Iodine Deficiency during Preconception Period of Adolescent Girls Residing in a District of Rajasthan, India

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Abstract

Background: In India, iodine deficiency (ID) still remains a serious concern even after five decades of enormous efforts. ID during the preconception period of adolescent girls may negatively affect future neonates, resulting in neonatal hypothyroidism. Hence, the present study was conducted to assess the prevalence of goiter and associated factors among adolescent girls in a poor socioeconomic district of Rajasthan. **Methodology:** A cross-sectional study was conducted during January–March 2015 in Tonk district of Rajasthan. A total of 1912 adolescent girls were selected from thirty schools using population proportionate to size sampling. Adolescent girls were clinically examined for thyroid using palpation method. Casual urine ($n = 344$) and salt samples ($n = 370$) were collected from a subgroup of girls for the estimation of urinary iodine concentration (UIC) and iodine content in salt, respectively. **Results:** The overall goiter prevalence was 15.3% (95% confidence interval 13.6%–16.9%) and the median UIC was 266 μg/l (interquartile range: 150–300 μg/l) among 1912 adolescent girls (age, 15.7 ± 1.4 years). Around 16.8% of the families of adolescent girls were consuming salt with inadequate iodine (<15 ppm). Goiter prevalence was statistically significantly different with respect to age groups ($P = 0.03$). There was no statistically significant difference in goiter prevalence with respect to iodine content of salt ($P = 0.98$) and UIC ($P = 0.41$). The median UIC increased with an increase in consumption of iodine content of salt from inadequacy to adequacy ($P = 0.15$). **Conclusion:** Adolescent girls, residing in an underdeveloped district, are in the transition phase from mild ID (goiter prevalence 15.3%) to iodine sufficiency (median UIC 266 μg/l).

Keywords: Adolescent girls, goiter, iodine deficiency, urinary iodine concentration

INTRODUCTION

Iodine deficiency (ID) still remains a significant problem in both developed and developing countries, even after decades of tremendous efforts.[1] According to the International Child Development Steering Group, ID has been found as one of the four key global health factors responsible for impaired child development.[2] Even today, around two billion people worldwide have insufficient iodine intake, of whom 246 million are children, who are at risk of the detrimental effects of ID. The health consequences of ID include endemic goiter, cretinism, intellectual impairment, growth retardation, neonatal hypothyroidism, and miscarriages.[1]

Adolescent girls are future mothers. Today, the overall health and nutritional status of adolescent girls are being placed at the center of the global agenda due to the changeover from millennium development goals to sustainable development goals. The poor nutritional status of adolescent girls not only negatively affects their well-being but also worsens maternal and newborn health if they do become pregnant.[3] However, it has already been studied that mild ID during the initial stages of development of fetus may impair the neurological development.[4]

In India, around 200 million people are at risk of ID, whereas more than 71 million people suffer from goiter and other ID disorders (IDDs). The Indian Council of Medical Research survey has been conducted in eight states and seven union

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territories, which revealed that out of 324 districts, 263 districts have been found to be endemic for IDDs. Earlier, ID was a serious problem only in the Himalayan goiter belt. However, recently, various studies have documented the endemic foci of ID outside the conventional goiter belt. National reports have been documented that no state is free from the problem of ID.[5]

Still, there is paucity of data on the status of ID among adolescent girls in the state of Rajasthan. Against this backdrop, the present cross-sectional study was conducted with the objective to assess the prevalence of goiter and factors associated with ID among adolescent girls in Tonk district of Rajasthan state, India.

METHODOLOGY

The present cross-sectional study was conducted during the period of January to March 2015 in Tonk district, which is situated in the northeastern part of Rajasthan state. In 2006, the Ministry of Panchayati Raj ranked Tonk as one of the districts in the list of backwardness: low agricultural production and wages, poor socioeconomic status, and high population of scheduled caste/scheduled tribes.[6]

Calculation of sample size

With an anticipated prevalence of ID as 15%, with a confidence level of 95%, an absolute precision of 2.0, a power of 80%, and a design effect of 1.5, a minimum of 1837 adolescent girls were estimated to be enrolled in the study.

Sampling procedure

School-based approach was utilized to cover adolescent girls as enrollment of girls in school is ≥90% in Rajasthan. All the senior secondary schools in rural and urban areas with their respective girls' enrollments were enlisted, and a total of thirty schools were selected by employing population proportionate to size sampling technique. From each school, we planned to enroll a minimum of 61 adolescent girls (1837/30 = 61.2) for goiter assessment and planned to randomly select ten for urine and salt sample collection, i.e., a minimum of 300 in each group.

