ORIGINAL ARTICLE

Goitre and urinary iodine excretion survey in schoolchildren of Kashmir Valley

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Summary

Background An extensive survey on schoolchildren in Kashmir Valley in 1995 showed a high prevalence of goitre, making it imperative to have a relook at our iodine status, 15 years postiodization.

Objective To study the total prevalence of goitre and urinary iodine excretion (UIE) in Kashmiri schoolchildren, 15 years postiodization.

Design A cross-sectional survey, covering 9576 schoolchildren, aged 5–15 years (5988 in 6–12 year age group) was conducted. Goitres were graded as per WHO/UNICEF/ICCIDD. UIE was measured by the arsenic acid reduction in ceric ions method and was estimated in 208 subsampled children. Results were compared with that of 1995 survey.

Results The overall prevalence of goitre in the present study was 3·8% (95% CI: 3·4–4·2) and 3·7% (95% CI: 3·2–4·2) in those aged 6–12 years. No significant difference in prevalence of goitre was observed between boys and girls overall (3·6% *vs* 4·1%. $P > 0·2$), nor in the 6–12 year age group (3·3% *vs* 4·0%, $P > 0·1$). There was a significant trend of increasing prevalence of goitre with age ($P < 0·005$). UIE ranged from 12 to 397 μg/g.creatinine (median, 104); 11% subjects had UIE of <50 μg/g.creatinine. Overall, prevalence of goitre was significantly lower (3·8% *vs* 45·2%, $P < 0·001$), and mean UIE was significantly higher (123·6 ± 5·3 *vs* 49·60 ± 3·55 μg/g.creatinine, $P < 0·001$), compared to that in the 1995 survey.

Conclusion The marked improvement in overall iodine nutrition in Kashmir Valley- one and a half decades after implementation of salt iodization should encourage healthcare providers to make tangible efforts for implementation of iodization programmes in areas with iodine deficiency.

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Introduction

Iodine deficiency is the leading cause of preventable brain damage.[1] Appropriate iodine intake is necessary to maintain normal thyroid function and prevent iodine deficiency disorders (IDD). The World Health Organisation estimates that 2·2 billion people are at risk of IDD and has called for new efforts to eradicate the problem in the Member States with a high incidence of iodine deficiency.[1] A resolution has been accepted which urges a renewed cooperative effort to eliminate IDD.[2] IDD can easily be prevented by a simple and cost-effective measure of adding iodine to table salt.[3]

Kashmir Valley in the north Indian state of Jammu and Kashmir has been a known iodine-deficient area. In 1995, we showed a prevalence of goitre of 45% along with very low urinary iodine levels in an extensive survey on schoolchildren.[4,5] In some highland areas of the valley, prevalence was as high as 77%.[6–8] Further studies revealed wide availability and consumption of noniodized salt along with lack of awareness about IDD in the valley; only one-third of the population in the valley were consuming iodized salt.[9] Thereafter, a massive campaign was initiated for implementation of existing National IDD control programme by mobilizing the government machinery and civil society, and reinforcing an official ban on availability and sale of noniodized salt in Kashmir Valley. An awareness campaign regarding the magnitude of IDD and its easy and certain mitigation through salt iodization was launched through print and electronic media among the public in general and medical fraternity in particular. In addition, help was sought from political, socio-religious and community leaders, making them partners in the awareness campaign. As universal salt iodization started getting implemented, gradually the dividends started emerging making it imperative to have a relook at our iodine status, postiodization. This study presents the results from the first postiodization goitre survey in Kashmir Valley, conducted to estimate residual prevalence of goitre and UIE among schoolchildren, approximately fifteen years after salt iodization was initiated.

Methods

This study, like our previous study, was conducted on schoolchildren, aged 5–15 years; a total of 9576 students (5416 boys,

4160 girls), including 5988 in the age group of 6–12 years, were surveyed.

