Original Article

Relationship between Iodine Content in Household Iodized Salt and Thyroid Volume Distribution in Children

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Abstract

Objective To assess the effect of different levels of salt iodine content on thyroid volume (ThV) distribution using data from the 1999, 2011, and 2014 Chinese national iodine deficiency disorder (IDD) surveys.

Methods Probability proportion to size (PPS) sampling method was used to obtain a representative national sample of 34,547, 38,932, and 47,188 Chinese children aged 8-10 years in 1999, 2011, and 2014 Chinese national IDD surveys, respectively. The iodine content in household iodized salt and urinary iodine concentration were measured and thyroid ultrasound examination was performed. The data were analyzed by SAS software using histograms and box plots. The skewness and kurtosis were calculated for testing the normality of ThV.

Results The median iodine content in household iodized salt dropped from 42.30 mg/kg in 1999 to 25.00 mg/kg in 2014. The median urinary iodine concentration of children aged 8-10 years decreased from 306.0 μg/L in 1999 to 197.9 μg/L in 2014. The median and interquartile range (IQR) of ThV in 1999, 2011, and 2014 surveys were 3.44 mL and 1.50 mL, 2.60 mL and 1.37 mL, 2.63 mL and 1.25 mL, respectively. The skewness and kurtosis of ThV distribution in 1999, 2011, and 2014 surveys were 1.34 and 5.84, 0.98 and 3.54, 1.27 and 5.49, respectively.

Conclusion With reduced salt iodization levels, the median urinary iodine concentration and median ThV of children decreased significantly, and the symmetry of the ThV distribution improved.

Key words: Thyroid volume; Iodized salt; Children; Iodine deficiency disorders; Universal salt iodization

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INTRODUCTION

Universal salt iodization (USI) is recommended as a safe, cost-effective and sustainable strategy to eliminate iodine deficiency disorders (IDD)[1-2]; however, determination of the appropriate iodine consumption in population is extremely important from a public health point of view, as both insufficient and excessive iodine intake can cause problems. The consequences of severe iodine deficiency are not only endemic goiter, but also hypothyroidism, cretinism, decreased fertility rate, increased perinatal death and infant mortality[3-4]. There is increasing evidence that excessive iodine may also induce thyroid disorders[5-6].

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China adopted USI as a national strategy in October 1994. At that time, national regulations were implemented that called for the iodine content in household salts to no less than 20 mg of iodine per kg of salt (i.e., 20 mg/kg of iodine). To reach this desired consumption level, the salt iodization level during manufacturing was set at 50 mg/kg to ensure a level of at least 40 mg/kg in the manufacturer's supply outlets. In 1996, a new law was created, stating that the upper limit of iodine content in household salt should be less than 60 mg/kg to avoid iodine excess. However, according to Chinese surveillance results of 1999, the median urinary iodine (UI) concentration of school-age children from 14 provinces in China was still higher than 300 μg/L[7-8], indicating excessive iodine intake. The major epidemiological consequence of iodine excess is iodine-induced hyperthyroidism[9-10]; therefore, the iodization of salt was reinstituted in 2000, and the level of salt iodization was reduced to 20-50 mg/kg. The latest adjustment of iodine content in salt took place in March 2012, and finished until March, 2014. In order to prevent population from the potential side effects caused by excessive iodine intake, the new national standard for salt iodization have been narrowed from 20-50 mg/kg to 18-39 mg/kg, which both lowers the iodine content in iodized salt and narrows down the range of iodine content allowed.

The World Health Organization (WHO) has proposed thyroid volume (ThV) as a useful indicator in baseline assessments of the severity of IDD, and in the assessment of the long-term impact of IDD control programs[2]. Accordingly, ThV was regarded as the best prevalence indicator for assessment of IDD[11]. ThV can be measured by ultrasonography, which provides a more precise measurement of ThV than palpation[2]. However, studies on the relationship between iodine content in household salt and ThV distribution have largely been neglected. Although many surveys have evaluated ThV and iodized salt[12-14], the emphasis of these studies was not on the relationship between the iodine content in household salt and ThV distribution, or the changes in the shape of ThV distribution, or the central tendency and dispersion tendency of the ThV altogether. Hence, we recently completed a national survey of iodine nutrition in China to estimate the ThV distribution of schoolchildren aged 8-10 years and to assess if the current iodine content in household salt is appropriate for the optimal iodine nutrition.

METHODS

Sampling Method

In 1999, 2011, 2014 national IDD surveys (hereafter mentioned as 1999 survey, 2011 survey, and 2014 survey), same probability proportion to size (PPS) sampling method was adopted. PPS is a two-stage cluster sampling method. In the first stage sampling, 30 counties were selected as 'clusters' according to the proportion of people from every county in each province. The second stage selected randomly a primary school from each of 30 clusters and 40-50 students of 8-10 years old from each primary school sampled. The areas with iodine content more than 150 μg/L in drinking water were not included in the three surveys.

Subjects

There were 31 provinces, municipalities, autonomous regions participating in the 1999, 2011, and 2014 surveys in China, and Xinjiang production and construction corps was also included in the 2011 and 2014 surveys. Using the method of PPS, we obtained a representative national sample of 34,547, 38,932, and 47,188 Chinese children aged 8-10 years in the 1999, 2011, and 2014 surveys, respectively. All salt samples were provided by the children taken from their home. The sample size in each province was 1200 in the 1999 and 2011 surveys, and was 1500 in the 2014 survey. Information about age, sex, and other indicators was also collected. School-age children were excluded who reported using of oral iodized oil within one year prior to the survey. One school-age child was excluded if his or her iodine content in household salt or ThV was missing.

Measures

Determination of Iodine Content in Household Salt The iodine content in household salt samples was determined by iodometric titration[15]. All chemical analyses were conducted in provincial laboratories accredited by the national IDD reference laboratory in Beijing.

Measurement of ThV The ThV of school-age children was precisely measured using portable ultrasound equipment with a 7.5-MHz linear transducer. The volume of each lobe was calculated from the measurements of the length, width, and thickness by the following formula: volume (mL) = length (cm) × width (cm) × thickness (cm) × correction factor 0.479. ThV was defined as the sum

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