URINARY IODINE LEVELS IN THREE ECOLOGICAL ZONES OF BANGLADESH

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ABSTRACT

Urinary iodine levels in children (5-11 years) and in adult males and females (15-44 years) of three ecological zones (hilly, flood-prone and plains) of Bangladesh were analyzed to determine the status of biochemical iodine deficiency in the country. Data indicated that a large majority of the population all over Bangladesh have biochemical iodine deficiency urinary iodine excretion (UIE) less than the accepted cut-off level of 10 µg/dl. Adults were deficient to comparable degrees, 31.3% severely iodine deficient. The flood-prone zone was less affected: 71.7% children had iodine deficiency and 25% were severely deficient. Adults of this zone were less affected than the children. Iodine deficiency was least severe in the plain zone: 59.8% children were biochemically iodine deficient and of them 23.4% had UIE less than 2.0 µg/dl. In the case of the adults of this zone, 60.8% were biochemically iodine deficient and 20.6% had severe iodine deficiency. The results indicate that Bangladesh as a whole is an iodine deficient region, with the hilly zone being the most severely affected. Children were slightly more affected than the adults, and females were more affected than the males.

KEYWORDS: Iodine Deficiency Disorders (IDD), Urinary iodine

INTRODUCTION

Iodine deficiency disorders (IDD) are recognized as a global public health problem today. A quarter of the world's population - nearly 1.6 billion people in 118 countries are estimated to be at risk of the deficiency. Fifty million children suffer from varying degrees of IDD; of these, an estimated 100,000 are born cretins every year (1). South East Asia shares the largest rates of prevalence of IDD (486 million at risk and 176 million goitrous), with Bangladesh, Bhutan, India, Indonesia, Myanmar, Nepal and Thailand having iodine deficiency in hyperendemic form (2).

Estimation of iodine in urine is currently being used as the most useful laboratory marker to assess iodine status of a population. For surveys it is most practical to collect 40-50 samples from an area, analyse iodine concentrations in the samples and express the results as concentrations

(µg/dl urine) (3). About 90% of ingested iodine is excreted in urine. While it is not generally possible to obtain 24 hour samples of urine, measurement of iodine concentration in a casual sample is an excellent surrogate (4). In general, urine iodine excretion (UIE) of 10.0 µg/dl is accepted as a cut-off level of adequate iodine nutriture in a defined population. UIE below this level indicates biochemical iodine deficiency (4).

A comprehensive national IDD survey was conducted in Bangladesh in 1993 in a total of 78 "mauzas" to assess the current iodine nutriture status in the country. In the survey, goitre, cretinism and urinary iodine excretion were assessed for the first time in Bangladesh. The findings of the prevalence of goitre and biochemical iodine deficiency in individual mauzas were reported earlier (5-7). In this paper, we present distribution analysis of the urinary iodine levels in the study subjects by age and sex in three ecological zones of the country.

METHODOLOGY

Sampling: For the purpose of survey, the country was divided into three ecological zones namely hilly, flood-prone and plains on the basis of subject knowledge that IDD is more severe in hilly and flood-prone zone than in the plains. The "EPI-30 Cluster" sampling methodology as recommended by the joint WHO/UNICEF/ICCIDD consultation on IDD indicators (2) was followed for selecting the survey sites. Accordingly, 30 "mauzas" (defined area generally equivalent to a village) were selected from each of the hilly flood-prone and the plain zones according to probability as a special area and from this zone 18 mauzas were selected randomly from 3 thana (6 from each thana). The total number of survey sites was thus 78.

The study population consisted of boys and girls, aged between 5 and 11 years and male and female adults aged between 15 and 44 years. It was decided to examine 100 samples in each of the population groups i.e. a total of 400 (100x4) respondents from each mauza. For collection of urine samples, 15% of the households were selected randomly from each mauza. A total of 60 urine samples were planned to be collected from each mauza. Since 78 mauzas were surveyed, in all a total of 4,680 samples was the target sample size. In actuality, the number of samples collected was 4,518 (96.5% of the target).

