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IODINE STATUS OF CHILDREN (8-11 YEARS) IN DISTRICT PESHAWAR, PAKISTAN

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ABSTRACT

A cross-sectional study was conducted in two urban (University Town and Gulberg) and two rural (Charkhana and Landi Akhoon Ahmad) communities of district Peshawar to estimate the consumption of iodized salt at household's level and to assess the prevalence of iodine deficiency disorders (IDD) by clinical and biochemical measurements. Three hundred and sixty eight households from the four communities were selected to assess the type of salt being consumed. A urine sample from every third child was also collected for urinary iodine excretion. The semi-quantitative results by rapid salt iodine spot test revealed that 67.7% of the households were consuming iodized salt and that consumption of non-iodized salt in the rural areas was higher (67.93%) than that of urban areas (4.3%). The results showed that 53.27% of the children had sub-normal urinary iodine level. Similarly, amongst the different communities, children from Charkhana and Landi Akhoon Ahmad had highest prevalence of sub-clinical iodine deficiency (100%). The study concludes that there was less consumption of iodized salt in the rural communities which was associated with low median urinary iodine levels and high prevalence of sub-clinical iodine deficiency disorders.

Keywords: iodine status, children, iodized salt, urinary iodine excretion, Peshawar.

INTRODUCTION

The importance of iodine as an essential element arises from the fact that it is a constituent of thyroid hormones; thyroxine (T4) and triiodothyronine (T3), which are essential for normal growth and development in man and animals (Hetzel, 2000). These hormones are produced by the thyroid gland, a butterfly-shaped structure in the front of the neck consisting of two ''lobes'' on either side of the windpipe connected by a narrow bridge called the isthmus (Dunn and Harr, 1990). These hormones regulate a large number of activities, which include energy transformation through an effect on oxygen consumption and heat production, growth, reproduction, neuromuscular function, skin and hair growth and cellular metabolism. The body normally contains 20-30 mg of iodine. About 60 percent of it is in the thyroid gland and the rest is diffused throughout all tissues, especially in the ovaries, muscles and blood (Narins-Czajka, 1984).

Dietary iodine is absorbed in small intestine in the form of iodides. These are loosely bound with proteins and carried by the blood to the thyroid gland. About one third of this iodide is selectively absorbed by the thyroid cells and removed from circulation while the remaining two thirds of the iodide is usually excreted in the urine within 2 to 3 days after ingestion (Williams, 1994).

Iodine deficiency develops due to imbalance between dietary iodine intake and body requirements. If an environment is adequate in iodine content, humans have no difficulty in obtaining the required small amount of iodine through food and water (WHO, 1990). According to recent estimates, about 1.6 billion of people are at risk of iodine deficiency, of which more than two-thirds are in Asia. More than 20 million are estimated to have some degree of preventable brain damage (Hetzel, 2000). In Pakistan, it has been estimated that 50 million people are affected from iodine deficiency while the prevalence of goiter ranges from 55% to as high as 80-90% in the plain and hilly areas, respectively (WHO, 1993).

Iodine deficiency disorders (IDD) includes wide spectrum of abnormalities in human physical and cognitive development. Goiter is common in all ages, but most significant are the effects on brain development during pregnancy and the first 2 years of infancy which are periods of rapid brain growth (Hetzel, 2000). Iodine deficiency is the single most common cause of preventable mental retardation and brain damage in the world. It also decreases child survival, causes goiters, and impairs growth and development. Iodine deficiency in pregnant women causes miscarriages, stillbirths, and other complications. Children with IDD may become stunted, apathetic, mentally retarded, and have difficulty in normal movements, speech, or hearing (Hetzel, 1989). The severe form of iodine deficiency results in endemic cretinism, characterized in its fully developed form by mental defect, deaf mutism and spastic diplegia. The extent of brain damage that occurs due to iodine deficiency in a given population varies considerably, a meta-analysis studies on evaluating the impact of iodine deficiency on intelligent quotient (IQ) of children revealed that iodine deficiency causes a mean loss of 13.5 IQ points in children (Hetzel, 2000).