Study design

A cross-sectional study, conducted by adopting multistage sampling procedure,[10] in which prevalence of goitre in schoolchildren was used to gauge the severity of IDD in the valley according to WHO/UNICEF/ICCIDD recommended criteria.[11]

Selection of study population

As a first stage, the valley was stratified according to already well-defined districts (administrative units). As a second step, a frame of tehsils (administrative subunit) from each district was made from which a sample of sixteen tehsils was drawn on random basis, ensuring at least two tehsils per district. Finally, a list of schools from the randomly drawn tehsils was prepared and a selection of schools was drawn by simple randomization. From these randomly selected schools, all students in the age group of 5–15 years were selected for the survey. While finalizing, effort was made to keep the number of included students from each district proportionate to the population of the district as per the last census. In areas where the number of children in the selected school was fewer or only boys or girls were available, more than one school (one primary and one secondary, or one boys' school and one girls' school) were chosen at random.

The list of schools along with their specifications was obtained from the Directorate of School Education Kashmir. The number of districts and tehsils from each district was obtained from the latest records of the office of the Divisional Commissioner of Kashmir Valley. When the previous survey was conducted in 1995, there were only six districts viz, Srinagar, Budgam, Baramula, Kupwara, Pulwama and Anantnag. Over time, four more districts were carved out of these six districts making a total of ten districts in the valley. Although the present survey comprises subjects from all the ten districts, the original classification of districts was retained for comparison purposes with the previous study. However, to avoid confusion with the present 10-district classification, the term 'administrative unit' has been used instead of district.

Clinical survey of goitre

The selected schools were visited during school hours; selected children were clinically examined for the enlargement of thyroid (goitre) by palpation method endorsed by WHO/UNICEF/ICCIDD (Grade 0: no goitre; Grade 1: thyroid palpable but not visible; and Grade 2: thyroid visible with the neck in normal position).[11] The age of the students was recorded from the school register and was rounded off to the nearest whole number.

The children were examined in the open or a well-lit school office or classroom. The subject would face the examiner at a close distance with front of subject's neck well exposed to light. The presence of visible goitre was thus detected with the neck in the normal position (grade 2). The thyroid gland was then palpated with the subject turning his back to examiner in the standing position and the consistency/nodularity of the gland was assessed. Two trained and experienced observers (AA & JAB) who were retrained on a standardized palpation method examined the children. Some co-authors (SRM, AIW & MIB) supervised the execution of the study in each area.

A urine sample was collected from every 50th child examined during the survey for estimation of UIE. These random urine samples of 20–70 ml were collected into 100-ml capacity screw-capped, wide-mouthed, iodine-free plastic bottles with a well-fitting inner lid. A total of 208 urine samples were collected irrespective of sex and the presence or absence of goitre. The samples were immediately processed for creatinine estimation and then stored at 4 °C to be processed for iodine estimation.

Iodine estimation in urine

Urine samples were analysed using the ammonium persulfate digestion method, based on Sandell–Kolthoff reaction.[12] The principle is that iodide is the catalyst in the reduction in ceric ammonium sulphate (yellow) to cerous form (colourless), and is detected by rate of colour disappearance (Sandell–Kolthoff reaction).[13]

The urinary creatinine was estimated by Jaffe's reaction without deproteinization on a Bohringer Mannhein system 4030. The urine samples were diluted 1:50 in double distilled water before the estimation.

Sample size

The sample size was estimated using Epi Info™ [from Centers for Disease Control and Prevention (CDC), Atlanta GA, USA], with the presumption that the expected prevalence of goitre at the time of the survey was 23%.[14] A confidence level of 90%, a relative precision of 1%, and a design effect of two were entered for calculation of sample size; using these parameters a sample size of 9600 was obtained.

