Original Article

Assessing Adequacy of Iodine Intake among Children from 6 Months to 15 Years of Age from Hilly Terrains of North India

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ABSTRACT

Background: Routine outcome-based monitoring is required to assess the status of consumption of iodized salt as USI strategy. **Objective:** To assess the extent of recent iodine intake among children from 6 to 15 years of age in the hilly terrain of northern states of India. **Methods:** A school-based cross-sectional observational study among 227 children attending school was done for assessment of socio-demographic, dietary, salt consumption and urinary iodine concentration (UIC). **Results:** Mean age of children was about 6 years and 87.7% were consuming salt of >30 and none with <15 ppm iodine content. Median UIC was 138.0 µg/L. Among those assessed, 37.9% had adequate level of UIC, whereas about 20% and 40% participants had less (<99.0 µg/L) and more than adequate to excessive (≥200 µg/L) levels of UIC. Insignificant difference ($p = 0.07$) was observed for mean log UIC between cabbage eaters (2.3) and non-eaters (1.9) consuming salt >5 grams/day. **Conclusion:** Recent iodine intake among children observed to be inadequate and effect of cruciferous food items on UIC needs to be studied despite high coverage of iodized salt among children.

Keywords: Children, goitrogens, urinary iodine

Introduction

Childhood growth and development is largely affected by the nature of diet and extent of nutrition. Level of iodine in diet in the form of salt is largely recommended as Universal Salt Iodization (USI) is recommended under National Iodine Deficiency Disorders Control Programme (NIDDCP) to address the wide spectrum of Iodine Deficiency Disorders (IDDs) such as goiter, cretinism, dwarfism, still-births, abortions and mental retardation.[1] Iodine is needed for synthesis of the thyroid hormone which is further required for metabolism of fat, utilization of glucose and production of protein.[2] Its sufficient amount in the body positively affects development of bone and muscles of a growing child.[3] Generally, 100-150 µg per day is essential for the thyroid function to squeeze the spectrum of IDDs. USI strategy recommends 30 ppm of iodine in cooking salt at production level and 15 ppm at consumption level.[4] Nature of diet in terms of amount and mix of food items ensures adequacy of nutrients. Dietary profile changes in relation to economic environment of the country and affects the nutrition profile of people and children.

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Effect of iodization of salt was successfully tested in the study area of the current study from 1956-72 and evolved to NIDDCP. In addition to USI, supplementary strategies like ban on sale of non-iodized salt, raising awareness among people, quantification to estimate iodine content in salt, and state level USI surveys are recommended. Role of medical colleges in establishing laboratories for salt iodine quantification and surveys are promoted to scale-up.[5] Urinary assessment of iodine is recommended to ascertain recent iodine intake. Iodine excretion in urine has a tumultuous pattern and collection of 24-hour urine is recommended for assessment. In surveys, 24-hour collection of urine was observed to be a cumbersome method, therefore spot urine collection and median urinary

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iodine concentration (UIC) is usually recommended to measure the population level iodine intake.[6,7] Median UIC is used as an indicator to assess the iodine status and evaluation of iodine supplementation strategies at the population level.[8] Under programmatic settings, routine monitoring and evaluation of household consumption of iodized salt is recommended to track the reach of USI strategy. The current study is planned as a routine district level monitoring of NIDDCP with the objective to assess the extent of recent iodine intake among children from 6 to 15 year of age in northern state of India.

Materials and Methods

It was a community-based cross-sectional observational study carried out in two districts of Himachal Pradesh from September to December 2019. Assuming 95% confidence interval and 5% margin of error a sample size of 207 was calculated assuming prevalence of 16% of goiter among school children in the study area.[9] Therefore, for the purpose of the study a sample size of 228 [207 + 21 (10% non-participation rate for urinary samples)] children of age 6 to 15 years was considered for recruitment. In each district, two community health centers (CHC) were selected randomly; then from each CHC 15 schools (clusters) were selected using population proportion to size. In each school, the in-charge was briefed about the survey and permission was sought to recruit participants. In the presence of the school teacher, children were also briefed about the study and asked to bring one parent along with the salt sample in zip lock pouches, which were given to them. Next day, parents were briefed about the study and informed consent was taken.

A team of post-graduated and medical interns of the department of community medicine were trained for data collection techniques. A pre-tested, structured questionnaire was used to collect information for socio-economic, demography, consumption of iodized salt, consumption of goitrogenic vegetables, and urinary iodine. Measurement of salt consumption was done by standard spoons of small, medium, and large with a capacity of 5, 10, and 15 grams respectively. Parents were showed the photograph of the standard spoon and asked about the amount of salt per spoon and number of spoons used during cooking. Later on, the total amount of salt was divided by number of family members in the household to calculate salt consumption per person.

