IODINE STATUS AFTER IODIZED SALT SUPPLEMENTATION IN SCHOOLCHILDREN OF EASTERN NEPAL

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Abstract. This study was designed to assess the urinary iodine concentrations of schoolchildren at baseline and after iodized salt supplementation in eastern region of Nepal. A cross sectional study was conducted from August 2009 to July 2011 among schoolchildren of three eastern districts of Nepal: Sunsari, Dhankuta, and Tehrathum. A sample of 828 school age children from the three districts was chosen for the study after obtaining written consent from their guardians. The schoolchildren treatment group (n=300) was provided with a supplement of iodized salt for six months. Urinary iodine concentration was estimated by ammonium persulfate digestion microplate method at baseline and after supplementation. Urinary iodine controls L_1, L_2 (Seronorm, Norway) were analyzed to obtain intra-assay CVs (L_1 = 7.4%, L_2 = 3.3%) and inter assay CVs (L_1=23.5%, L_2=11.26%). Median interquartile range urinary iodine concentration in the three districts: Sunsari, Dhankuta and Tehrathum at baseline *vs* intervention were 272.0 (131.5-473.0) g/l *vs* 294.0 (265.0-304.0) g/l (p=0.379), 247.0 (144.5-332.32) *vs* 361.0 (225.66-456.52) g/l (p<0.001), and 349.5 (203.75-458.09) g/l *vs* 268.76 (165.30-331.67) g/l (p<0.001), respectively. This study indicated improved iodine status and increased median urinary iodine concentration after iodized salt supplementation. Regular monitoring of population urinary iodine concentration at national and regional levels should be performed to ensure that all individuals have optimal delivery of iodine nutrition.

Keywords: iodine deficiency, iodized salt supplementation, Nepal

INTRODUCTION

Globally one-third of children are at risk of iodine deficiency disorders (IDD), with most susceptibility in developing countries, including Nepal (Zimmermann *et al*, 2007; Gelal *et al*, 2009, 2011). Iodization of salt, a common food used by the majority of population, is a proven intervention to prevent IDD (Chaudhari *et al*, 2012; Nepal *et al*, 2013). Universal Salt Iodization has remained the best strategy to control iodine deficiency disorders in Nepal, since 1993 (Baral *et al*, 1999, 2002;

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WHO, 2007). Three nationwide studies conducted in 1998, 2005, and 2007 have shown sustainable improvement towards iodine nutrition in Nepal with median urinary iodine concentrations (UIC) 143.8 g/l, 188 g/l, and 202.8 g/l, respectively (MOH, 1998, 2005, 2007). The present study was designed to assess the UIC of school age children, residing in hilly and plain districts of eastern Nepal and to evaluate the UIC after iodized salt supplementation.

MATERIALS AND METHODS

This cross sectional quasi-experimental study was conducted from August 2009 to July 2011 in schoolchildren of three districts from eastern Nepal: Sunsari, Dhankuta and Tehrathum. Sunsari lies in the plains, whereas Dhankuta, and Tehrathum lie in hilly regions. A total of 828 school age children from the three districts were chosen for the study. Urinary iodine concentration was estimated in these subjects at baseline (*n*=828), and after iodized salt supplementation (*n*=300) for six continuous months.

Iodized salt supplementation and urinary iodine concentration

Packet salt containing approximately 50 ppm iodine (Salt Trading Corp, NPL) was supplied to the schoolchildren for six months. Proper awareness and counseling were offered regarding the usage and practice of iodized salt. Spot urine samples (5-10 ml) were collected in tightly screwed plastic vials, and transferred to the laboratory, maintaining a cold chain in an ice cool bag, and were stored in refrigerator at 2-8ºC until analysis. Urinary iodine concentration at baseline and after supplementation was estimated by ammonium persulfate digestion microplate method (Ohashi *et al*, 2000). Urinary iodine controls L_1, L_2 (Seronorm™, Billingstad, Norway) were analyzed to obtain intra-assay CVs ($L_1 = 7.4\%$, $L_2 = 3.3\%$) and inter assay CVs (L_1=23.5%, L_2=11.26%), respectively.

Statistical analysis

Data were entered in MS Excel 2007® and Statistical Package for Social Sciences (SPSS® version 16.0; IMB Corp, Armonk, NY) was used to calculate descriptive and inferential statistics. Chi-square test was applied to compare the association of qualitative non-parametric data. Mann-Whitney test and Wilcoxon signed-rank tests were applied for the non-parametric numerical data. A *p*-value >0.05 was considered statistically significant at 95% confidence intervals.