Inclusion and exclusion criteria

All the girls aged 13–18 years, who were present in the school on the day of survey, were considered for selecting the sample size. Girls who denied to participate or were having menstruation cycle on the day of survey were excluded from the study.

Data collection

Prior permission from relevant authorities was taken to conduct the survey in the school, and prior information pertaining to the assessment of iodine status among adolescent girls was given to the selected schools. Date and time were decided as per the convenience of the school. All girls were briefed about the objectives of the study. In each school, all the girls were categorized and arranged as per their age groups: 13–14, 15–16, and 17–18 years. With the help of a random number

table, a total of 21 girls were selected from each age group. Each girl was clinically examined for thyroid. Goiter was defined as a condition when "each of the lateral lobes of the thyroid gland is larger than the terminal phalanges of the thumb of the person examined."[7] A single investigator conducted the clinical examination of thyroid using palpation method. The intraobserver variation was controlled by getting prior training, retraining, and random examination of goiter grades by an expert. When in doubt, the immediate lower grade was noted. Goiter grading was done as per the criteria jointly recommended by the World Health Organization (WHO)/ United Nations Children's Fund (UNICEF)/International Council for Control of IDDs (ICCIDD).[8] The total goiter rate (TGR) is the sum of participants with goiter grades 1 and 2.

Girls randomly selected for urine samples were provided sterile plastic bottles with screw caps to collect urine sample. These samples were transported to the institutional laboratory within 24 h of collection and stored at 4°C to prevent bacterial growth. The analysis of urinary iodine concentration (UIC) was done within 2 months of urine sample collection. Participants selected for salt samples were requested to bring four teaspoons of salt (about 20 g) from their family kitchen. Salt samples were collected in autoseal polythene pouches. Identification details of each participant were filled in identification slips and kept in the pouches along with the collected salt samples. The pouches were stored at an ambient temperature away from direct sunlight.

Biochemical analysis

Urine and salt samples were transported to the WHO Regional Laboratory, Human Nutrition Unit, AIIMS, New Delhi, in cold boxes for iodine analysis. Iodine concentration of urine sample was analyzed by utilizing wet digestion method.[9] The median UIC <100 µg/l was considered as the indicator of ID.[8] The iodine content of the salt was analyzed by standard iodometric titration method.[10] Salt samples with iodine content <15 ppm were categorized as salts with inadequate iodine.[8]

Quality control measures

Internal quality control (IQC) methodology was adopted during UIC analysis. A pooled urine sample was prepared which was considered the IQC sample. It was analyzed hundred times with standards and blank in duplicate. The mean (X) UIC and standard deviation (SD) of the IQC sample were calculated. The IQC sample was stored in the refrigerator. The 95% confidence interval (CI) for the mean UIC of the IQC sample was then calculated. This was used as the operating control range. The sample mean (X) ±2SD was used to calculate lower concentration value (LCV) and upper concentration value (UCV). A regular linear graph paper was utilized to prepare Levey–Jennings plot. The operating control range for the IQC sample was 8.9–12.5 µg/l. The mean UIC (10.7 µg/l) of the IQC sample was plotted as a continuous horizontal line on the Y-axis. The LCV (8.9 µg/l) and UCV (12.5 µg/l) were plotted below and above the mean line on the Y-axis scale, respectively. The X-axis was used to plot the date on which

the IQC sample was analyzed. This chart was used to plot the date-specific analysis. The IQC sample was analyzed with every batch of UIC estimation. The UIC was obtained for the IQC sample for each batch. If the value of the IQC sample was between the operating control ranges, then the UIC test was deemed in control, and all results were accepted. If any value of the IQC sample was plotted outside the operating control range, then the test was considered as out of control, and the entire batch was repeated.[11]

Statistical analysis

Data were entered, cleaned, and managed in Microsoft Excel spreadsheet. The Statistical Package for the Social Sciences version 22.0 statistical software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp) was used for statistical analysis of data. Categorical data were presented as frequency or proportion with 95% of CI. Continuous data were presented as either mean with SD or median with interquartile range (IQR). Histogram with normal curve was plotted to show the frequency distribution of UIC and iodine content of salt consumed by participants. Chi-square test was used to compare two proportions, whereas Fisher's exact test was used as and when required. Kruskal–Wallis test was used to compare more than two groups, whereas Mann–Whitney U-test was used to compare two groups with nonparametric distribution. Chi-square test and odds ratio were calculated to document the association between goiter, UIC, and salt iodine content. The difference was considered statistically significant at $P < 0.05$.

