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Epidemiology

Incidence of thyroid diseases in Zhejiang Province, China, after 15 years of salt iodization

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ABSTRACT

Thyroid diseases(TD) can be induced by either deficient or excessive iodine intake. Universal Salt Iodization(USI) program has been implemented in China since 1995, to prevent iodine deficiency disorders (IDD). To evaluate the current conditions of TD and the role of USI, a multi-stage stratified random sampling scheme was used to perform a cross-sectional survey on the incidence of TD among participants in 6600 households in Zhejiang Province, a coastal area in China. Iodine nutrition status of the population was assessed by dietary iodine intake recall and urinary iodine concentration (UIC) of the participants, and TD were diagnosed by thyroid ultrasonography for 15122 participants and for 5873 participants by serum criteria for thyroid function(fT3, fT4, TSH, TRAb, TgAb, TPOAb; see Introduction for abbreviations). The median UIC of the surveyed population was 163 μg iodine/L. From the participants 23.2% had UIC < 100 μg/L which is moderately iodine-deficient according to WHO classification. Diffuse goiter was present in 2.3% of the population and thyroid nodule in 20.9%. The incidence of hyperthyroidism, subclinical hyperthyroidism, hypothyroidism, subclinical hypothyroidism, Graves' disease and chronic lymphocytic thyroiditis was 0.5%, 0.6%, 0.6%, 7.8%, 0.2% and 0.3%, respectively. The proportion of several TD for participants with non-iodized salt intake was higher than that for participants with iodized salt intake.

1. Introduction

Iodine is the essential trace element for thyroid hormones synthesis. Iodine deficiency disorders (IDD) occur when the amount of iodine in the diet is too low to meet the need of the body [1]. Meanwhile, excessive iodine intake can also lead to thyroid disorders, like goiter, hypothyroidism, hyperthyroidism and autoimmune thyroiditis [2–4]. Then, it is necessary to enhance monitoring of iodine nutrition status and maintain it at the optimum. Before the Universal Salt Iodization(USI) program was introduced in 1995, China was a country with the most widespread IDD in the world, while in 2003 [5,6], WHO claimed IDD had been eliminated in China as a whole. However, after the elimination of IDD in China, some people stopped to consume iodized salt, since they were worried about the adverse health effects of excessive iodide. Some researchers [3,4] found that the incidence of either hypothyroidism or hyperthyroidism or autoimmune thyroiditis was increased with the increase of iodine intake.

The cross-sectional epidemiological study was conducted to explore the relationship between dietary iodine intake, it's urinary excretion, and the incidence of thyroid diseases (TD). According to the 1984 and 2009 dietary survey assessments, Zhejiang was an iodine deficiency area, for 2009 contrary to the WHO statement for China mentioned above. The government set up an organization to take responsibility for the national IDD surveillance 1995 when USI program was launched. In accordance with other regions of China surveillance of TD focused on the incidence of diffuse goiter among 8–10 year-old school-age children since implementation of USI program. Since the iodine status and the incidence of TD seems to be affected by region or age [7,8], the survey was extended on broader population and more TD. More TD means inclusion of diagnostic criteria (biomarkers) as free triiodothyronine (fT3), free tetraiodothyronine (fT4), serum thyroid stimulating hormone (TSH), TSH receptor antibodies (TRAb), thyroglobulin antibodies (TgAb) and thyroid peroxidase antibodies (TPOAb), in addition to dietary iodine and urinary iodine concentration (UCI). TSH is secreted by the anterior pituitary gland and regulates thyroid hor-

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mone synthesis and secretion. Serum TSH is widely used in the field of thyroidology as a sensitive marker for both hypothyroidism and hyperthyroidism. Triiodothyronine (T3) and tetraiodothyronine (T4) are the hormones secreted by the thyroid gland. More than 99% of the T3 and T4 circulating in the blood is bound to proteins. However, it is only the small amount of free (unbound) thyroid hormone that is bioactive, fT3, fT4, so we determined fT3, fT4, rather than total T3, T4 [9]. In this study, TRAb, TPOAb are auxiliary diagnostic indicators for Graves' disease; and TPOAb, TgAb are auxiliary diagnostic indicators for chronic lymphocytic thyroiditis.

2. Subjects and methods

2.1. Subjects

In this cross-sectional survey on the population in Zhejiang Province from April to October in 2011, the involved subjects lived there for more than 3 years, aged ≥6 years (examination was not appropriate for the younger children due to the smaller size of thyroid gland [10]). Also, by preliminary investigation, those subjects were excluded when they covered any of the following items in recent 6 months: iodinated contrast media for coronary angiography, endoscopic retrograde cholangiopancreatography, amiodarone drugs, and serious psychological disorders or dementia.

