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ORIGINAL ARTICLE

Iodine Deficiency Disorders Among Primary School Children in Eastern Nepal

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Abstract
Objective To assess the iodine status among primary school children of Dhankuta and Dharan in eastern Nepal.
Methods A population based cross sectional study was conducted on schools of Dhankuta and Dharan from January–March 2008. 385 samples of both urine and salt were collected from school children aged 6–11 yrs. Urinary iodine excretion (UIE) was measured in casual urine samples by the ammonium-persulphate digestion microplate (APDM) method and salt iodine content by using a semi quantitative rapid test kit.
Results The median UIEs of school children of Dhankuta and Dharan were 157.1 μg/L and 180.3 μg/L respectively. The percentage of iodine deficient (UIE <100 μg/L) children were 26.6% in Dhankuta and 15.6% in Dharan. The majority of children consumed packet salt. The percentages of salt samples with adequately iodized salt (≥15 ppm) were 81.3% in Dhankuta and 89.6% in Dharan.
Conclusions Eastern Nepal is continuously progressing towards the sustainable elimination of iodine deficiency disease as illustrated by a normal median UIE and the majority of households consuming adequately iodized packet salt. It is necessary to maintain the program continuously to ensure adequate iodine nutrition of the population.

Keywords APDM method · Iodine deficiency disorders · Iodized salt · Urinary iodine excretion

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Introduction

Iodine is an essential element for thyroid function, which is necessary for the growth, development and function of the brain and body [1]. Iodine is continuously eroded from soil by glaciations, snow and floods [2]. Environmental iodine deficiency causes a wide spectrum of devastating mental and physical disabilities, collectively described as an iodine deficiency disorders (IDD). While iodine deficiency is known to cause endemic goiter, its most deleterious effect may be on the developing brain of the fetus ranging from mild brain dysfunction to irreversible mental impairment. It is the most common cause of preventable mental retardation and brain damage in the world today [1, 3, 4].

Urinary iodine excretion (UIE) is the prime indicator of a person's current iodine nutrition status and is used to measure the success of iodine supplementation in a population along with salt iodine content at household level. According to the current recommendations by the World Health Organization (WHO), the United Nation's Children's Fund (UNICEF) and the International Council for Control of Iodine Deficiency Disorders (ICCIDD), median UIE of 100–199 μg/L in samples from school children indicate adequate iodine intake and optimal iodine nutrition [4]. Primary school children are the basis for a useful study group for assessing iodine deficiency because of their physiological vulnerability, their accessibility through school and because they reflect current iodine intake [1, 3, 5].

Iodized salt is the most appropriate measure for iodine supplementation because it is used by all section of community irrespective of their social and economical status and consumed roughly at the same level throughout the year [4, 6]. Iodine content of iodized salt is determined by storage time, temperature, relative humidity and moisture content of the salt [7]. For the sustainable elimination of IDD more than 90% of household of population should be using adequately iodized salt [4].

Material and Methods

This study was undertaken to establish the iodine status of school children from rural and urban area of Eastern Nepal and to compare their iodine status. This was a school based cross-sectional study in which one school from Dhhankuta and another from Dharan were randomly selected as study locations. According to WHO/UNICEF/ICCIDD guidelines 200 school children were required from each school but eight children from Dhankuta and seven from Dharan withdrew from the study. A total of 385 urine samples and an equal number of salt samples were collected; 192 samples were from Dhankuta and 193 from Dharan. Demographic and anthopometric data of all children were recorded on a pre-structured proforma. This study was carried out after ethical consent was received from school authorities. Biochemical analysis was undertaken in the Department of Biochemistry, B.P. Koirala Institute of Health Sciences, Dharan, Nepal during the period November 2007 to October 2008.

A 24 h urine sample is considered to be a reliable marker of UIE [8]. However, in school children this was considered too difficult to ensure, so 10 ml casual urine samples were collected in a plastic container. These containers were tightly closed with screw caps to prevent leakage and evaporation and labeled with an identification number. The concentration of iodine in these urine samples was measured by the ammonium persulfate digestion microplate (APDM) method. In this method, urine samples were digested with ammonium persulfate to remove interfering substances, and then urinary iodine concentration was measured by the Sandell-Kalthoff's (S-K) reaction. This reaction is iodine catalyzed reduction of cerric (Ce^{4+}) to cerrous (Ce^{3+}) ion by arsenate (As^{3+}) ion in an acidic medium [9].

Salt samples were collected in a plastic pouch following instructions to collect two tea-spoonsful of salt used for human consumption. Salt iodine content was measured using a semi-quantitative rapid test kit, which detected salt iodine content as 0 ppm (no iodine), <15 ppm (inadequate iodine) and >15 ppm (adequate iodine).

UIE was not normally distributed and expressed as a median. The prevalence was expressed as a percentage. The *chi-square* test and the *t*-test were applied for categorized and continuous data respectively. Data were analyzed by SPSS version 11.5.

Results

The height ($p=0.002$) and weight ($p=0.01$) of school children from Dhankuta and Dharan were significantly different with Dharan children being shorter and lighter. The urinary iodine ($p=0.013$) was significantly different in school children in Dhankuta and Dharan (Table 1)

Table 2 depicts the iodine nutrition levels among the school children of Dhankuta and Dharan on the basis of UIE. The median UIE was 157.1 μg/L for Dhankuta and 180.3 μg/L for Dharan, indicating an adequate iodine intake and optimal iodine nutrition. Overall 26.6% of the children in Dhankuta and 15.6% in Dharan had mild to moderate degree of iodine deficiency with 4.2% in Dhankuta and 1.6% in Dharan being severely deficient. The proportions of children having UIE less than 50 μg/L were 11.5% in Dhankuta and 3.7% in Dharan.