Collected sample of salt was tested for levels of iodine using rapid iodized salt testing (MBI) kit. It contained starch-based solution that caused a color-based reaction. Salt turned light blue or dark violet relative to iodine content. The cut-off of >15 ppm was considered for consumption of adequately iodized salt. Consumption and frequency in the last week of goitrogen vegetables were asked from the participants. Vegetables were listed based on dietary culture of the study area and their potential to reduce thyroidal iodine uptake. These were cauliflower, cabbage, turnip, and sweet potato.[10] After obtaining informed consent, questionnaire was administered by the interviewer and sterile urine container was handed to participants. They were given a wide opening screw capped double lid bottle for collection of spot random urine. Bottles were prelabelled with unique identifiers and handed over to participants with instructions. All samples were stored in refrigerator from the time of sampling to transportation to laboratory. At laboratory, samples were stored at minus 80°C until analysis of UIC. It was assessed using ammonium per sulphate digestion using spectrophotometer (ND 2000, Thermo Fisher Scientific, USA).[11] Median UIC of <99.0 μg/l were considered to be insufficient, 100-199 μg/l as adequate, 200-299 μg/l as more than adequate, and >300 μg/l as excessive iodine intake by participants.[7] Thyroid examination of children was carried out by inspection and palpation with anterior and lateral approach, from behind while the child was sitting on a chair with a slightly flexed neck. Classification of goiter was done according to the recommended criteria by WHO/UNICEF/ICCIDD and done previously in the same study area as: Grade-0: Not palpable; Grade-1: Palpable but not visible; Grade-2: Palpable and visible.[9]

Data was entered in Microsoft excel and analyzed using Epiinfo software (version: 7.2.3.1).[12] UIC levels were checked for normality and found to be positively skewed, therefore both mean and median values are reported. As normal distribution was observed after logarithmic transformation with base 10 of UIC level, so log UIC was used to assess the statistically significant difference. The study was approved by the Institutional Ethics Committee (IEC), Dr. RPGMC (IEC/121/2019; date 13/08/2019).

Results

A total of 227 children were surveyed with the mean age of about 6.0 ± 2.9 years (Median; 6 years; IQR: 3-8 year). Participants belonged to a household with median monthly family income of ₹8,000 (Mean: ₹13,044.0); 27.3% and 18.1% participant's family had income below 25th (₹5000.0) and above 75th (₹15,000) percentile respectively. Ground water reported to be common (46.7%) source of drinking water. Totally 185 (81.5%) participants were going to school (Public: 55.7; Private: 44.3%) and the rest were not eligible due to low age at the time of the survey. None of the participants was observed with goiter on examination.

Consumption of iodized salt (>15 ppm) at the family level was found to be 100% and the families of 199 (87.7%) participants were consuming salt with iodine content >30 ppm. Salt was reported to be stored in a container with a lid in 78.4% of families. Families of school going children (192) had an average salt consumption that was found to be 4.7 grams/person/day. About half (53.2%) of the participants were consuming salt less than 5 gram/day and 44.1% were consuming salt 6-10 grams/day. Among school going children, assessment for UIC was done among participants' mean and median values of 166.0 and 138.0 μg/L respectively. Among assessed, 22.2% had insufficient and 37.9% had adequate levels of median UIC, whereas 20.7% and 19.2% had more than adequate and excessive levels of median UIC. [Table 1]

Assessment for consumption of cruciferous vegetables and food items containing goitrogens was done where commonly eaten were cauliflower (96%), cabbage (82.4%), soyabean (63.9%), soya-nuggets (62.1%), turnip (55.5%), sweet potato (28.6%), and tofu (22.9%). Frequency distribution of vegetables on an average of one day in a week were; cauliflower: 1.3 ± 0.7; cabbage: 0.9 ± 0.6; soyabean: 0.7 ± 0.7; soya-nuggets: 0.9 ± 0.8; turnip: 0.6 ± 0.7; sweet potato: 0.3 ± 0.7; and tofu: 0.4 ± 0.7. As the listed vegetables reduce the iodine uptake at thyroid gland, median UIC was compared with frequency. Median UIC increases with increasing frequency in days per week for cabbage (133.4 to 155.6 µg/l), soyabean (157.2 to 165.5 µg/l), sweet-potato (157.0 to 200.8 µg/l), and tofu (160.0 to 207.3 µg/l). [Table 2].

Participants did not observe any significant deviation of UIC levels for eating vegetables and food items with goitrogen potential. About 40% of participants eating food items with goitrogen potential had more than adequate to excessive UIC. [Table 3].

