Iodine Deficiency Disorders After Sixteen Years of Universal Dietary Salt Iodization in a Severe Iodine Deficiency Village in Niger

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Abstract: *Introduction:* Since 1996, Niger has officially adopted the universal dietary salt iodization program (UDSI).

Objective: It is a before‑after trial study conducted to determine the impact of UDSI program in Tiguey 16 years after.

Subjects and methods: The study was centered on 371 volunteers whose thyroid gland was palpated and urinary iodine concentration (UIC) determined in 319 of them.

Results: The total goitre rate (TGR) was 13.20% with 9.70% invisible but palpable goitre (G1) and 3.50% visible goitre (G2). In 1987, the TGR was 77.15%, with 25.25% G1 and 51.90 % G2. The median UIC was 166.00 µg/L, the 20th percentile 66.40 µg/L and the 80th percentile was 300 µg/L. 68.34 % of the volunteers had a UIC ≥ 100 µg/L, 2.51% <20 µg/L, 10.97% between 20 and 49 µg/L and 18.18% between 50 and 99 µg/L. In 1987, only 3.96% of the studied sample had a UIC ≥ 100 µg/L, 45 % had a UIC <20 µg/L, 35% between 20 and 49 µg/L and 16% from 50 to 99 µg/L. No significant relationship was found between UIC and age and gender or goitre prevalence and gender (P> 0.05). However, goitre prevalence increases significantly with age ($p < 0.05$).

Conclusion: The implementation of the UDSI program in Niger decreased goitre prevalence and significantly improved the nutritional iodine status of the populations of Tiguey. However a slight endemic goitre and mild to moderate iodine deficiency persists.

Keywords: Goitre, iodine deficiency disorders (IDD), salt iodization, thyroid, urinary iodine concentrations (UIC).

INTRODUCTION

Iodine is a trace element essential for normal growth and development of human beings and whose deficiency is responsible of various pathologies commonly called iodine deficiency disorders (IDD) [1-4]. Indeed, Iodine depletion can have serious consequences, causing abnormal neuronal development, mental retardation, congenital abnormalities, spontaneous miscarriage, congenital hypothyroidism, and infertility [5, 6]. According to the United Nations Children's Fund, in 2007, nearly 2 billion individuals had insufficient iodine intake, a third being of school age [7]. In 1984, an epidemiological survey revealed a prevalence of endemic goitre of 78% in 386 patients examined in the village of Tiguey [8]. In 1987, another study undertaken in the same village showed that endemic goitre was associated with iodine deficiency. Indeed, five months after deep intramuscular injection of 0.5 mL of lipiodol, the average UIC increased and went from 34 µg/L to 902 mg/L in non-goitrous and from 37 µg/L to 911 mg/L among goitrous [9].

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The first national survey on IDD conducted in 1994, in schools, showed that Niger was among the countries in the south of the Sahara affected by iodine deficiency and related pathologies. This survey was centred on 8933 schoolchildren aged 10–15 years. The total goitre rate was 35.8% and the visible goitre rate was 5.7%. UIC from 795 pupils gave a median of 34 µg/L, and about 90% of pupils tested had UI concentration (UIC) below 100 µg/L, which is defined as optimal [10]. In 1996, universal dietary salt iodisation (UDSI) was adopted by Niger as a strategy for prevention, control and elimination of iodine deficiency. Thus, the production, importation, distribution and marketing of dietary iodized salt were made mandatory by an inter-ministerial act in October 1995, which came into force on April 1st, 1996 [11, 12]. A system of dietary iodized salt quality control was introduced at the customs offices, distribution channels and sales stands. Control agents were provided with rapid test kits consisting of drip containing starch paste and a coloration strip graduated at zero, 25, 50, 75 and 100 p.p.m.

In 1998, 2 years after the introduction of the dietary iodized salt, a survey was conducted to assess 944 pupils from 237 primary schools in eight regions of the country. The results obtained indicated that the use of iodized salt led

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to an increase in iodine content of the urine. Thus, the median UIC increased from 34 µg/L in 1994 to 270 µg/L in 1998, with a range of 116–796 µg/L. The percentage of schoolchildren with adequate UIC increased from 10.0% to 77.3%. The same study obtained 894 dietary salt samples from retailers and found that iodine content in 64% of the samples were > 25 parts per million (p.p.m.) against 7% before the implementation of the UDSI programme [10,13].