Ethical considerations

Ethical clearance was obtained as per the guidelines of Institutional Ethical Review Board (IERB) of BP Koirala Institute of Health Sciences (BPKIHS), Dharan, Nepal (Ref Nº ACA/216/068/069). The subjects' guardians and the school authorities provided written consent.

RESULTS

Among the 828 urine samples collected from the schoolchildren, the median inter-quartile range (IQR) values of urinary iodine concentration (UIC) in the three districts (Sunsari, Dhankuta and Tehrathum) at baseline *vs* intervention were 272.0 (131.5-473.0) g/l *vs* 294.0 (265.0-304.0) g/l (*p*=0.379), 247.0 (144.5-332.32) *vs* 361.0 (225.66-456.52) g/l (*p*<0.001), and 349.5 (203.75-458.09) g/l *vs* 268.76 (165.30-331.67) g/l (*p*<0.001), respectively. Significant differences were observed between the median IQR UIC of the three districts at baseline 273.12 (152.75-402.75) g/l and intervention 297.0

Table 1
Median inter-quartile range (IQR) urinary iodine concentration (UIC) at baseline survey and after intervention in three districts.

Districts	Baseline survey Median IQR UIC (g/l)	Intervention Median IQR UIC (g/l)	*p*-value
Sunsari	272.00 (131.50-473.00)	294.00 (265.00-304.00)	0.379
Dhankuta	247.00 (144.50-332.32)	361.00 (225.66-456.52)	<0.001
Tehrathum	349.50 (203.75-458.09)	268.76 (165.30-331.67)	<0.001
Total	273.12 (152.75-402.75)	297.00 (225.05-382.08)	0.024

Wilcoxon signed-rank test was used to see difference between baseline and intervention UIC of the schoolchildren of the three districts UIC at 95% confidence intervals.

Table 2
Median inter-quartile range (IQR) urinary iodine concentration (UIC) among male and female at baseline survey and after intervention.

Urinary iodine	Gender	Median IQR UIC (g/l)	*p*-value
Baseline UIC	Male	298.00 (179.67-428.45	<0.001
	Female	249.91 (125.21-376.71)	
	Total	273.12 (152.75-402.75)	
Intervention UIC	Male	301.81 (230.25-381.00)	0.248
	Female	292.00 (213.28-387.96)	
	Total	297.00 (225.05-382.08)	

Mann-Whitney test was used among the male *vs* female UIC at baseline and after intervention at 95% confidence intervals.

(225.05-382.08) g/l (p=0.024) (Table 1).

A significant difference was observed in the median UIC of the male *vs* female schoolchildren: 298.00 (179.67-428.45) g/l *vs* 249.91 (125.21-376.71) g/l in the baseline study (p<0.001), but not after intervention with male *vs* female: 301.81 (230.25-381.00) *vs* 292.00 (213.28-387.96) g/l (p=0.248) (Table 2). Our study showed significant differences in the iodine status according to WHO/UNICEF/ICCIDD criteria (WHO, 2007) in schoolchildren of the three districts, Dhankuta and Tehrathum and Sunsari at baseline and intervention study (p<0.001). There were more iodine deficient schoolchildren at baseline [severe 31(3.7%), moderate 25(3.0%) and mild 73(8.8%)] than at intervention [severe=1(0.3%), moderate=5(1.7%), mild=7(2.3%)] in the three districts (Tables 3 and 4).

DISCUSSION

Our finding suggested significant improvement in iodine status of the schoolchildren, and increased median UIC was observed in the schoolchildren of the

Table 3
Iodine status in three districts during baseline survey according to WHO/UNICEF/ICCIDD Criteria.

Districts	Iodine status						*p*-value
	Severe (<20 g/l)	Moderate (20-49 g/l)	Mild (50-99 g/l)	Adequate (100-199 g/l)	More than adequate (200-299 g/l)	Excessive (≥300 g/l)	
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Sunsari (*N*=217)	12 (5.5)	4 (1.8)	20 (9.2)	47 (21.7)	32 (14.7)	102 (47.0)	<0.001
Dhankuta (*N*=405)	14 (3.5)	11 (2.7)	43 (10.6)	79 (19.5)	108 (26.7)	150 (37.0)	
Tehrathum (*N*=206)	5 (2.4)	10 (4.9)	10 (4.9)	25 (12.1)	31 (15.0)	125 (60.7)	
Total (*N*=828)	31 (3.7)	25 (3.0)	73 (8.8)	151 (18.2)	171 (20.7)	377 (45.5)	

Chi-square test was used among the UIC status of the schoolchildren of the three districts.