Assessment of iodine nutrition status at population level relies initially on estimates of goiter rate and measurement of iodine excretion in urine. A population is defined to have a public health problem if more than 5% of children aged 6-12 years are found to have an enlarged thyroid. It is important that the median urine iodine exceeds 100µg/L to prevent iodine deficiency but is not above 200µg/L in order to minimize the occurrence of iodine induced hyperthyroidism. Only regular monitoring of salt iodine and urine iodine levels will ensure a satisfactory maintenance of normal iodine nutrition (Hetzel, 2000).

The deleterious effects of iodine deficiency on human's physical and mental performance led the international and national efforts to eradicate the menace of iodine deficiency from the developing countries. Since 1987, the Government of Pakistan has launched many projects to combat iodine deficiency; however, there is a limited success in achieving the goal of universal salt iodization. The Government of Khyber Pukhtunkhwa has passed the legislation to fortify edible salt with iodine, but the implementation of legislation has not been promulgated in true sprit. District Peshawar, the provincial capital of Khyber Pukhtunkhwa having a population of almost 2.01 million (Population Census Organization, 1998) with different ethnic and cultural background has been suspected to be iodine deficient area. The exact magnitude of iodine deficiency disorders and consumption of iodized salt by the households in Peshawar is not known. The baseline information is prerequisite for any kind of intervention programme. Therefore, the study was undertaken to assess the consumption of iodized salt by households in district Peshawar and to estimate the prevalence of iodine deficiency in 8-11 year old children by clinical and biochemical measurements.

MATERIAL AND METHODS

Study site

A community-based study was conducted on households of two urban and rural communities of district Peshawar to assess the nature of salt consumption and iodine status of children. Amongst the communities of urban area, University Town and Gulberg were selected while amongst the communities of rural area; Charkhana and Landi Akhoon Ahmad were selected.

Sample Selection and salt analysis

Sample size estimated for the study was 368 households based on the assumption of 40% prevalence of IDD in children with 95% confidence interval with a bound error of 10%. In each selected community, a responsible community worker(s) was contacted to act as guide for identification and selection of households. The head or any other member of the household was contacted by visiting each household till the required numbers of 92 households per community were completed. A house in which a child of 8-11 year old was present registered for the study. The purpose of the study was explained to the person concerned and consent was sought from the respondents for the enrollment of a child and bringing a teaspoon of salt from the house.

The salt sample was tested for iodine content using a rapid spot iodine test. A drop of solution was poured on a salt and waited for a few seconds for change in the salt color. Salt samples without iodine produced no coloration with the addition of a drop of solution. While there containing iodine produced from light bluish to heavy bluish color (Jaman color). The color produced by the salt was matched with the color on the box of the rapid test kit. The value printed against the matched color was recorded on the questionnaire. While urine sample from every third child was collected for assessment of iodine status.

Clinical assessment

For clinical assessment of goiter, children aged between 8-11 years were called for the clinical examination of thyroid gland. Each child was examined by placing two thumbs on either side of the subject's windpipe several centimeters below the notch of the thyroid gland, which lies next to windpipe. By observing palpation of the thyroid gland, the ICCIDD/WHO/UNICEF (1990) method was followed for identifying children as normal or grade 0 goiter (no palpable or visible goiter), grade 1 goiter (a mass in the neck that is palpable but not visible when the neck is in the normal position) and grade 2 goiter (a swelling in the neck that is visible when the neck is in the normal position and is consistent with an enlarged thyroid when the neck is palpated).