Table 1: Salt Consumption and Iodine Excretion Among 227 Children of 6-15 Years of Age for IDDs Survey in Districts of Himachal Pradesh 2019

Characteristics	Values
Salt with adequate iodine of >30 ppm (%)	87.7
Can identify iodized salt (%)	72.3
Storage of salt in container with lid (%)	78.4
Mean salt intake in grams (SD)	4.7 (2.7)
Daily salt consumption in grams per person (%)	
<5	53.2
6-10	44.1
>10	2.7
Mean UIC in µg/L (SD)	166.0 (126.2)
Median Urinary Iodine in µg/L (IQR)	138.0 (71.0-235.0)
Iodine intake based on UIC (%)	
Insufficient (<99 µg/l)	22.2
Adequate (100-199 µg/l)	37.9
More than adequate (200-299 µg/l)	20.7
Excessive (>300 µg/l)	19.2

Non-significant difference was observed for mean log UIC between eaters and non-eaters of cauliflower (2.2 vs. 2.2; $P = 0.71$); cabbage (2.2 vs. 2.1; $P = 0.23$), soyabean (2.2 vs. 2.2; $P = 0.59$), soya-nuggets (2.2 vs. 2.2; $P = 0.83$), turnip (2.2 vs. 2.1; $P = 0.50$), sweet potato (2.2 vs. 2.2; $P = 0.86$), and tofu (2.2 vs. 2.1; $P = 0.45$). Mean log UIC was observed to be statistically similar ($p = 0.78$) among women consuming salt of >15 ppm (2.2) and >30 ppm (2.2).

Mean log UIC matrix for amount of daily salt consumption and vegetables consumption showed significantly more mean levels of log UIC among cabbage (2.3 vs. 1.9) and tofu (2.2 vs. 1.9) eaters as compared to non-eaters among participants consuming high consumption of salt. Non-cauliflower eaters who were consuming salt less and more than 5 grams a day were found with a non-significantly high mean value of log UIC. [Table 4].

Discussion

In the current study, assessment for goiter and extent of recent iodine intake was assessed among 227 school going children from 6 to 15 years of age in rural areas of Himachal Pradesh and no child with goiter was observed. Study participants had median UIC of 138.0 (Mean: 166.0) µg/L indicating the absence of population level of iodine deficiency. Overall, about 38% indicated adequate and 22% insufficient iodine intake. UIC suggested that about 40% children had more than adequate to excessive iodine intake. The current study observed that about 88% households of study participants were consuming salt >30 ppm. As a measure of success of monitoring progress of program required that more than 90% households should be consuming iodized salt and less than 50% of children had UIC below 100 µg/L.[7] These findings indicated the program to be progressing well to eliminate IDDs in the study area. It also indicates that there is no biochemical deficiency of iodine among children. Wide variation of UIC and consumption of iodized salt appears to be across geography and time period. UIC level in hilly terrains and plain settings around the study area observed with a range from 100 to 218 µg/L with consumption of adequately iodized salt from 46 to 82 percent.[9,13-17]

Salt is an essential and relatively cheap commodity in India and therefore chosen to be fortified with iodine to eliminate IDDs

Table 2: Matrix of Median UIC Between Cruciferous Vegetables and Their Consumption in Days Per Week Among 227 Children of 6-15 Years of Age for IDDs Survey in Districts of Himachal Pradesh 2019

Items	Days of Consumption in a Week					*P*
	0	1	2	3	4	
Cauliflower	136.0 (9)	171.2 (161)	169.2 (36)	138.9 (17)	115.0 (4)	0.67
Cabbage	133.4 (41)	174.6 (160)	165.7 (23)	155.6 (3)	-	0.33
Soyabean	157.2 (82)	171.6 (121)	157.3 (20)	277.0 (2)	165.5 (2)	0.63
Soya-nuggets	166.7 (87)	167.7 (76)	165.7 (60)	154.0 (4)	-	0.81
Turnip	160.0 (101)	171.4 (110)	180.0 (12)	167.6 (4)	-	0.66
Sweet potato	158.0 (162)	174.9 (41)	200.8 (24)	-	-	0.84
Tofu	160.0 (175)	143.1 (17)	207.3 (35)	-	-	0.21

Amount in parenthesis is number of children

Table 3: Relationship between UIC and Consumed Vegetables Among 227 Children of 6-15 Years of Age for IDDs Survey in Districts of Himachal Pradesh 2019

Items	UIC Levels (μg/L)				*P*
	Less (<99)	Adequate (100-199)	More than adequate (200-299)	Excessive (>300)	
Cauliflower	23.0	37.2	19.9	19.9	0.87
Cabbage	22.4	36.4	20.0	21.2	0.34
Soyabean	27.0	29.4	19.8	23.8	0.51
Soya-nuggets	23.2	36.0	20.8	20.0	0.89
Turnip	22.9	33.0	21.1	22.9	0.28
Sweet potato	26.2	34.4	14.8	24.6	0.93
Tofu	25.0	33.3	16.7	25.0	0.64