Since the significant results of 1998, several studies reported a slowdown in progress against iodine deficiency in Niger [10, 14-16]. Many countries achieved success at the beginning of the UDSI program implementation, but these failed due to the lack of permenent evaluations [17-19]. This study is a before-after preventive trial and was conducted to determine the effect of iodized salt in the prevalence of endemic goitre and the nutritional iodine status of Tiguey villagers 16 years after the implementation of the UDSI program, in a context where national controls are not effective at ensuring the universal availability of adequately iodized salt.

SUBJECTS AND METHODS

It is a cross-sectional survey conducted in the village of Tiguey, Dosso region. The village is located in the transition zone of the Sahel steppe in the north and Sudan savanna in the south and approximately 108.5 km from the capital Niamey. It is located at 2 ° 44" longitude east and 12 ° 45" latitude north. The village has a population of 770 according to the census of 1987 but estimated to 2230 inhabitants in 2012 by the National Institute of Statistics. No socioprofessional categories. In fact the whole population practises subsistence agriculture during the rainy season that lasts from June to September. The staple crop is millet. Additional crops are sorghum, beans, groundnuts, okra and sorrel. They also breed sheeps, goats, or cows for their milk but also as a source of income. In dry season abled-bodied men leave the village to go either to the national urban centers or to coastal countries for small paying jobs. The village has no market. A Community health center has just been built for a community health agent. There is only one primary school created in October 1986. In 1987, the village had a single class of 60 primary one pupils. In 2012 the school had eight classes with an enrolment of 393 pupils including 210 boys and 183 girls. The village chief was informed by our arrival and so, he gathered the villagers in the school compound that served as a meeting and volunteers recruitment framework.

371 patients mainly schoolchildren volunteered. They all have been palpated the thyroid gland. 52 patients whose thyroid have been palpated were not able to or refused to give their urine. Thus 319 urine samples were collected from 169 male and 150 female. All subjects with previous history of thyroid disease or medications that affected thyroid status, including those with systemic illness, were excluded from the study. The protocol was in accordance with the Helsinki Declaration of 1975 revised in 2008. The study was endorsed by the National Ethics Committee and the Abdou Moumouni University Academic Scientific Council. Participation in the study was voluntary. The aim of the study was explained to the subjects and consents were obtained. Once enrolled, the volunteer completed a questionnaire that included age, educational level and income of the family. The two main ways to assess iodine deficiency in a population are goitre prevalence and urinary iodine excretion.

Clinical Examination of the Thyroid

Palpation technique was used to assess the volume of the thyroid gland. Palpation of the thyroid gland is performed according to the two inches technique. In some cases, swallowing movements are required. At the end of the tests, stages of goitre were determined according to the WHO simplified classification [20]. G0: no goitre, not visible goitre, not palpable. G1: invisible but palpable goitre. G2: palpable and visible goitre. Epidemiological criteria [21] were used to assess the degree of endemic goitre (Table **1**). It is recommended that a total goitre rate or TGR (number of school children with grades 1 and 2 goitres divided by total examined) of 5% or more in school-children 6 to 12 years of age be used to signal the presence of a public health problem [21].

Biochemical Tests

The measurement of UIC was used as a criterion for the assessment of nutritional status in iodine. The participants were asked to provide 5–10 ml casual urine samples. These were used for the assessment of UIC [4] and analysed using the method of Wawschinek as modified by [22].

Statistical Analysis

The statistical analysis was carried out using SPSS 17.0 program (SPSS Inc., Chicago, IL, USA). The Kolmogorov–Smirnov test indicated that the UICs were not normally distributed; thus, the Mann–Whitney U-test and Kruskal–Wallis test were used to check if relationship existed between UIC or goitre rate and age and gender. $P < 0.05$ was considered significant.

RESULTS

Distribution of Goitre Grades Among the Population in 1987 and 2012

The 371 volunteers were aged 4 to 45 years with a mean of 10.8 ± 5.6 years, of which 53 % (197) were male. Table **2**

Table 1. Epidemiological criteria for assessing the severity of IDD based on the prevalence of goitre in school-age children*.

Degrees of IDD, expressed As percentage of the total of the number of Children surveyed				
Total goitre rate (TGR)	None	Mild	Moderate	Severe
	0.0 – 4.9%	5.0 – 19.9%	20.0-29.9%	30%

*goitre prevalence responds slowly to changes in iodine intake.

Table 2. Results of thyroid examination of the subjects in 1987 and 2012.