Biochemical assessment

For biochemical assessment of IDD, urine sample from every third child was collected in a clean plastic bottle, which was labeled and stored for chemical analysis. Iodine in urine sample was determined by following the recommended improved ammonium persulfate method of ICCIDD/WHO/UNICEF (1990), which works under the principal of oxidation reduction of ceric ammonium sulfate solution and arsenious acid solution, in which urine samples are digested with ammonium persulfate solution. After digestion, iodide in urine reacts with ceric ammonium sulfate solution reduces ceric ion (Ce^{+4}) to cerous (Ce^{+3}) ion and oxidation of arsenic ion from $as+^{3}$ to $as+^{5}$. The reaction is called Sandell-Kolthoff reaction and chemically described as follows:

$$2Ce^{4+} + 2I^{-} \longrightarrow 2Ce^{3+} + I_2$$

$$I_2 + As^{3+} \longrightarrow As^{5+} + 2I^{-}$$

The ceric ion (Ce^{+4}) has a yellow color, while the cerous ion (Ce^{+3}) is colorless. Thus, the course of the reaction can be followed by the disappearance of yellow color as the ceric ion is reduced. Children were characterized as normal (no iodine deficiency) when iodine concentration exceeds 10 µg/dl, mild iodine deficiency when iodine concentration falls between 5.0-9.9 µg/dl, moderate iodine deficiency when the value of iodine falls between 2.0-4.9 µg/dl and severe iodine deficiency when the value of iodine falls bellow 2 µg/dl.

Data analysis

Rapid salt iodine spot test, clinical and biochemical data were entered into the computer from the questionnaires. A program was developed in Epi Info for data entry and statistical analysis (Dean, 1996). Descriptive statistics like frequency were run to check the distribution of the data and to check for errors in data

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entry. Student's t-test and analysis of variance were run on the data to examine the mean differences in biochemical and clinical variables between gender, age groups and geographical locations. A 5% level of significance was used to accept or reject the null hypothesis.

RESULTS AND DISCUSSIONS

Table-1 shows the knowledge of the respondents about iodized salt and goiter. The Table shows that 51.1% of the responded had heard about iodized salt and 49.7% had seen the logo of iodized salt. When the respondents were asked about the source of information from where did they hear about iodized salt, 72.3% of the respondents replied that they heard about it from TV, while 0.5%, 0.3% and 26.9% heard and read through radio, newspaper and other sources (books, health worker's etc), respectively.

General characteristics including age and gender of children are summarized in Table-2. The table shows that 60% of the children were boys and 40% were girls. Mean age of boys was 9.84 years while that of girls was 9.64 years.

Table-3 summarizes the estimated iodine content in household's salt samples by a rapid salt iodine spot test. As shown in the table, 32.3 % of the households were consuming salt with no iodine content while 67.7 % of the households were consuming salt with varying amount of iodine. The range of iodine content in the household's salt samples varied between 15ppm to 100ppm. Further analysis of households consuming iodized salt revealed that 16% were consuming salt with iodine content of 15ppm while the remaining 51.7% of the households were consuming salt with iodine content ranging from 25ppm to 100ppm (Figure-1). These results suggest that about 50% of the households were consuming salt with no or below the recommended amount of iodine (~ 20ppm). These results are comparable to PMRC (1999) results where it was found that 22.4% of salt samples from Swat contained no iodine while 25.6% contained low iodine concentration.

Table-1. Knowledge, attitude and practice of the respondents about iodized salt consumption and goiter.

Variables		N (%)
Knowledge	Yes	188 (51.1)
	No	180 (48.9)
Logo of iodized	Seen	183 (49.7)
	Not Seen	185 (50.3)
Source of	TV	266 (72.3)
	Radio	2 (0.5)
	Newspaper	1 (0.3)
	Others	99 (26.9)
Knowledge	Yes	76 (20.7)
	No	292 (79.3)

Table-2. General characteristics of children.

Children studied	=	**368**
Boys	=	220 (60%)
Girls	=	148 (40%)
Children mean age ± SD	=	9.76 ± 0.77
Boys mean age ± SD	=	9.84± 0.74
Girls mean age ± SD	=	9.64 ± 0.80

Table-3. Estimation of iodine in household's salt samples by a rapid salt iodine spot test.