Data processing and statistical analysis

Data were keyed into Excel 2007, and entries were validated through frequency and cross-tabulations, and errors rectified against original data forms. Kappa statistics was used to test inter-observer or intra-observer agreement (or reliability), which was 92% (Kappa, 0·84; $P < 0·001$) and 94% (Kappa, 0·88; $P < 0·001$), respectively. Total prevalence of goitre was calculated by adding the number with grades 1 and 2 goitre and dividing by total examined. Data were analysed using Epi Info™ 7 (CDC Atlanta) and Statistical Package for Social Sciences (SPSS) version 11.5 (SPSS Inc., Chicago, IL, USA) using standard analytical and statistical methodology accepted for epidemiological studies. Number and percentage were calculated for categorical data. Pearson's Chi-square test and Fisher's exact test were applied to examine difference between proportions. For continuous quantitative data mean, standard deviation or standard error of the mean and median were calculated. The confidence intervals for the median were calculated according to Gardner and

Altman.[15] Data were checked for normal distribution with Kolmogorov–Smirnov test. For normally distributed data, unpaired *t*-test was applied, and for skewed data, Mann–Whitney test was used to compare difference between means. Two-tailed tests were performed, and a *P*-value of less than 0·05 was considered significant.

Results

A total of 9576 schoolchildren (5416 boys) aged 5–15 years including 5988 children (3143 boys) in the age group of 6–12 years were studied. The sample of selected children was drawn among 16 tehsils from all the administrative units (erstwhile six districts) of the valley. Age and sex distribution of study population is shown in Table 1. Overall, 363 (3·8%) children had different grades of goitre including 219 (3·7%) children with goitre in the age-group of 6–12 years (Table 2). Although the prevalence of goitre in the older peri-pubertal children, of 13–15 years age, was not significantly higher than that of children aged 6–12 years (4·4% *vs* 3·7%, *P* > 0·1), the trend of increasing goitre prevalence with age was statistically significant (*P* < 0·005; Fig. 1). There was no significant difference in prevalence of goitre between boys and girls, neither overall (3·6% *vs* 4·1%) nor in the age group of 6–12 years (3·3% *vs* 4·0%). Tehsil-wise prevalence of goitre in relation to their respective administrative units is shown in Table 3. As shown in the table, goitre prevalence varied from 1·8% (95% CI: 1·3–2·5) in administrative unit Srinagar to 6·1% (95% CI: 5·0 – 7·4) in erstwhile Pulwama district. The tehsil-wise goitre prevalence varied widely;

the respective prevalence in boys and girls ranging from 0 and 0·6% in the capital city of Srinagar to 6·3% and 8·3% in the hilly Shopian region of erstwhile Pulwama district (Table 3).

Urinary iodine excretion ranged from 12 to 397 *μ*g/g. of creatinine with a median of 104 and was less than 25 in 2%, 25–50 in 9%, 50–75 in 9%, 75–100 in 29% and 100 or more in the remaining 51%. Mean UIE values were lowest in the administrative unit Pulwama, which also had the highest goitre prevalence (Fig. 2). Overall, there was slight but significant correlation between goitre prevalence and UIE. Comparative analysis with that of 1995 survey showed a remarkable improvement in the iodine status of Kashmiri schoolchildren after 15 years of salt iodization (Table 4). As shown in the table, mean (±SEM) UIE was remarkably better than that of previous survey (123·6 ± 5·3 *vs* 49·6 ± 3·6 *μ*g/g. creatinine).

Discussion

Iodine is a micronutrient that is essential for normal human growth and development. While endemic goitre is the most visible consequence of iodine deficiency, the most significant and profound effects are on the developing brain. Iodine deficiency can cause a wide spectrum of devastating mental and physical disorders, collectively described as IDD. Although eliminated completely in a number of countries, iodine deficiency continues to persist in mild, moderate or severe forms in many parts of world, even in highly industrialized Western Europe.[16]

Our results show that, within the age range of 5–15 years, 3·79% of schoolchildren in Kashmir Valley in the northern