Age group (years)	Number		Goitre grade (%)						Total goitre rate (%)	
			0		1		2			
	1987	2012	1987	2012	1987	2012	1987	2012	1987	2012
≤ 5	3	30	66.67	93.33	33.33	6.67	0.00	0.00	33.33	6.67
6-12	110	257	24.55	87.16	24.55	10.51	50.91	2.33	75.45	12.84
13-18	65	61	24.62	76.66	33.85	11.67	41.54	11.67	75.39	23.34
≥19	32	23	9.33	100	9.38	0.00	81.25	0.00	90.62	0.00
Total	210	371	22.86	86.79	25.24	9.70	51.90	3.50	77.14	13.21

shows that endemic goitre was of a severe type (77.12%) in 1987 [9].

In addition, proportion of G2 stage subjects is relatively two times higher than that of subjects in G1 stage. In 2012 the endemic goitre persists in the population beyond the tolerated threshold of 5%, but it was of a mild type (13.21%) [21]. Moreover, unlike in 1987, proportions of stage 1 goitre is higher in our sample compared to stage 2 goitre. The 1987 survey also reported a total goitre prevalence of 51.2 % among subjects aged 6 to 12 years. In this age group, we observed a prevalence of 12.84%. All this shows a positive impact of UDSI program on the prevalence of endemic goitre ($p = 0.001$).

Distribution of UIC Values Among the Population in 1987 and 2012

Urinary iodine was assessed in 319 of the subjects, whose thyroid gland has been subjected to a clinical examination, representing 86.20 %. The mean age was 10.67±5.62 years. UIC ranged between 40 and 950 µg/L, the 20^{th} percentile was 66.4 µg/L and the 80^{th} percentile was 300 µg/L. The median UIC is greater than the minimum value of 100 µg/L recommended as appropriate in a given population. In addition, less than 20 % of the volunteers have a UIC less than 50 µg/L which according to WHO indicates adequate iodine nutritional status [4]. The comparison of our results with those reported in 1987, expressed in Table **3** and Fig. (**1**), showed a significant decrease in moderate and severe iodine deficiency in the endemic goitre population of the village of Tiguey. Indeed, severe iodine deficiency decreased from 45 to 2.5 % and moderate iodine deficiency from 35 to 10.97% [9]. UIC distribution, among the population in 1987 according to WHO criteria, was significantly different of that observe in 2012 ($p < 0.001$). This without doubt showed the beneficial effects of dietary iodized salt introduction. However, a suboptimal iodine status could still affect 31.66% of subjects studied.

No significant relationship was found between gender and goitre prevalence ($p > .05$). Similarly, no significant relationship was found between gender, age and urinary iodine status. However, a significant relationship was found among children aged 4 to 14 years, between age and the goitre rate ($p = 0.001$).

DISCUSSION

The results of this survey helped see an overall improvement in the nutritional iodine status of Tiguey villagers. The endemic goitre which was severe in 1987 [9] became mild during this survey. Thus, the total goitre rate was virtually divided by 6 and stage 2 goitre rate by 15. The total goitre rate is an indicator of chronic iodine deficiency while UIC is an indicator of individual daily variations in the iodine nutritional status. The median UIC is greater than the minimum value of 100 µg/L recommended as appropriate in a given population. In addition, less than 20 % of the volunteers have UIC less than 50 µg/L [4]. The proportion of subjects with UIC ≥ 100 µg/L in 2012 was significantly higher than in 1987($p < 0.001$). The moderate and severe iodine deficiency decreased from 45% to 2.51 % and from 35 % to 10.97 % between 1987 and 2012 [9]. The marked reduction in endemic goitre rate and the significant improvement in the nutritional iodine status achieved in Tiguey showed the positive impact of the UDSI program.

Table 3. Urinary iodine concentration (UIC) of the subjects in 1987 and 2012.

Year	n	Median UIC µg/L	Frequency distribution (percent) of urinary iodine excretion level					
			0-19	20-49	50-99	100-199	200-299	≥300 µg/L
			Moderate	Mild	Severe	Normal	Risk of IIH*	Risk of IIH*
1987	328	-	45.43	35.06	15.55	3.96	-	- %
2012	319	166	2.51	10.97	18.18	28.84	19.12	20.38 %