Salt samples N	Concentration of iodine in salt samples					
	0 ppm N (%)	15 ppm N (%)	25 ppm N (%)	50 ppm N (%)	75 ppm N (%)	100 ppm N (%)
368	119 (32.3)	59 (16)	5 (1.4)	43 (11.7)	36 (9.8)	106 (28.8)

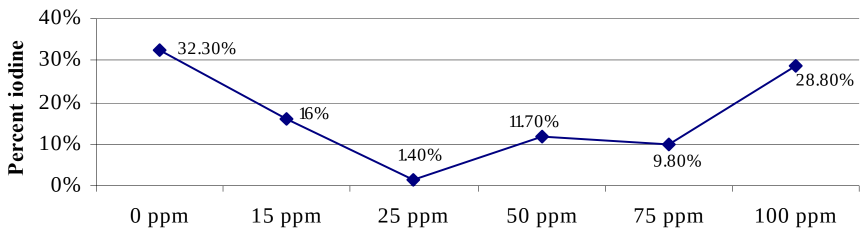

Figure-1. Percent consumption of iodized and non-iodized salt in households of district Peshawar.

Figure-2 shows the estimated iodine content in household's salt samples by area wise. As evident from the figure, in University Town 100% of the households were consuming iodized salt while in the area Landi Akhoon Ahmad a very low percentage (25%) of the households were consuming iodized salt. The concentration of iodine in the salt samples was also very low (15ppm) (Table-4). This was followed by Charkhana where about 50% of the households were consuming non iodized salt and majority (39.1%) of those consuming iodized salt had a low iodine content of 15ppm.

The differences in percent consumption of salt amongst different areas of Peshawar may be due to difference in salt availability, education and socio-economic conditions of households which may influence their decision to buy iodized or non-iodized salt. Since Charkhana and Landi Akhoon Ahmad fall under rural area their preference for consuming non-iodized salt may be based on salt availability and different beliefs, etc.

Table-4. Estimation of iodine in household's salt samples by area wise by rapid salt iodine spot test.

Area name	Concentration of iodine in salt samples					
	0ppm **N** (%)	**15ppm** **N** (%)	**25ppm** **N** (%)	**50ppm** **N** (%)	**75ppm** **N** (%)	**100ppm** **N** (%)
Charkhana (N=92)	46 (50)	36(39.1)	4 (4.3)	2 (2.2)	3 (3.3)	1 (1.1)
Landi Akhoon Ahmad (N=92)	69 (75)	23 (25)	*	*	*	*
Gulberg (N=92)	4 (4.3)	*	1(1.1)	37 (40.2)	22 (23.9)	28(30.4)
University Town (N=92)	*	*	*	4 (4.3)	11(12)	77 (83.7)

(*) No values were found

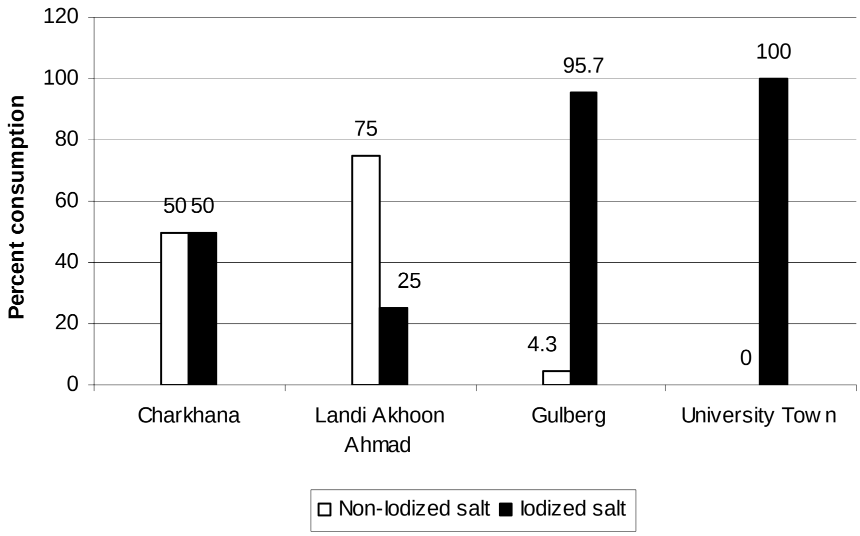

Figure-2. Percent consumption of iodized and non-iodized salt by different areas of district Peshawar.