Table 1. Age and sex distribution of study population

Administrative area	<6 years			6–12 years			13–15 years		
	N	Boys (%)	Girls (%)	N	Boys (%)	Girls (%)	N	Boys (%)	Girls (%)
Srinagar (*n* = 1967)	109	64 (21·8)	45 (16·7)	1185	566 (18·0)	619 (21·8)	673	352 (17·8)	321 (30·7)
Budgam (*n* = 1405)	80	49 (16·7)	31 (11·5)	1148	640 (20·4)	508 (17·9)	177	119 (6·0)	58 (5·5)
Baramula (*n* = 1906)	118	51 (17·3)	67 (24·9)	1161	582 (18·5)	579 (20·4)	627	362 (18·3)	265 (25·3)
Kupwara (*n* = 959)	109	52 (17·7)	57 (21·2)	616	273 (8·7)	343 (12·1)	234	129 (6·5)	105 (10·0)
Pulwama (*n* = 1682)	58	36 (12·2)	22 (8·2)	887	554 (17·6)	333 (11·7)	737	629 (31·8)	108 (10·3)
Anantnag (*n* = 1657)	89	42 (14·3)	47 (17·5)	991	528 (16·8)	463 (16·3)	577	388 (19·6)	189 (18·1)
Total (*n* = 9576)	563	294 (100)	269 (100)	5988	3143 (100)	2845 (100)	3025	1979 (100)	1046 (100)

Table 2. Prevalence of goitre in the study population in various age groups

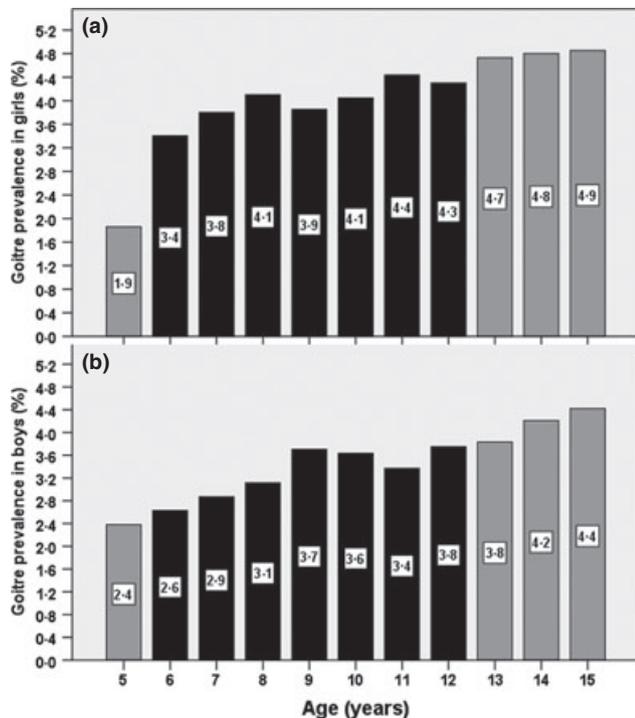| Age group (years)	N	Grade of goitre			Total no. with goitre	Total goitre prevalence * (%)	95% CI of goitre prevalence
		0 (%)	1 (%)	2 (%)			
<6	563	551 (97·9)	10 (1·8)	2 (0·4)	12	2·1	1·2–3·8
6–12	5988	5769 (96·3)	167 (2·8)	52 (0·9)	219	3·7	3·2–4·2
13–15	3025	2893 (95·6)	103 (3·4)	29 (1·0)	132	4·4	3·7–5·2
Total	9576	9213 (96·2)	280 (2·9)	83 (0·9)	363	3·8	3·4–4·2

*P = 0·026 (*vs* age group).

Fig. 1 Age-wise goitre prevalence in the study subjects, girls (a) and boys (b) showing a significant trend with increase in age ($P < 0.01$ in girls & <0.03 in boys). The dark bars show goitre prevalence in 6–12 year age group.