Estimation of iodine in Urine: On the spot urine samples were collected in wide mouthed screw capped plastic bottles. One drop toluene was added to each urine sample. Iodine was determined by the wet digestion method adopted by Gutekunst (8). The validation of urinary iodine estimation was checked both internally and externally. The internal

assay variation was less than 2%. Samples with very low (0.5 µg/dl) and high (15.0 µg/dl) values were always repeated, but no differences were observed.

For external quality assurance, 20 urine samples with low, medium and high amounts of iodine were analyzed in the PAMM/CDC laboratory at Atlanta, Georgia, USA for iodine estimation by the same method. The average CDC laboratory value (2.295 µg/dl) was not significantly different ($z = -0.6763$; $p = 0.4989$) from the average INFS laboratory value (2.880 µg/dl).

RESULTS

The distribution of urinary iodine levels in children (5-11 years) and in adults (15-44 years) of the hilly zone is shown in Tables 1 and 2. Distribution analysis of urinary iodine levels shows that only 15.5% of the children were biochemically sufficient in iodine by having a normal urinary iodine level (i.e. 10.0 µg/dl). The remaining 84.5% were deficient to varying degrees; about 1/3rd of the children (33.1%) were severely deficient having urinary iodine level below 2.0 µg/dl. In this respect, the male children seemed to be in a somewhat better position, for 18.9% of them had normal level compared to 11.6% females, and 28.7% of the males had values less than 2.0 µg/dl compared to 38.4% females (Table 1). Distribution analysis of the adult population according to various levels of urinary iodine shows that, like the children, as much as 84.4% of the adult population were biochemically iodine deficient, 31.3% being severely iodine deficient. The females were more affected than the males; 69.0% of the adult females had urinary iodine less than 5.0 µg/dl compared to 53.5% of the males (Table 2).

Table 1. Distribution of urinary iodine levels in children (5-11 years) of the hilly zone by sex.

Sex	Urinary iodine (µg/dl)				Total
	<2.0	2.0-4.99	5.0-9.99	≥10.0	
Male	28.7 (82)	30.8 (88)	21.7 (62)	18.9 (54)	100.0 (286)
Female	38.4 (93)	28.5 (69)	21.5 (52)	11.6 (28)	100.0 (242)
Total	33.1 (175)	29.7 (157)	21.6 (114)	15.5 (82)	100.0 (528)

Type of test: Chi-square = 8.50; df = 3; P = 0.0367

Figure in each parenthesis represents the cell frequency.

Table 2. Distribution of urinary iodine levels in adults (15-44 years) of the hilly zone by sex.

Sex	Urinary iodine ($\mu\text{g/dl}$)				Total
	<2.0	2.0-4.99	5.0-9.99	≥ 10.0	
Male	28.4 (81)	24.9 (71)	27.7 (77)	19.6 (56)	100.0 (285)
Female	34.0 (103)	35.0 (106)	19.1 (58)	11.9 (36)	100.0 (303)
Total	31.3 (184)	30.1 (177)	23.0 (135)	15.6 (92)	100.0 (588)

Type of test: Chi-square = 16.04; df = 3; P = 0.0011

Figure in each parenthesis represents the cell frequency.