Table-5 reveals the urinary iodine concentration of children by age group. The table shows that the median urinary iodine values of the children were between 6.50 µg/dl to 13.10 µ g/dl. Amongst the age groups, the 11 year old children had the lowest median urinary iodine value (6.50µg/dl) while 8 year old children had the highest median urinary iodine level (13.10 µ g/dl). The highest prevalence of sub-clinical mild to severe iodine deficiency was found in 11 year old children (81.23 %) while the lowest prevalence was found in 8 year old children (26.66%). Most of the 8-11 year old children were mild to moderately iodine deficient and the prevalence of severe iodine deficient children was very low.

Table-6 depicts the urinary iodine concentration of boys by age group. The Table shows that amongst 8-11 year old boys, the 9 year old boys had the lowest median urinary iodine value (7.30 µg/dl) while the 8 year old boys had the highest median urinary iodine value (14.80 µg/dl). The highest prevalence of iodine deficiency (66.66 %) was found in 11 year old boys, while no prevalence was found in 8 year old boys. The combined result showed that mild to severe deficiency was prevalent in 53.22% of boys.

Table-7 shows the urinary iodine concentration of girls by age group. As indicated in the Table, the 10 year old girls had the lowest median urinary iodine level (4.60 µg/dl) while the 8 year old girls had the highest median urinary iodine level (13.00 µg/dl). The lowest median urinary iodine level in 10 year old girls may be due to increased iodine requirements of this age group because of higher growth rate or due to greater physiological changes that might have been initiated during this time. Conversely, the highest prevalence of mild to severe iodine deficiency (100%) was found in 11 year old girls; where as the lowest prevalence (21.73%) was found in 9 year old girls. The combined results showed that mild to severe iodine deficiency was found among 53.33% of girls.

Table-5. Urinary iodine excretion of children by age group.

Age (yrs)	**Median urinary iodine level**	**Urinary iodine concentration** (µg/dl)				**Percent children with low iodine levels**
		Normal ≥10 µg/dl	**Mild 5-9.9 µg/dl**	**Moderate 2-4.9 µg/dl**	**Severe < 2 µg/dl**	
		N (%)	N (%)	N (%)	N (%)	
8 (N=15)	13.10[a]	11 (73.33)	3 (20)	1 (6.66)	***	26.66
9 (N=51)	10.70[a]	29 (56.86)	15 (29.41)	4 (7.84)	3 (5.88)	43.13
10 (N=40)	7.25[b]	14 (35)	13 (32.5)	7 (17.5)	6 (15)	65
11 (N=16)	6.50[b]	3 (18.75)	10 (62.5)	2 (12.5)	1 (6.25)	81.25
Total (N=122)	8.25	57 (46.72)	41 (33.60)	14 (11.47)	10(8.19)	53.27

* Medians in columns with similar letters are not significantly different at 5 % level of significance.
(***) No value was foun

Table-6. Urinary iodine excretion in boys by age group.

5**Age** (yrs)	**Median urinary iodine level**	**Urinary iodine concentration** (µg/dl)				**Percent children with low iodine levels**
		Normal ≥10 µg/dl	**Mild 5-9.9 µg/dl**	**Moderate 2-4.9 µg/dl**	**Severe < 2 µg/dl**	
		N (%)	N (%)	N (%)	N (%)	
8 (N=4)	14.80[a]	4 (100)	***	***	***	***
9 (N=28)	7.30[b]	11 (39.28)	14 (50)	2 (7.14)	1 (3.57)	60.71
10 (N=21)	10.10[c]	11 (52.38)	7 (25)	3 (14.28)	***	47.61
11 (N=9)	7.60[b]	3 (33.33)	6 (66.66)	***	***	66.66
Total(N=62)	8.50	29 (47)	27 (43.54)	5 (8.06)	1 (1.61)	53.22

* Medians in columns with similar letters are not significantly different at 5 % level of significance.
(***) No values were found.