Table 3 shows that 83.3% of the salt samples were adequately iodized in Dhankuta and 89.6% in Dharan. However, 2.6% of salt samples from Dhankuta and 0.5% from Dharan had no iodine (0 ppm). In both areas most of the children consumed packet salt, with 12.5% from Dhankuta and 16.1% from Dharan consuming bora salt.

Discussion

The median UIEs of school children of Dhankuta and Dharan were found to be 157.10 μg/L and 180.30 μg/L respectively. This median value indicates adequate iodine

Table 1 General characteristics of school children of both areas

Characteristics	Dhankuta ($n=192$)	Dharan ($n=193$)	p Value
Age (Yrs)	9.04±1.11	8.98±1.38	0.685
Height (M)	1.25±0.08	1.22±0.08	0.002
Weight (Kg)	24.64±4.65	23.41±4.68	0.010
Urinary Iodine (μg/L)	177.16±105.32	195.06±90.98	0.013

Table 2 Iodine nutrition among school children of both areas on the basis of UIE

UIE (μg/L)	Iodine intake	Iodine nutrition	Dhankuta n=192	Dharan n=193	Total n=385
<20	Insufficient	Severe deficiency	8 (4.2)	3 (1.6)	11 (2.9)
20–49	Insufficient	Moderate deficiency	14 (7.3)	4 (2.1)	18 (4.7)
50–99	Insufficient	Mild deficiency	29 (15.1)	23 (11.9)	52 (13.5)
100–199	Adequate	Optimal	70 (36.5)	86 (44.6)	156 (40.5)
200–299	More than adequate	Risk of IIH	37 (19.3)	38 (19.7)	75 (19.5)
>300	Possible excess	Risk of IIH and autoimmune disease of thyroids	34 (17.7)	34 (20.2)	73 (19.0)

*Figures in parenthesis indicate percentage

intake and optimal iodine nutrition in both areas [4]. However 26.6% of children in Dhankuta and 16.6% in Dharan had UIEs less than 100 μg/L indicating insufficient iodine intake and mild, moderate and severe degree of iodine deficiency. In Nepal the prevalence of low UIE was decreased successfully from 35.4% in 1998 to 19.4% in 2007 [10–13]. The lower median UIE and higher porportion of severe, moderate and mild iodine deficienct children in Dhankuta as compared to Dharan appears to be related to the iodine content of salt sample (Tables 1, 2 and 3). UIE is consistently higher in the urban/terai population as compared with the rural hilly and mountainous population [13].

Iodine deficiency is the most common cause of preventable mental retardation in the world today [4]. It remains as a hidden danger in developing countries [14] like Nepal because only 10% is manifest as a goiter and/or cretinism. Loss of energy because of hypothyroidism and impaired cognitive function are often unrecognized. Universal salt iodization (USI) was launched worldwide in 1990 to correct iodine deficiency through fortification of iodine in salt. To assess the impact of the programme, salt iodine content at the production, retailer and household level should be monitored [4]. In this study, salt iodine content was monitored specifically at the household level. 83.3% of households in Dhankuta and 89.6% in Dharan consumed adequately iodized salt. In Nepal, 77.0% of households overall consumed adequately iodized salt [12]. Stability of iodine in iodized salt is determined by storage practice, time and relative humidity. Dhankuta is a hilly area and requires long transportation time. It also suffers from high relative humidity which affects the stability of iodine in iodized salt.

This study shows that optimal iodine nutrition is occurring in the majority of people in both areas, but there may be a chance of reemergence of iodine deficiency as happened relatively recently in Mellbourne [15]. Further evidence for the incidence is that a hospital-based study on thyroid dysfunction showed 17.2% of eastern Nepal population were suffering from hypothyroidism [16]. A limitation of the study is the use of a rapid test kit for salt iodine assessment. It is recognized that a quantitative method would be preferable, but this was not available to the researchers working within a limited budget.

Conclusion

Dhankuta and Dharan are continuously progressing towards the sustainable elimination of iodine deficiency disorders but cases of severe iodine deficiency are also present in these area. 2.6% of households in Dhankuta and 0.5% in Dharan are still consuming salt with no iodine and 4.2% of children in Dhankuta and 1.6% in Dharan are suffering from severe iodine deficiency. Effective monitoring, combined with an educational awareness program about salt procurement, storage and cooking habits at the household level, is essential to continue to reduce the severe outcome of iodine deficiency and brain damage. To achieve the overall objectives of optimal iodine status for all, it is also necessary to change the strategy of the iodized salt supply in this population, improve the salt transportation, system, optimize the storage method at the retailer's level and re-evaluate cooking habits.

Further research is required to establish the outcome of an intervention strategy by providing salt to an area known

Table 3 Salt iodine content at household level in both areas

Salt iodine content (ppm)	Dhankuta n=192	Dharan n=193	Total n=385
0	5 (2.6)	1 (0.5)	6 (1.6)
<15	27 (14.1)	19 (9.9)	46 (11.9)
>15	160 (83.3)	173 (89.6)	333 (86.5)

*Figures in parenthesis indicate percentage to be in need. A further logical development of this important work would be to extend the program to remote rural areas, where the iodine deficiency is known to be more severe.

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