Table 4: Relationship between Mean Log UIC, Amount of Daily Salt Consumption, and Often Consumed Cruciferous Vegetables Among 227 Children of 6-15 Years of Age for IDDs Survey in Districts of Himachal Pradesh 2019

Items	Daily Salt Consumption (grams)	
	≤5	>5
Cauliflower		
Yes	2.1	2.2
No	2.3	2.4
P	0.30	0.96
Cabbage		
Yes	2.1	2.3
No	2.1	1.9
P	0.71	0.07
Soyabean		
Yes	2.1	2.2
No	2.1	2.3
P	0.75	0.30
Soya-nuggets		
Yes	2.1	2.2
No	2.1	2.2
P	0.75	0.99
Turnip		
Yes	2.2	2.2
No	2.1	2.2
P	0.10	0.97
Sweet potato		
Yes	2.2	2.2
No	2.1	2.2
P	0.44	0.66
Tofu		
Yes	2.2	2.2
No	2.1	1.9
P	0.44	0.54

among children. It is expected that consumption of iodized salt after adjusting for dose of fortification, iodine is expected to increase UIC to the effect of 1.59 μg/L (95%CI: 0.95-2.23).[18] So, USI is known as a key and an effective strategy to reduce population level iodine insufficiency. In India, the current study area gave an enriching evidence favoring salt iodization as USI is said be achieved if at least 90% households consume iodized salt.[1,19] Population can be at risk of iodine insufficiency when coverage of iodized salt falls below 90% consistently over two years.[20] Since the current study was a point estimate and coverage of adequately iodized salt is found to be hundred percent. However, it is observed that despite the high levels of salt iodization, persistence of IDDs were reported and were largely attributed to effective implementation to ensure its availability.[21] Therefore, efforts need to be continued to ensure universal coverage of iodized salt but also an eye is required at possible explanations for low levels of population level of median UIC which could affect thyroid function.

We carried out a sub-group analysis to assess an alternative possibility of low median UIC despite high coverage of iodized salt. It was done for consumption of food items which affects uptake of iodine by thyroid gland influences. It could give rise to a condition of effective iodine inadequacy despite supplementation.[22]

Evidence found that lower UIC is associated with overconsumption of goitrogenic food items and underconsumption of iodized salt. Frequent cabbage consumption was observed to be associated with low UIC.[23] Although insignificant, median UIC was observed to be low among frequent eaters of cauliflower, cabbage, and soya nuggets. Unexpectedly, low median UIC was observed among non-eaters of cruciferous food items and high UIC in relatively frequent eaters of turnip and sweet potato. Moreover, distribution of participants with high UIC indicating excessive intake of iodine was almost same about 40% for types of cruciferous food items. Relationship of mean log UIC was observed to be insignificantly high among cabbage eaters as compare to non-eaters (2.3 vs. 1.9; $P = 0.07$) with high consumption of salt of more than 5 grams/day.

This study has some limitations that could explain the results and affect generalizability. Firstly, UIC estimation based on spot over 24-hour urine sample could underestimate the estimate about recent iodine intake. However, it is observed that at group level, spot urine sample provides similar estimates to a 24-hour sample for suboptimal UIC (<100 μg/L) iodine status and provides reasonable estimate for UIC.[24] Secondly, sub-group analysis could be limited due to inadequate number in respective categories especially the frequency of consumption of cruciferous food items. Thirdly, inability to quantify the consumption of vegetables could have limited the assessment of their association with UIC. Valid nutritional assessment techniques need to be administered to differentiate frequency of consumption. With an adequate sample size, household-based assessment for valid quantification of consumption of vegetables and salt could have provided valid measures to assess the association. Fourthly, thyroid examination was carried out by one person, so inter-observer variation was not assessed, although it was carried out by a trained medical graduate.

The current study did not observe a single case of clinical goiter and has achieved recommended monitoring indicators of NIDDCP in the study area. However, observance of relatively low population level median UIC indicates underlying possible thyroid function among participants due to impersistent iodine levels. So, an area which has surmounted the set monitoring indicators can proceed for ultrasonographic assessment of the thyroid gland either in a sub-sample of children during survey or at outpatient settings of hospitals/facilities. In addition, prospective household-based cohort study could answer the question that whether frequent consumption of cruciferous food item(s) lowers median UIC despite the consumption of adequately iodized salt (>15 ppm)?

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Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the parents of children have described about purpose of study, right to withdraw from study, and utilization of information to be reported in the journal. The parents understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity can be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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