* IIH: Iodine-Induced Hyperthyroidism

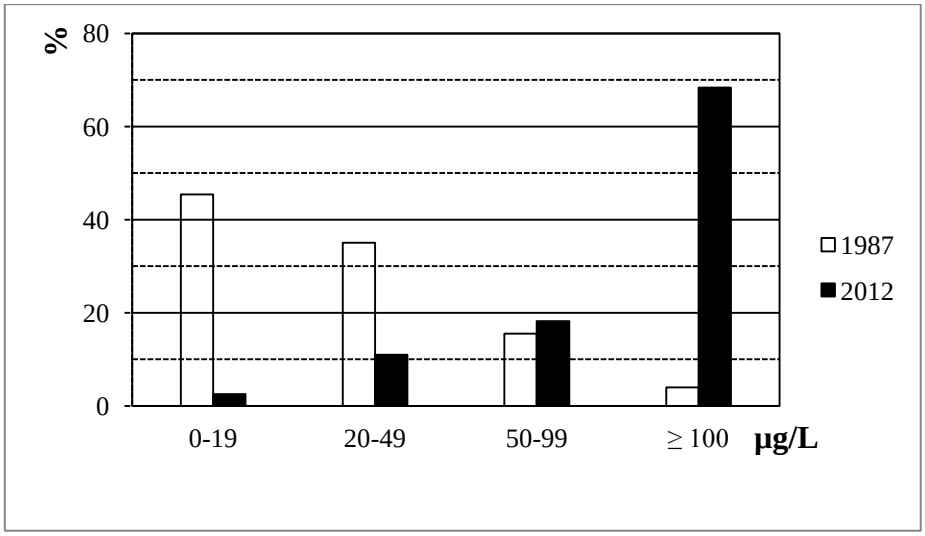

Fig. (1). Frequency distribution of urinary iodine excretion level of the subjects in 1987 and 2012

Gansu Province in China was ranked in 1995 as an area of severe IDD prevalence according to the criteria of the WHO/UNICEF/ICCIDD [4]. Ten years after the UDSI program, the total goitre rate went from 38.7 % to 13.5 % and median UIC from 119.9 µg/L to 191.8 µg/L in schools [23]. In Iran, after 7 years of optimized iodized-salt supplementation, adequate UIC values and marked reduction in goitre rate have been achieved. Indeed, in 2001 versus 1996, total, grade 1, and grade 2 goitre rates were 13.9 versus 53.8%, 11.0 versus 44.8%, and 2.9 versus 9.0%, respectively [24]. Since 1995, iodized salt had been distributed in Tabas,Yazd province in Iran. Total goitre prevalence had decreased from 34 to 25 percent after 10 years; it decreased from 35.8 to 23.5% in urban areas and from 35.6 to 28.5% in rural areas [25]. It should be noted that Tiguey basic values of goitre prevalence and iodine deficiency were higher compared to the above mentioned results.

Most certainly, the UDSI program has markedly decreased the total and stage 2 goitre rates and significantly improved the nutritional iodine status of the populations of Tiguey. However, a slight endemic goitre persists within the population and mild to moderate iodine deficiency could affect 31.66%. This could be due to a suboptimal consumption of adequately iodized salt. Indeed, in 2006, of the 1,000 samples of dietary salt collected from retailers in the eight regions of Niger, 78.7 % had iodine content below 25 ppm [14]. In a previous study we reported the limits of UDSI program in the Dosso region where Tiguey is located. Indeed, this hinterland region straddles two major international borders where non-iodized salt passes. Moreover non-iodized salt for the treatment of uranium is often diverted by importers and sold in local markets as iodized table salt [15]. This should be a serious concern because data from several countries indicated that lack of a well-monitored SI program was matched with iodine deficiency recurrence and related iodine deficiency pathologies [26-31]. As seen in Azerbaijan, Kazakhstan, Kyrgyzstan, Guatemala, Thailand, Brazil, Colombia, and Mexico, failure of monitoring in any previously successful program may result in recurrence of iodine deficiency [26, 28-30, 32-34]. And so, it is essential to strengthen and revitalize the UDSI program by efficiently fighting against the distribution of non-iodized salt on markets in the region and by conducting intensive education and awareness campaigns among the populations to incite them consume adequate amount of iodized salt.

Tables **3** shows the percentage of subjects at risk of iodine-induced hyperthyroidism (IIH) in the2012 survey. Most individuals can relatively tolerate high intake of iodine without any obvious adverse effect [4, 35, 36]. However, excessive daily iodine intake (over 1000.0 µg per day) may be potentially harmful to susceptible individuals [4, 35-39]. Note that in the 1987 survey no UIC superior to199 µg/L was registered before the administration of the lipiodol.