Table-7. Urinary iodine excretion in girls by age group.

Age (yrs)	**Median urinary iodine level**	**Urinary iodine concentration** (µg/dl)				**Percent children with low iodine levels**
		Normal ≥10 µg/dl	**Mild 5-9.9 µg/dl**	**Moderate 2-4.9 µg/dl**	**Severe < 2 µg/dl**	
		N (%)	N (%)	N (%)	N (%)	
8 (N=11)	13.00[a]	7 (63.63)	3 (27.27)	1 (9.09)	***	36.36
9 (N=23)	12.70[a]	18 (78.26)	1 (4.34)	2 (8.69)	2 (8.69)	21.73
10 (N=19)	4.60[b]	3 (15.78)	6 (31.57)	4 (21.05)	6 (31.57)	84.21
11 (N=7)	5.50[b]	***	4 (57.14)	2 (28.57)	1 (14.28)	100
Total (N=60)	7.70	28 (46.66)	14 (23.33)	9 (15)	9 (15)	53.33

* Medians in columns with similar letters are not significantly different at 5 % level of significance.
(***) No values were found.

Table-8 shows the urinary iodine concentration of 8-11 year old children from four different areas of District Peshawar. The Table indicates that the children from Charkhana and Landi Akhoon Ahmad had the lowest median urinary iodine levels (5.70 µg/dl) while children from University Town had the highest median urinary iodine level (14.70 µg/dl) followed by Gulberg (11.60 µg/dl). The prevalence of sub-clinical iodine deficiency assessed by urinary iodine analysis showed that children from Charkhana and Landi Akhoon Ahmad had the highest prevalence of iodine deficiency (100%) followed by Gulberg (10%). The high concentration of median urinary iodine in children from University Town and Gulberg may be attributed to high consumption of iodized salt demonstrated by their results of iodized salt consumption. The low median urinary iodine concentration of children from Charkhana and Landi Akhoon Ahmad and high prevalence of sub clinical iodine deficiency in children implies that they may be consuming salt with no or little iodine content along with poor salt quality. The results are in conformity with those of Malik *et al*., (2000) who reported low urinary iodine levels in rural children from UAE, where the consumption of iodized salt had reported very low (6.5%). Likewise Selga *et al*., (2000) also reported lowest urinary iodine levels from the relatively less developed regions in Latvia, attributed to low level of iodine in salt and its poor quality.

Table-8. Urinary iodine excretion of children by area wise of district Peshawar

Areas	Median urinary iodine level	**Urinary iodine concentration** (µg/dl)				Percent children with low iodine levels
		Normal ≥10 µg/dl	**Mild 5-9.9 µg/dl**	**Moderate 2-4.9 µg/dl**	**Severe < 2 µg/dl**	
		N (%)	N (%)	N (%)	N (%)	
Charkhana (N=31)	5.70[a]	***	20 (64.51)	10 (32.25)	1 (3.2)	100
Landi Akhoon Ahmad (N=31)	5.70[a]	***	18 (58.06)	4 (12.90)	9 (29.03)	100
Gulberg (N=30)	11.60[b]	27 (90)	3 (10)	***	***	10
University Town (N=30)	14.70[b]	30 (100)	***	***	***	***
Total (N=122)	8.25	57 (46.72)	41 (33.60)	14 (11.47)	10 (8.19)	53

* Medians in columns with similar letters are not significantly different at 5 % level of significance.
(***) No values were found.

CONCLUSIONS

The present study concludes that there is a definite sub-clinical iodine deficiency in rural areas of District Peshawar so immediate measures must be taken to eradicate the evil menace of iodine deficiency. The study also concludes that households of the rural communities had lower knowledge, attitude and practice towards iodized salt and goiter than those of the urban communities. Therefore, efforts must be made for the regular fortification of salt with iodine.

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