.16-5.28)	0.01
	Tikamgarh	33	93	1.47 (0.72-2.97)	0.28

OBC: Other backward caste; SC: Schedule Caste; ST: Schedule Tribe.
†Other backward caste, ‡Schedule Caste, §Schedule Tribe, ¶Odds ratio ††Reference.

classified as one of the endemic districts for IDD in Madhya Pradesh (MP). However, our study found the TGR in Tikamgarh district was 1.9%, implying that it is no more an endemic for IDD (TGR >5%).[6] The majority of the goitre cases identified were in grade I (1.7% in Grade I). In past 10 years, there was no published study to reassess goitre prevalence in Tikamgarh district. A study conducted (the year 2000-2001) by RK Gakkhar et al in Jabalpur district of Madhya Pradesh found the total goitre prevalence of 2.4% among school-going children.[12] Similar studies available from different parts of Madhya Pradesh have conducted almost 10 years ago; hence, it would not be appropriate to compare those results with the present study.[12,15] Shinde et al in 2015 reported high goitre prevalence of 21.23% among school-going children in Central India.[7]

The median UIE level of 200 µg/L indicates no biochemical deficiency of iodine among the population; however, the median value falls marginally in "more than adequate iodine intake" category (200-299 µg/L). Approximately 20% population had sub-optimal Iodine nutrition and around half of the populations were having more than adequate iodine intake. Among the population found to have more than adequate iodine intake, around 29.6% were having excess iodine intake at the toxic level which may lead to adverse health consequence.[16] So, the major challenge for the programme will be to bring both the section of the population ("deficient iodine nutrition" group and "more than adequate iodine nutrition" group) into "adequate iodine nutrition" category. Currently, only 28.9% of the population had adequate iodine nutrition (100-199 µg/L).

Our study found that around 75.9% of the population were consuming adequately iodized salt (≥15 ppm). Recently published data under National Family Health Survey-4 (2015-16) also showed the similar result with 72.3% of the households consuming adequately iodized salt (≥15 ppm) in Tikamgarh district.[21] The momentum in

the district towards USI can also be ascertained by the fact that around 72.6% (109) households were consuming packet salt and in 72.7% households interviewed where family members were aware of iodized salt. Out of 30 shopkeepers interviewed, 80% shopkeepers were selling packet salt and 56.7% shopkeepers were aware of iodization salt.

For a remote district like Tikamgarh which borders to Jhansi and Lalitpur district of Uttar Pradesh, the journey from being identified as IDD endemic in 2006 to being iodine non-endemic district (TGR=1.9%), and a coverage of more than 75% of the population consuming adequately iodized salt; the achievement has been remarkable. It is the rights time to gear-up towards achieving USI status. The goal of USI is to cover more than 90% of the household to consume adequate iodized salt, the study findings indicate that Tikamgarh district is nearing the target of achieving universal salt iodization. Hence, programme need to be more vigilant through continuous monitoring, monitoring of non-iodized salt trading, regular salt testing towards achieving the targets.[1,6] Our findings suggest that NIDDCP should monitor not only USI but also the toxic effect of the iodine intake. Studies from different parts of the globe have reported iodine toxicity associated with USI. Countries like Zimbabwe, Denmark, Costa Rica and Guangxi Zhuang Region exposed to iodine excess, through iodine salt amalgamated with poor monitoring of the quality of the iodized salt led to increasing prevalence of iodine-induced hyperthyroidism after the introduction of USI in these countries.[21-23]

The strength of our study is that we had a rigorous study design which measured and quantified the IDD through internationally accepted tools.[1,6] The findings of this study are built over a large sample size representative of the whole district and with appropriate sampling design. Our reporting style is based on the internationally accepted guideline.[20] One of the limitations of our study may be the clinical evaluation of goitre. There are possibilities that misclassification of grades of goitre might have occurred at individual assessment level. We couldn't compare the prevalence of IDD of the district as the information of previous years was not available. It is assumed that due to USI the prevalence has decreased in last one decade.

The study has several programmatic implications and we make the following recommendations to the NIDDCP. First, USI should be made mandatory for every district. Second, re-assessment must be done at in all districts of Madhya Pradesh especially in the 14 districts enlisted as IDD-endemic in revised policy guideline of NIDDCP 2006 on the priority basis and re-assessment should continue in every five-year interval.[6] Third, there has to be an inbuilt mechanism to monitor the iodine toxicity like Iodine-induced hyperthyroidism.

The study concludes that the Tikamgarh district is non-endemic for IDD and there is no biochemical iodine deficiency. Although NIDDCP has been very effective in reducing the goitre prevalence, further action is required towards achieving elimination of IDD. A more worrying situation is the sub-optimal consumption (75.9%) of iodized salt which indicates that the district is yet to achieve the minimum target of universal salt iodization (>90%). A strict enforcement of mandatory sale of only iodized salt should be ensured to improve the coverage of iodized salt use. Effort should be made towards behavior change through various Information Education Communication (IEC) activities in the area. Identifying poor performing pockets, stringent action on non-iodized salt trading and regular salt testing may further improve the situation in the district. Approximately 20% population is having 'iodine deficiency' but at the same time approximately 51% population has either 'more than adequate iodine intake' or 'toxic level of iodine'. Similar observations about toxic level of urinary iodine were found in Damoh and Jabalpur Districts of Madhya Pradesh.[25,26] We recommend, apart from routine activities under NIDDCP, strict monitoring and evaluation through surveys to assess not only IDDs but also for Iodine-induced hyperthyroidism after every 5 years in the district.

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AUTHOR DISCLOSURES

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