Ethical consideration

Ethical clearance was obtained from the Ethical Committee of Banasthali University. All procedures performed in the study involving human participants were in accordance with the ethical standards and with 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consents were obtained from all the study participants.

RESULTS

A total of 1912 adolescent girls were included in the study. The median number of participants enrolled per cluster was 63 (IQR: 62–65). The mean age of adolescent girls was 15.7 ± 1.4 years. The proportion of girls was higher in 15–16 years (46.3%), followed by 17–18 (32.1%) and 13–14 years (21.6%).

In the present study, the overall goiter prevalence was found to be 15.3% (95% CI: 13.6–16.9), indicating mild ID among the studied population. Out of 15.3% of participants with goiter, 14.3% had Grade 1 goiter and the remaining had Grade 2. The TGR was found to be higher in girls aged 13–14 (18.7%) years, followed by 15–16 (15.4%) years and then 17–18 years (12.7%) and was statistically significantly different among the three age groups ($P = 0.03$). It was also found that there was no statistically significant difference in goiter prevalence with respect to girls consuming salt with inadequate and adequate iodine ($P = 0.98$).

Urine samples were collected from 344 adolescent girls. The median UIC was found to be 266 µg/l (IQR: 150–300), which indicated adequate iodine status among adolescent girls. The percentages of participants with UIC <50, 50–99, 100–199, 200–299, and 300 µg/l and above were 4.1%, 7.0%, 23.3%, 17.1%, and 48.5%, respectively.

The mean UIC was not statistically significantly different with respect to the age groups of 13–14, 15–16, and 17–18 years ($P = 0.45$). The median UIC (µg/l) decreased with increasing age from 300 (IQR, 174–300) in 13–14 years to 274 (IQR, 150–300) in 15–16 years and 250 (IQR, 150–300) in 17–18 years. Urinary iodine ranged from 10 to >300 µg/l. Participants with insufficient iodine intake (UIC <100 µg/l) were different among three age groups, but not at a statistically significant level ($P = 0.41$).

Histogram in Figure 1a shows the frequency distribution of UIC levels of adolescent girls. The mean UIC (µg/l) of the 344 urine samples was 224.2 ± 89.2. The histogram is slightly skewed to the left, which is negatively skewed as most of the urine samples had their iodine concentration nearby 300 µg/l.

A total of 370 salt samples were collected from girls. It was found that 1.4% of the salt samples had no iodine at consumption level. Participants consuming salt with inadequate iodine content (<15 ppm) and adequate (≥15 ppm) were 16.8% and 83.2%, respectively. Histogram in Figure 1b displays the frequency distribution of iodine content of household salt consumed by families of girls. The mean iodine (ppm) of 370 salt samples was 25.4 ± 11.3. The distribution of iodine content of salt was observed to be symmetrical.

It was observed that the mean UIC did not differ statistically significantly with respect to girls categorized as per their consumption of iodine content of salt: 0, 0.1–14.9, 15.0–29.9, and ≥30 ppm ($P = 0.15$). As the subject consumption of iodine content of salt increased from 0 to >30 ppm, the median UIC increased from 174 to 300 µg/l, but not at a statistically significant level ($P = 0.27$). Histograms in Figure 1c and d show the distribution of UIC of girls, consuming salt with iodine content, either inadequate (<15 ppm) or adequate (≥15 ppm). The mean UIC of those consuming salt with inadequate iodine was lower (204.0 ± 96.8) than those consuming adequately iodized (226.9 ± 87.6); however, it was statistically not significant ($P = 0.08$). With an increase in iodine content of salt, a slight change was observed in the shape and location of the UIC curve with respect to iodine content of salt.