Table 3. Tehsil-wise goitre prevalence in the 6–12 age group as per administrative units (erstwhile districts)

Administrative unit	Tehsil	Goitre Boys (%)	Girls (%)	Total (%)
Srinagar		9 (1·6)*	13 (2·1)	22 (1·9)
	Ganderbal	2 (1·2)	6 (3·3)	8 (2·3)
	Kangan	7 (4·2)	5 (2·9)	12 (3·6)
	Srinagar	0	2 (0·7)	2 (0·4)
Budgam		23 (3·6)	20 (3·9)	43 (3·7)
	Budgam	7 (2·1)	8 (3·1)	15 (2·5)
	Chadoora	16 (5·3)	12 (4·8)	28 (5·1)
Baramula		24 (4·1)	30 (5·2)	54 (4·7)
	Baramula	4 (3·0)	14 (8·6)	18 (6·1)
	Pattan	10 (4·3)	5 (2·5)	15 (3·5)
	Sopore	10 (4·6)	11 (5·1)	21 (4·8)
Kupwara		7 (2·6)	15 (4·4)	22 (3·6)
	Handwara	3 (2·6)	9 (4·6)	12 (3·9)
	Kupwara	4 (2·5)	6 (4·1)	10 (3·3)
Pulwama		28 (5·1)	27 (8·1)	55 (6·2)
	Pulwama	17 (5·3)	8 (7·8)	25 (5·9)
	Shopian	8 (7·3)	9 (9·3)	17 (8·2)
	Tral	3 (2·4)	10 (7·5)	13 (5·0)
Anantnag		14 (2·7)	9 1·9)	23 (2·3)
	Anantnag	10 (5·8)	3 (1·8)	13 (3·9)
	Dooru	1 (0·5)	2 (1·6)	3 (0·9)
	Kulgam	3 (1·8)	4 (2·4)	7 (2·1)
Total		105 (3·3)†	114 (4·0)	219 (3·7)

*$P < 0.001$ (among administrative unit).
†$P > 0.1$ (boys *vs* girls).

Indian State of Jammu and Kashmir have goitre. In 1995, we reported that more than half of the Kashmiri population was iodine deficient, with 45% of schoolchildren having goitre.[4] The present study demonstrated an impressive improvement in iodine nutrition in Kashmir Valley, one and a half decades after the real implementation of universal salt iodization (USI). Kashmir has moved from a situation where only less than one-third of its population was using iodized salt,[9] and when the mean (±SEM) UIE was 49.6 ± 3.5 μg/g. creatinine[4] to one where 96% of the schoolchildren do not have a visible goitre and the mean UIE is 123.6 ± 5.3 μg/g creatinine. Despite an adequate median iodine intake (overall), this survey revealed evidence of iodine deficiency in some areas.

An estimate by the National Goitre Control Programme (NGCP), Ministry of Health, Government of India, revealed that approximately 300 million people were exposed to the risk of IDD throughout the country and over 60 million were goitrous.[17] A study carried out in Kangra Valley in 1973, a subHimalayan iodine depleted region, showed that after 6 years of iodized salt supplementation, there was an appreciable decline in prevalence of goitre from 40 to 15%.[18] After this landmark observation, the Government of India in 1987 decided to implement USI programme.[19] Subsequent impact evaluation showed a remarkable decline in neonatal hypothyroidism and prevalence of goitre and normalization of UIE within 5 years of salt iodization.[20] Despite these long-term national efforts to control and eradicate IDD with iodized salt at national level, prevalence of goitre in Kashmir Valley continued to be high with UIE less

