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

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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 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].

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 UIC 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
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 permanent 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 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 Mounouni 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.

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>Number</th>
<th>Goitre grade (%)</th>
<th>Total goitre rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>3</td>
<td>30</td>
<td>66.67</td>
</tr>
<tr>
<td>6-12</td>
<td>110</td>
<td>257</td>
<td>24.55</td>
</tr>
<tr>
<td>13-18</td>
<td>65</td>
<td>61</td>
<td>24.62</td>
</tr>
<tr>
<td>≥19</td>
<td>32</td>
<td>23</td>
<td>9.33</td>
</tr>
<tr>
<td>Total</td>
<td>210</td>
<td>371</td>
<td>22.86</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Year</th>
<th>n</th>
<th>Median UIC µg/L</th>
<th>Frequency distribution (percent) of urinary iodine excretion level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>0-19</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Moderate</td>
</tr>
<tr>
<td>1987</td>
<td>328</td>
<td>-</td>
<td>45.43</td>
</tr>
<tr>
<td>2012</td>
<td>319</td>
<td>166</td>
<td>2.51</td>
</tr>
</tbody>
</table>

Risk of IIH*: Iodine-Induced Hyperthyroidism
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 the 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**