DISCUSSION

If TGR is >5%, it indicates public health problem of ID. However, the present study documented TGR as 15.3%, indicating mild endemicity of ID in the population studied. Similarly, a recent study conducted among adolescent girls in Udham Singh Nagar, Nainital, and Pauri-Garhwal regions of Uttarakhand documented the prevalence of goiter as 6.8%, 8.2%, and 5.6%, respectively.[12] Our study also found
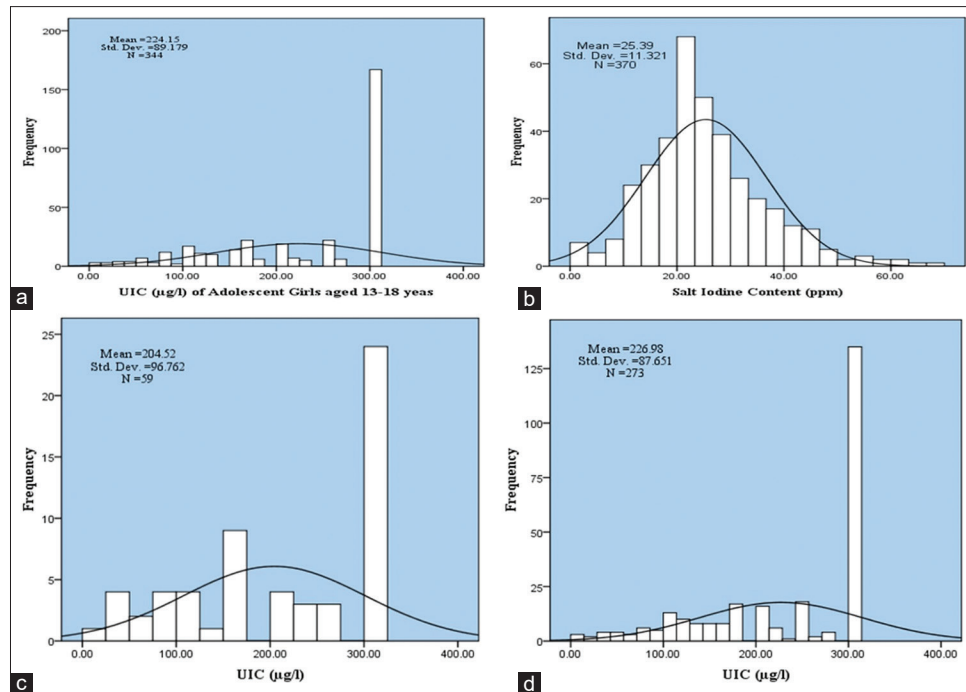
Figure 1: Distribution of urinary iodine concentration and iodine content of salt. (a) Frequency distribution of urinary iodine concentration (μg/l) of adolescent girls. (b) - Frequency distribution of iodine content of salt (ppm) consumed by adolescent girls. (c) - Frequency distribution of urinary iodine concentration of adolescent girls consuming salt with iodine content <15 ppm. (d) - Frequency distribution of urinary iodine concentration of adolescent girls consuming salt with iodine content ≥15 ppm

a significant difference in goiter prevalence with respect to 13–14, 15–16, and 17–18 years of age groups.

It is recommended that the median UIC of >100 μg/l shows no ID among the study population. This study revealed the median UIC as 266 μg/l, which indicated adequate iodine intake among adolescent girls. Similar findings of 250, 200, and 185 μg/l of UIC were reported by a recent study from Uttarakhand.[12] Earlier, two studies conducted in Bangladesh among adolescents have reported a median UIC level of 186.3 and 135 μg/l.[13,14]

It is an interesting combination of mild endemicity of ID with adequate UIC in the population. This can be explained as TGR indicates past or chronic deficiency of iodine in the body and UIC indicates the current or acute status of iodine levels in the body. Therefore, our finding indicates that the population is currently showing features of past chronic ID with current adequate intake of iodine.

WHO/UNICEF/ICCIDD suggests that household coverage of iodized salt should be >90%. However, in the present study, we found that 83.2% of adolescent girls were consuming sufficiently iodized salt, which was below the satisfactory cutoff. Similarly, in Haryana, which is a nearby state of Rajasthan, about 70% of households were found using salt with stipulated iodine levels.[15] Earlier, a decade back, a study from Rajasthan reported about 60% of families of pregnant mothers consuming inadequately iodized salt.[16]

A possible intraobserver variability during goiter examination could be a limitation of our study, which we tried to control

by repeated training and random examination of goiter grades by an expert. Although there is still the possibility for misclassification of a normal thyroid gland as goiter grade 1 and *vice versa* i.e. goiter grade 1 as normal thyroid gland. Due to the scarcity of resources, the size of the thyroid gland could not be assessed using ultrasound.

Conclusion

TGR shows past chronic iodine status and UIC shows current iodine intake. In conclusion, the findings suggest that the study population, of a district with poor socioeconomic status, is in the transition phase from ID (goiter prevalence 15.3%) to sufficiency (median UIC 266 μg/l). There is a need to reinforce regular monitoring and evaluation of the National Iodine Deficiency Disorder Control Program in the district.

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Conflicts of interest
There are no conflicts of interest.

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