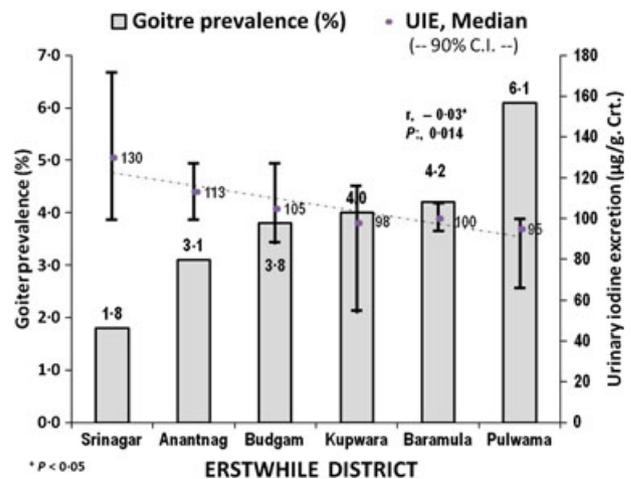**Fig. 2** Correlation of urinary iodine excretion (UIE) with goitre prevalence, administrative unit-wise.

than 50 μg/g.creatinine in half of the population, thereby indicating severe iodine deficiency.[4] Thereafter, a massive campaign was initiated for implementation of existing National IDD control programme and reinforcing the existing official ban on availability and sale of noniodized salt in Kashmir Valley. Now it has been more than 15 years since the National IDD control

Table 4. Statistical comparison of the current survey with that of 1995

Characteristic	1995 Survey	Current survey	P-value
Age group studied	5–15 years	5–15 years	–
No. of children surveyed	10 196	9576 (5988 in 6–12 years)	–
Proportion of girls	44·3%	43·4%	0·208
Proportion of children with goitre	45·2%	3·8%	<0·001
Grade I goitre	21·7%	2·9%	
Grade II goitre	16·1%	0·9%	
Grade III goitre	7·4%	0%	
Proportion of boys with goitre	46·2%	3·6%	<0·001
Proportion of girls with goitre	43·9%	4·1%	<0·001
No. of urine samples analysed	202	208	0·369
Mean UIE (μg/g.creatinine)	49·7 ± 3·5	123·6 ± 5·3	<0·001
UIE < 50 μg/g.creatinine	50%	11%	<0·001

UIE, urinary iodine excretion.

program was implemented here in Kashmir. Also, in the postsalt iodization phase, endemic goitre has been reported from many new areas in India.[21,22] Thus, it was important for us to re-examine the situation and to know the status of goitre in the postiodization era.

School-aged children are an appropriate population group for the assessment of iodine deficiency because of their high physiological vulnerability and their accessibility through school for testing.[17] In the present study, of the 9576 students studied, 363 had different grades of goitre with an overall prevalence of 3·79%; 280 had grade 1 goitre and 83 had grade 2 goitre. The prevalence of goitre was found to be 3·6% in boys and 4·1% in girls. The prevalence of goitre in the older (10–15 years) children was marginally higher than that in younger (5–10 years) children (4·2% vs 3·4%; P = 0·034). These results show a significant decrease in the prevalence of goitre in the study population as compared to the pre-iodization era.[4] In the 1995 pre-iodization survey by our department, of the 10 196 students studied, 4609 had different grades of goitre with an overall prevalence of 45·2%. Overall goitre prevalence was higher (P < 0·001) in children aged 11–15 years than in children aged 5–10 years. Goitre was more prevalent in males (46·23%) than in females (43·9%); male predominance was statistically significant (P < 0·025). In some highland areas of the valley, goitre prevalence was as high as 77%.[7]

The prevalence of goitre reported by our present study is consistent with recent studies from the sub-Himalayan belt. Toteja, et al.,[23] on behalf of ICMR, reported an overall goitre prevalence of 4·78% in 15 districts of 10 States. There are many other reports of goitre prevalence less than 10% in India,[24,25] though some have reported a slightly higher prevalence of goitre ranging from 11·3 to 13·1%.[26,27] Taken as a whole, various studies across India have revealed a wide-ranging prevalence of goitre of 1·5 to 44·5%.[28] However, the most recent studies on the subject from well-known authors in India reveal a goitre prevalence of 8·8% to 15·5%.[29–31]