We found no significant relationship between gender and goitre prevalence and between gender, age and urinary iodine. However, goitre prevalence seem significantly increased with age ($P = 0.001$), and this even when we consider children from 5 to 14 years. Other authors have also reported the influence of age on goitre prevalence [22]. However unlike in their target survey sample, all children aged 5 to 14 years in our sample were born after the formal adoption of UDSI program.

CONCLUSION

After sixteen years of the UDSI program, the nutritional iodine status of the endemic goitre of Tiguey population had improved significantly. The median UIC was within the range defined as optimal and endemic goitre went from severe to mild. Dietary salt iodization has played a key role. To achieve the goal of elimination of IDD, the USI program should be permanent and the quality of iodized salt provided to beneficiaries must be continuously monitored. In addition, emphasis should be put on educating people and traders about the prophylaxis importance of iodized salt in the prevention of IDD.

DECLARATION OF INTEREST

The authors declare that there is no conflict of interest that would prejudice the impartiality of this scientific work.

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CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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REFERENCES

[1] Hetzel BS. Iodine deficiency and fetal brain damage. N Engl J Med 1994; 332: 170-1.

[2] Dunn JT. Iodine. In: Shils ME, Shike M, Ross CA, Caballero B, Cousins RJ, Eds. Modern Nutrition in Health and Disease. 10 th ed. Philadelphia: Lippincott Williams & Wilkins. 2006; pp. 300-11.

[3] Zimmermann MB, Jooste PL, Pandav CS. Iodine-deficiency disorders. Lancet 2008; 372: 1251-62.

[4] World Health Organization / International Council for the Control of Iodine Deficiency Disorders/United Nations Children's Fund, Assessment of Iodine Deficiency Disorders and monitoring their elimination: A guide for program managers. 3rd eds. Geneva: WHO 2007.

[5] Andersson M, Takkouche B, Egli I, Allen HE, Benoist B. Current global iodine status and progress over the last decade towards the elimination of iodine deficiency. Bull World Health Organ 2005; 83: 518-25.

[6] Jooste PL and. Zimmermann MB. Progress towards eliminating iodine deficiency in South Africa. S Afr J Clin Nutr 2008; 21: 8-14.

[7] United Nations Children's Fund. Sustainable elimination of iodine deficiency: progress since the 1990. UNICEF. World Summit for Children. New York, 2008; 52. Available on http://www. childinfo.org/files/idd_sustainable_elimination.pdf [Access on 01 Feb. 2014].

[9] Aquaron R, Daouda H, Madi N. Etude de 2 foyers d'endémie goitreuse au Niger: Belley-Koira et Tiguey-Tallawal. Ann Endocrinol 1990 ; 51: 231-40.

[10] International Council for Control of Iodine Deficiency Disorders. Iodine deficiency disorders in Some Sub-Saharian Countries. IDD Newsletter 2002; 18: 3-4.

[11] République du Niger. Arrêté interministériel no 61/MDI/CAT/ MSP/MPF du 4 octobre 1995 réglementant la production, l'importation et la commercialisation du sel iodé au Niger; 1995.

[12] Mamane NH, Sadou H, Alma MM, Daouda H. Evaluation de la teneur en iode des sels alimentaires dans la communauté urbaine de Niamey au Niger. J Soc Ouest-Afr Chim 2013; 35: 35-40.

[13] Attama S, Seroussi M, Kourguéni AI, Koché H, Barrère B. Enquête Démographique et de Santé, Niger, 1998. Calverton, Maryland, U.S.A.: Care International [Niger] and Macro International Inc. 1999. 358p. Available on http://www.measuredhs.com/pubs/pdf/ FR98/00FrontMatter.pdf [Access on 01 Feb. 2014].

[14] Wuehler SE , Biga H. Situational analysis of infant and young child nutrition policies and programmatic activities in Niger. Matin Child Nutr; 2011; 7: 133-56.

[15] Sadou H, Moussa Y, Alma MM , Daouda H. Iodine Status of Breastfed Infants and their Mothers after Sixteen Years of Universal Dietary Salt Iodization Program in Dosso, Niger. Open Nutr J 2013; 7: 7-12.

[16] Sadou H, Seyfoulaye A, Alma MM , Daouda H. Inadequate status of iodine nutrition among pregnant women residing in three districts of Niamey, the Niger Republic's capital. Matin Child Nutr; 2013. [Epub a head of print].

[17] Hetzel BS ,Dunn JT. The iodine deficiency disorders: Their nature and prevention. Annu Rev Nutr 1989; 9: 21-38.