overall three districts after iodized salt supplementation. This reflects the effectiveness of iodized salt supplementation in these regions to maintain the optimal levels of urinary iodine concentration in the schoolchildren. However, there was a decrease in UIC after supplementation in the schoolchildren of Tehrathum District. The increased baseline UIC of Tehrathum can be explained on the basis of: a short time of intervention (6 months), possible loss to follow-up cases, seasonal variation of urinary iodine in the schoolchildren, or other factors such as stability, storage condition, and lack of awareness to consume iodized salt (Schulze *et al*, 2003). Moreover, the possibility of more schoolchildren with iodine deficiency states at baseline, who were available for follow-up in Tehrathum can be accredited to the decreased UIC after supplementation. There were significant differences in the iodine status of male *vs* female in our study at baseline but not at intervention, which corresponds to the possibility that male and female schoolchildren were disproportionately consuming iodized salt after salt supplementation.

In our previous studies, the median UIC values of schoolchildren in Sunsari, Dhankuta, and Tehrathum were 157.1 g/l, 180.3 g/l, and 333 g/l, respectively (Gelal *et al*, 2011; Shakya *et al*, 2011). The present study has shown an increased median urinary iodine concentration in Dhankuta (247.0 g/l), Sunsari (273.2 g/l), and Tehrathum (349.5 g/l) districts than the previous studies at baseline.

Other studies have shown increased urinary iodine concentration after supplementation in follow-up studies in infants (101 g/l to 240 g/l), increased breast milk iodine concentrations in lactating mothers (55 g/l to 76 g/l) (Zimmermann, 2007), and pregnant women (130 g/l to 194 g/l) (Smyth *et al*, 1999).

Table 4
Iodine status in three districts after iodized salt supplementation according to WHO/UNICEF/ICCIDD criteria.

Districts	Iodine status						*p*-value
	Severe (<20 g/l)	Moderate (20-49 g/l)	Mild (50-99 g/l)	Adequate (100-199 g/l)	More than adequate (200-299 g/l)	Excessive (≥300 g/l)	
	n (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	*n* (%)	
Sunsari (*N*=81)	-	-	-	7 (8.6)	41 (50.6)	33 (40.7)	<0.001
Dhankuta (*N*=145)	1 (0.7)	3 (2.1)	5 (3.4)	21 (14.5)	30 (20.7)	85 (58.6)	
Tehrathum (*N*=74)	-	2 (2.7)	2 (2.7)	20 (27.0)	22 (29.7)	28 (37.8)	
Total (*N*=300)	1 (0.3)	5 (1.7)	7 (2.3)	48 (16.0)	93 (31.0)	146 (48.7)	

Chi-square test was used among the districts and their iodine deficiency status.

Zimmermann and others (2006) reported that iodine supplementation with iodized oil (400 mg) increased median urinary iodine concentration from 44 g/l to 172 g/l and also showed that iodine supplementation improved cognition in Albanian schoolchildren. A study in Lesotho reported an effect of iodine supplementation on a pediatric population, where significantly different median UIC from 63.3 g/l to 115.7 g/l after 14 years ensured consumption of 60 mg/kg iodized salt (Garcia-Mayor *et al*, 1999).

Another study in New Zealand reported that a supplement of 80 g of iodine tablet significantly increased geometric mean of UIC, for both week 0 and week 12 from 35 g/l to 68 g/l in the iodine-supplemented groups (*n*=21), and increase of median UIC from 67 g/l to 97 g/l in the groups supplemented with both selenium and iodine (*n*=20) (Thomson *et al*, 2009). Our study showed improved iodine status in the schoolchildren in eastern Nepal after iodized salt supplementation, comparable with these previous studies.

The present study has few limitations: the follow-up population chosen for intervention included only 300 schoolchildren, the intervention period was short (6 months), and the baseline UIC of Tehrathum District was more than intervention. The lower number of follow-up schoolchildren was due to fewer numbers of parents of schoolchildren available to give consent for the follow-up study. The decreased UIC in Tehrathum after intervention may be due to limited time period (6 months) for intervention and may be due to a greater number of deficient schoolchildren at baseline who were available for follow-up.

The present study has indicated

improved iodine nutrition after iodized salt supplementation. Continuous provisions of iodized salt should be ensured and awareness campaigns at national and regional levels regarding the usage and practice of iodized salt should be conducted at regular intervals. Regular monitoring of urinary iodine and usage and practice of iodized salt, should be performed to ensure that each individual consumes iodized salt for the delivery of optimal iodine nutrition, and for the sustainable elimination of iodine deficiency in these regions.

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