Our study showed a prevalence of goitre of 3·8%, which is remarkably better than that reported in most other Indian studies. The likely reasons for much improved iodine status and prevalence of goitre in our population include awareness campaigns, wider availability and consumption of iodized salt, non-availability of noniodized salt (it is easier to enforce a ban in Kashmir because there is only one entry-point for supplies), and, improved socio-economic status. Also, it is quite possible to eliminate IDD as demonstrated by Hetzel et al., in his historical studies, carried out in the Highlands of Papua New Guinea, in collaboration with the Public Health Department of the Territory. A single injection of iodized oil was shown to correct severe iodine deficiency in subjects in the Highlands for over 4 years depending on the dosage.[31] However, the wide differences in goitre prevalence compared to other studies could also relate to differences in approaches and methods used, particularly use of ultrasonography to assess thyroid status.[32]

Goitre assessment by palpation or by ultrasound may be useful in assessing thyroid size but is difficult to interpret once salt iodization has begun.[17] Because the bioavailability of iodine is high, and about 90% of iodine consumed is excreted in urine, the urinary iodine serves as a good reflection of recent dietary iodine intake and therefore of iodine status.[13] In our study, urinary iodine ranged from 12 to 397 μg/g. creatinine with a median of 104; only 11% subjects had UIE of <50 μg/g. creatinine as compared to 50% having such low UIE in 1995 survey. These results suggest a remarkable improvement of iodine status of Kashmiri schoolchildren and hence of the population as a whole. We calculated urinary iodine in terms of micrograms per gram of creatinine for comparative analysis with our previous study, but it is pertinent to mention that relating urinary iodine to creatinine is cumbersome, expensive and described as unreliable by many.[17]

It is recommended that a goitre prevalence of 5% or more in schoolchildren be used to signal the presence of iodine deficiency as a public health problem.[17] This recommendation is based on the observation that in normal, iodine-replete populations, the prevalence of goitre should be quite low. Now that our goitre prevalence is only 3·8%, it is a triumph for all stakeholders, but it does not mean that iodine deficiency is no longer a public health problem in Kashmir. Already there are reports of re-emergence of iodine deficiency in populations that have been iodine replete for several decades.[33,34] A recent study from Australia reported that the iodine status of women in one region of New South Wales was low with a median UIE of 56 μg/l.[35] In addition, the authors also found that knowledge about iodine was poor with less than half New South Wales women associating low iodine status with adverse pregnancy outcomes.

With lifting of ban on the sale of noniodized salt and hiking of the freight for transporting salt by rail, there is a major drop in the household coverage of iodized salt in the rest of India.[36] With the opening of cross-border trade with neighbouring Pakistan, Kashmir Valley may no longer be a landlocked area where entry of noniodized salt could be banned at its only entry point, the Jawahar tunnel. Already, many trade items are finding their way into Kashmir, including much fancied red-rock salt, which is essentially a noniodized salt. With more urbanization

the problem may get further aggravated as more people may start using packaged, processed and restaurant foods. Because iodized salt is not used in the food industry, the risk of re-emergence of iodine deficiency remains high.

Therefore, there is a need for continued surveillance and timely periodic surveys like the present one to know the iodine status of our population. It is through surveys like this that one can know which way our society is going as a far as our iodine status is concerned. There is a genuine need of ban on sale of noniodized salt for human consumption. Some might argue 'Why is there a need for compulsory salt iodization and why can't people have a choice?' There are situations in which, in the absence of proper education, 'the freedom to choose' may not offer the right choice, and salt iodization is one of them. Individuals often need to be convinced to make good choices when the benefits are preventive in nature. Iodine deficiency disorder is an equally important public health issue for developing as well as developed countries. It could be a major threat to both the underdeveloped and the developed.

Acknowledgements

Disclosure

Nothing to declare.

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