The urinary iodine levels in children (5-11 years) and in adults (15-44 years) of the flood-prone zone are shown in Tables 3 and 4. Distribution analysis of the children according to urinary iodine level shows that only 30.6% of the male children and 25.4% of the female children had satisfactory urinary iodine level ($10.0 \mu\text{g/dl}$). The remaining 69.4% of the boys and 74.6% of the girls were biochemically iodine deficient; 23.6% to 26.8% were severely deficient and had urinary iodine level below $2.0 \mu\text{g/dl}$ (Table 3). This was in respect of the median level and also in respect of percentage distribution of the children according to various levels of urinary iodine

level. The male and female children were indistinguishable in the flood-prone, in contrast to the hilly zone, where the girls were found slightly more affected than the boys. On the other hand, 62.3% of the adult males and 65.2% of the adult females were biochemically iodine deficient having urinary iodine level less than $10.0 \mu\text{g/dl}$ (Table 4). About a fifth (21.1%) of the adult population in this zone were severely iodine deficient (urinary iodine less than $2.0 \mu\text{g/dl}$), compared to 31.3% in the hilly zone. Moreover, unlike in the hilly zone, males and females of flood-prone zone were almost equally affected. This indicates iodine deficiency situation in the flood-prone zone to be milder than in the hilly zone.

Table 3. Distribution of urinary iodine levels ($\mu\text{g/dl}$) in children (5-11 years) of the flood-prone zone by sex.

Sex	Urinary iodine ($\mu\text{g/dl}$)				Total
	<2.0	2.0-4.99	5.0-9.99	≥ 10.0	
Male	23.6 (105)	26.5 (118)	19.3 (86)	30.6 (136)	100.0 (445)
Female	26.8 (94)	28.2 (99)	19.7 (69)	25.4 (89)	100.0 (351)
Total	25.0 (199)	27.3 (217)	19.5 (155)	28.3 (225)	100.0 (696)

Type of test: Chi-square = 2.89; df = 3; P = 0.4083

Figure in each parenthesis represents the cell frequency.

Table 4. Distribution of urinary iodine levels in adults (15-44 years) of the flood-prone zone by sex.

Sex	Urinary iodine ($\mu\text{g/dl}$)				Total
	<2.0	2.0-4.99	5.0-9.99	≥ 10.0	
Male	19.0 (92)	26.0 (122)	16.6 (78)	37.7 (177)	100.0 (469)
Female	22.6 (108)	27.5 (131)	15.1 (72)	34.8 (166)	100.0 (477)
Total	21.1 (200)	26.7 (253)	15.0 (150)	36.3 (343)	100.0 (946)

Type of test: Chi-square = 2.13; df = 3; P = 0.5468

Figure in each parenthesis represents the cell frequency.

Table 5. Distribution of urinary iodine levels in children (5-11 years) of the plain zone by sex.

Sex	Urinary iodine ($\mu\text{g/dl}$)				Total
	<2.0	2.0-4.99	5.0-9.99	≥ 10.0	
Male	18.8 (80)	16.5 (70)	20.5 (87)	44.2 (188)	100.0 (425)
Female	29.8 (91)	15.4 (47)	20.3 (62)	34.4 (105)	100.0 (305)
Total	23.4 (171)	16.0 (117)	20.4 (149)	40.2 (293)	100.0 (730)

Type of test: Chi-square = 13.58; df = 3; P = 0.0035

Figure in each parenthesis represents the cell frequency.

Iodine deficiency was least severe in the plain zone. Distribution analysis of the children (5-11 years) of this zone in order of various urinary iodine levels shows that 55.8% of the boys and 65.5% of the girls were biochemically iodine deficient (Table 5). The percentages of boys and girls who were severely deficient in iodine (urinary iodine level below 2.0 $\mu\text{g/dl}$) were 18.8% and 29.8% respectively. The female children were thus more deficient in hilly zone, but different from that observed in the flood-prone zone.

Further analysis of the distribution of adult males and females in order to various levels of urinary iodine shows that 41.7% of the males and 36.6% of the females had normal iodine level (Table 6). The rest were biochemically deficient: 17.7% of the males and 23.9% of the females had urinary iodine level below 2.0 $\mu\text{g/dl}$. Thus in all ecological zones, children were slightly more affected than the adults and in both age groups, females were more affected than the males.

Table 6. Distribution of urinary iodine levels in adults (15-44 years) of the plain zone by sex.

