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Original Research Article

Unsatisfactory results of the Tunisian universal salt iodization program on national iodine levels

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ABSTRACT

Lack of iodine intake may promote a spectrum of disorders termed iodine deficiency disorders. Universal salt iodization laws were adopted in Tunisia to overcome this problem. This study examines the adequacy of iodized salt in the distribution chain two decades after its last assessment. A cross-sectional design was carried out in 2012 using the multi-stage cluster sampling technique. Salt samples from 24 governorates were collected at wholesaler level (n = 635), retailer level (n = 1440) and household level (n = 1560), and analyzed using a validated iodometric titration method. Iodine concentration at each level of distribution chain was within the recommended range of 15–27 mg/kg. Iodine content in household salt was significantly different according to the salt manufacturer and also between geographical regions ($p < 0.0001$). Moreover, an insufficient coverage of adequately iodized salt consumption (less than 90%) was found with reference to international standards (≥15 mg/kg). About 85.6% (95%CI: 78.3–90.8) of analyzed samples were adequately iodized at the intermediate levels of supply-chain (wholesalers and retailers). Our study demonstrates a decrease in the availability of iodized salt in households. It can thus be concluded that universal salt iodization legislation has not been sufficient to ensure an adequate supply of iodine in the population, and an evaluation system needs to be reactivated.

1. Introduction

Thyroid hormone production requires a regular and sufficient dietary iodine intake. In case of chronic imbalance for iodine intake, a spectrum of morbidities termed iodine deficiency disorders (IDD) may be promoted from growth retardation, reproduction impairments, hypothyroidism, cardiovascular diseases, endemic goiter to prenatal mortality, cretinism and irreversible mental disability (WHO, 2007). Iodine deficiency (ID) is actually considered as a public health problem and is one of the most widespread micronutrient deficiencies in the world (2 billion people are affected) (Zimmermann and Andersson, 2012). In 1811, Bernard Coutrois discovered the element iodine. Twenty years later, the French nutritional chemist Jean Baptiste Boussingault recommended salt iodization to prevent goiter formation (Abraham, 2006). Nearly 150 years after the discovery of iodine, universal salt iodization (USI) was adopted as the main strategy to fight against IDD. Significant progress was made toward IDD elimination throughout the world with approximately 70% of households worldwide consuming adequately iodized salt (≥15 mg/kg) (Zimmermann, 2014).

In contrast to potassium iodate (KIO_3), potassium iodide (KI) shows poor stability under various conditions (humidity, impurities, moisture, exposure to sunlight, high temperature, etc.) (Mannar and Dunn, 1995). Potassium iodate was adopted by the Tunisian authorities as recommended for salt iodization.

In Tunisia, the first law toward mandatory iodized salt commercialization was recommended only for the North West region (with iodine level of 10–15 mg/kg), which was considered an endemic area for ID (JORT, 1984). In 1995, a second national survey conducted among 8–11-year-old children reported that the median urinary iodine concentration was 158 μg/L, indicating an optimal iodine intake. The prevalence of children with urinary iodine level less than 50 μg/L (corresponding to moderate ID) was 7.1% and the iodine level in household salt fell below the recommended threshold (only 1.8 to

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7.1 mg/kg of iodine). Thereafter, a second national law (decree n° 95–1633) was adopted requiring the compulsory commercialization of iodized salt with 15–27 mg/kg at the household level (JORT, 1995). A national survey conducted in 1996–1997 among school-age children reported a median urinary iodine concentration of about 126 µg/L (INNTA, 2000). Five years after the implementation of the USI program, during the Multiple Indicator Cluster Surveys 2 (MICS 2), more than 90% of Tunisian households were found to be consuming adequate quantities of iodized salt (≥15 mg/kg). Thus, Tunisia was declared free from IDD. The last major component of the IDD control program was the elaboration of a national committee to tackle IDD in 2005 (JORT, 2005).

The aims of the present study were: i) to evaluate the adequacy of salt iodine content in commercialized salt in the distribution chain according to region and living area; and ii) to identify eventual weaknesses and problems to improve future interventions.

2. Material and methods

2.1. Study area

A Tunisian survey was carried out between May and June 2012. Tunisia is located in Northern Africa and shares boundaries with Libya (459 km) on the West and with Algeria (965 km) on the South East. It is bordered by the Mediterranean Sea on the North and East. The Northern area of Africa is commonly referred to as the Maghreb, and consists of Egypt, Libya, Tunisia, Algeria and Morocco.

Tunisia, the smallest country in the Maghreb with a territorial area of approximately 164,000 km^2, is divided into seven administrative divisions or regions (Fig. 1). Tunisia has a varied landscape with access to the sea on the North and the Sahara from the South. The mountains that range from the South West to the North East are an extension of the Atlas Mountain chain. The Tunisian dorsal provides a significant influence on the country's climate. In 2013, the human development index ranked Tunisia 90th out of 187 countries (UNDP, 2014). It is necessary to mention that regional disparities for human development index exist. Life expectancy in 2013 was 75.9 years.

The production of Tunisian sea salt was estimated at approximately 888,000 t in 2014. This production had reached over 1.38 million t in 2013. However, the Grand Erg Oriental (vast desert), composed of *chotts* (salt pans), is an important source of salt, especially after the rainy season. Both the Sousse and Sfax salt flats have recorded the highest production rates (Mobbs, 2000). Finally, there are six producers of salt in Tunisia making Tunisia an active salt exporter (US$27million in 2014) (INS, 2014).

2.2. Study design and sample collection

2.2.1. Sampling design at wholesaler and retailer level

The sampling scheme of the survey was defined based on multistage stratified clusters. Stratification was made depending on each governorate and type of economic activity (Wholesale coffee, tea, cocoa and spices; Wholesale food − Specialized divers; Trade of general food; Mini markets, supermarkets and hypermarkets; Retail cereal, pulses, dry groceries). Sampling was exhaustive for some strata regarding the low number of traders.

Overall, 3635 salt samples were obtained from 349 wholesalers (635 samples), 857 retailers (1440 samples) and 1560 households (1560 samples). Samples were purchased from 97% of the selected points of sale. The non-response rate was due to the traders who ceased their commercial activities within the period of this study.

From each retailer and wholesaler, 500 g of packed salt from the available brands were purchased by our team of workers. A total of 2075 samples were purchased (635 from wholesalers and 1440 from retailers).

Fig. 1. Tunisia map according to region.

2.2.2. Sampling design at consumer level

The study sample at household level was intended to represent the sub-national status as well as the national status (two-stage cluster sampling were employed). A survey for the assessment of iodized salt status among households was conducted in parallel to the cross-sectional survey designed to evaluate the iodine status of school-age children. The complete scheme of sampling was published in a previous paper (Doggui et al., 2017). A total of 1560 children were enrolled in that study and were asked to bring 30 g of salt from home to school in polythene devices provided by our team. For monitoring iodine content in salt according to producer, codes were used to protect the anonymity and privacy of the salt producers. In total, the products from two major manufactures were identified in the study (identified as Producer 1 and Producer 2).

2.3. Iodine content in salt

To monitor the availability of iodized salt, the lab technicians measured iodine content for the provided samples in triplicate using the recommended WHO titration method (Sullivan et al., 1995; Jooste and Strydom, 2010). This method of free iodine liberation is started by adding 2 N sulfuric acid (Schar Lan, Spain, 95–98%), then free iodine is titrated with 0.005 M sodium thiosulfate solution (LOBA Chemie, India,