[18] Murdoch DR, Harding EG, Dunn JT. Persistence of iodine deficiency 25 years after initial correction efforts in the Khumbu region of Nepal. N Z Med J 1999; 112: 26-68.

[19] Delshad, H., Mehran L, Azizi F. Appropriate iodine nutrition in Iran: 20 years of success. Acta Med Iran 2010; 48: 361-6.

[20] Perez C, Scrimshaw NS, Munoz JA. Technique of endemic goitre surveys. Monogr Ser World Health Organization 1960; N 44: 369-83.

[21] World Health Organization / United Nations Children's Fund/ International Council for the Control of Iodine Deficiency Disorders. Indicators for assessing iodine deficiency disorders and their control through salt iodization. WHO. Geneva: WHO ;1994.

[22] Dunn JT, Crutchfield HE, Gutekunst R, Dunn AD. Methods for Measuring Iodine in Urine (ICCIDD/UNICEF/WHO). Netherlands: World Health Oranization 1993; pp. 18-27.

[23] Wang Y, Zhang Z, Ge P, Wang Ya, Wang S. Iodine deficiency disorders after a decade of Universal Salt Iodization in a severe deficiency region in China. Ind J Med Res 2009; 130: 413-4.

[24] Azizi F, Mehran L, Sheikholeslam R, *et al*. Sustainability of a well-monitored salt iodization program in Iran: marked reduction in goiter prevalence and eventual normalization of urinary iodine concentrations without alteration in iodine content of salt. J Endocrinol Invest 2008; 31: 422-31.

[25] Khajedaluee M, Rajabian R, Seyyednozadi M. Education achievements and goiter size ten years after iodized salt consuming. Int J Prev Med 2013; 4: 876-80.

[26] Dunn JT. What's happening to our iodine? J Clin Endocrinol Metab 1998; 83:3398-400.

[27] Dunn JT. Complacency: the most dangerous enemy in the war against iodine deficiency. Thyroid 2000; 10:681-3.

[28] Jooste PL, Weight MJ, Lombard CJ. Short-term effectiveness of mandatory iodization of table salt, at an elevated iodine concentration, on the iodine and goiter status of school children with endemic goiter. Am J Clin Nutr 2000; 71: 75-80.

[29] Zimmermann MB, Wegmuller R, Zeder C, Torresani T, Chaouki N. Rapid relapse of thyroid dysfunction and goiter in school-age children after discontinuation of salt iodization. Am J Clin Nutr 2004; 79: 642-5.

[30] Zimmermann MB. Assessing iodine status and monitoring progress of iodized salt programs. Am J Clin Nutr 2004; 134: 1673-77.

[31] Nazeri P, Mirmiran P, Mehrabi Y, Hedayati M, Delshad H ,Azizi F. Evaluation of iodine nutritional status in Tehran, Iran: iodine deficiency within iodine sufficiency. Thyroid 2010; 20: 1399-406.

[32] Markou KB, Georgopoulos NA, Makri M, *et al*. Iodine deficiency in Azerbaijan after the discontinuation an iodine prophylaxis program: reassessment of iodine intake and goiter prevalence in schoolchildren. Thyroid 2001; 11: 1141-6.

[33] International Council for Control of Iodine Deficiency Disorders. Current IDD status Database. ICCIDD 2009.

[34] Medeiros-Neto G. Iodine nutrition in Brazil: where do we stand? Arq Bras Endocrinol Metab 2009; 53: 470-4.

[35] Delange F. Optimal iodine nutrition during pregnancy, lactation and the neonatal period. Int J Endocrinol Metab 2004; 2: 547-53.

[36] Delange F, Dunn JT. Iodine deficiency. In: Braverman LE, Utiger RD Eds. The thyroid: A Fundamental of Clinical Test. 9th ed. Philadelphia: Lippincott Williams & Wilkins 2005; pp. 264-88.

[37] Yang F, Shan Z, Teng X, *et al*. Chronic iodine excess does not increase the incidence of hyperthyroidism: a prospective community-based epidemiological survey in China. Eur J Endocrinol 2007; 156: 403-8.

[38] Teng W, Shan Z, Teng X, *et al*. Effect of iodine intake on thyroiddiseases in China. N Engl J Med 2006; 354: 2783-93.

[39] Temple VJ, Oge R, Daphne I, *et al*. Salt iodization and iodine status among infants and lactating mothers in Papua New Guinea. Afr J Food Agric Nutr Dev 2009; 9: 1807-23.

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