Sex	Urinary iodine ($\mu\text{g/dl}$)				Total
	<2.0	2.0-4.99	5.0-9.99	≥ 10.0	
Male	17.7 (86)	19.3 (94)	21.4 (104)	41.7 (203)	100.0 (487)
Female	23.9 (106)	20.8 (92)	18.7 (83)	36.6 (162)	100.0 (443)
Total	20.6 (192)	20.0 (186)	20.1 (187)	39.2 (365)	100.0 (930)

Type of test: Chi-square = 7.00; df = 3; P = 0.0718

Figure in each parenthesis represents the cell frequency.

Table 7. Distribution of urinary iodine levels in Bangladesh population by ecological zone.

Zones	Urinary iodine level	
	<10 $\mu\text{g/dl}$	$\geq 10 \mu\text{g/dl}$
Hilly	84.4 (942)	15.6 (174)
Flood-prone	67.3 (1174)	32.7 (568)
Plains	60.6 (1002)	39.4 (658)

Type of test: Chi-square = 183.9; df = 2; P = 0.000

Figure in each parenthesis represents the cell frequency.

Table 8: Distribution of urinary iodine levels in Bangladesh population by age.

Age	Urinary iodine level	
	<10 µg/dl	≥10 µg/dl
Children (5-11 years)	69.8 (1454)	30.2 (600)
Adults (15-44 years)	67.0 (1664)	33.0 (800)

Type of test: Chi-square = 5.40; df = 1; P = 0.02

Figure in each parenthesis represents the cell frequency.

DISCUSSION

We reported earlier that the median urinary iodine in the study population was 3.4 µg/dl in the hilly zone, 5.1 µg/dl in the flood-prone zone and 7.4 µg/dl in the plain zone (6,7). It was also reported that 84.4% of the study population in the hilly zone, 67.1% in the flood-prone zone and 60.4% in the plain zone (overall 68.9%) are biochemically iodine deficient.

Distribution analysis of the urinary iodine level of the study population presented in this paper showed that 81.1% male children, 88.4% female children, 80.4% adult males, and 88.4% adult females of the hilly zone were biochemically iodine deficient. In the flood-prone zone, the figures were 69.4%, 74.7%, 62.3% and 65.3%, respectively, and in the plain zone 55.8%, 65.6%, 58.3% and 63.4% respectively. Of them 33.1% children and 31.3% adults of hilly zone, 25.0% children and 21.1% adults of flood-prone zone, and 23.4% children and 20.6% adults of plain zone were severely iodine deficient. In general, if the median urinary iodine concentration is below 10 µg/dl, there is a strong suspicion of IDD. If the value is in between 5.0-5.99 µg/dl, there is mild IDD; between 2.0-4.99 µg/dl, IDD is moderate, and if the value is below 2.0 µg/dl, then the problem is a serious one demanding immediate attention (4).

Thus according to the IDD indicators set forth by the joint WHO/UNICEF/ICCIDD consultation (3), the hilly zone of Bangladesh represents a severely iodine deficient area with respect to urinary iodine level and the flood-prone zone represents mild to

moderately deficient area. A slightly better condition was found in the study population of the plain zone. Thus, in terms of urinary iodine indicator, the zones may be ordered in the ascending degree of severity as hilly > flood-prone > plains (Chi-square = 183.9; df = 2; p = 0.000) (Table 7)

Also, determination of the association of urinary iodine with age groups of the subjects studied in all the three zones showed that the children were slightly more (16%) affected than the adults (Chi-square = 5.40; df = 1; p = 0.02) (Table 8).

It is concluded from the present study that Bangladesh as a whole is an iodine deficient region. A vast majority of the population suffer from biochemical iodine deficiency and it is feared that the entire population is at risk of iodine deficiency. The hilly zone is the worst hit area. Children and the females are more affected than adults and the males. Fortunately, the Government of Bangladesh has taken appropriate measures to combat the situation by introducing a universal salt iodization programme in the country.

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