A multi-stage stratified random sampling method was adopted to recruit participants from Zhejiang province. There were 11 cities under the direct jurisdiction of Zhejiang provincial government, including Hangzhou, Ningbo, Wenzhou, Jiaxing, Huzhou, Shaoxing, Jinhua, Quzhou, Zhoushan, Taizhou and Lishui, under which there were 90 counties (districts). Firstly, two counties (or districts) were randomly selected in each city as a total of 22 counties; secondly, three towns (or streets) were randomly selected in each county (district) as a total of 66 towns or streets; thirdly, one community was randomly selected from each town (or street); fourthly, 100 households were randomly selected in each community, with a total of 6600 households.

The iodine content in drinking water and Table salt was analyzed, and questionnaire survey, determination of the UIC and thyroid ultrasonography were performed on the participants aged ≥6 in the selected 6600 households with a total of 17056 studied participants. Furthermore, one participant aged ≥6 in each household was determined, and a blood sample was taken to test thyroid function. Fifty households were randomly selected from above 100 households for dietary survey. In the preliminary investigation, great difference in eating habits was found between the coastal and inland areas, e.g, the coastal areas had more consumption of sea products than inland areas, while the inland areas had higher consumption of salt than coastal areas. Coastal areas were defined as those cities with a long coastline, including Ningbo, Taizhou, Wenzhou, Jiaxing and Zhoushan city, and the rest of the regions was defined as inland areas.

The geographical distribution of survey counties (districts) in Zhejiang province is shown in Fig. 1. The survey protocol was authorized by Academy of Medical Sciences Ethics Committee in Zhejiang province. All respondents had signed up the informed consent.

3. Methods

For dietary survey, all family members in 66 × 50 selected households reported individual food intake data for consecutive 3 days (including two working days and one rest day). Investigators used the 24-h recall method [11]. The dietary iodine intake was calculated according to the iodine intake from foods, water and salt. The drinking water intake was calculated according to daily intake of 1.2 L for a normal adult [12]. The iodine content in all kinds of foods was referred to the "China food Composition Table" [13], and the iodine content in drinking water and Table salt was referred to the analysis results. The dietary iodine intake was calculated according to the iodine intake from foods, water and salt. The formula was: dietary iodine intake = $\sum(C_i \times FC_i)$, where, C_i was the iodine content in foods, drinking water and Table salt and FC_i was the consumptions of foods, drinking water and Table salt. Due to the study population including different age groups, the dietary iodine intake was calculated based on a reference man, and expressed as daily dietary iodine intake of a reference man who was a male, 18 years old, 60 kg body weight, low physical activity [14].

One salt sample and water sample were collected from each household of the selected 66 × 100 households for iodine content determination. The participants aged ≥6 underwent questionnaire survey, UIC determination and thyroid ultrasonography.

The face-to-face questionnaire survey was conducted by trained and qualified investigators. The questionnaire included questions related to gender, age, nationality, and personal or family history of TD. The morning fasting urine samples of all participants (not less than 20 mL) were collected, sealed and stored at −20 °C, followed by urinary iodine determination via arsenic-cerium catalytic spectrophotometry. Thyroid ultrasonography was performed by specially trained technicians using equipment with 7.5 MHz linear transducers (MicroMaxx Ultrasound System, SonoSite Inc. Bothell, WA, USA).

For thyroid function investigation from one participant per household approximately 5 mL fasting venous blood was collected and after winning the serum by centrifuging it was stored at −70 °C. fT3, fT4, TSH and TRAb were measured using radioimmunoassay (Beijing Atom High Tech Co., Ltd). TgAb and TPOAb were determined by chemiluminescence immunoassay method (Bayer ADVIA Cetaur System, Bayer Healthcare, Leverkusen, Germany).

Our certified iodized salt has iodine concentrations 15–40 μg per g salt, the poorly iodized salt (PIS) has iodine concentrations below 15 μg per g salt, and there were no detectable iodine in the non-iodized salt.

The diagnostic criteria of TD is listed in Table 1 [15–17]. Given the purposes of this study, patients would be termed 'euthyroid', if their thyroid gland was normal by both blood assays.

3.1. Statistical analysis

Data was processed using SAS 9.13 statistical software (SAS Institute Inc., Cary, NC, USA). Table salt iodine concentration, drinking water iodine concentration and UIC was expressed by median with 25th–75th percentile, recommended by WHO/UNICEF/ICCIDD 2007 [10], and dietary iodine intake was expressed by mean ± standard deviation (SD). A relationship between UIC and dietary iodine intake was calculated by Spearman correlation analysis. Table salt iodine concentration, drinking water iodine concentration and UIC frequencies distribution and dietary iodine intake distribution between different areas, and the incidence of TD between gender, age and region groups were compared by Cochran-Mantel-Haenszel test. Wilcoxon test was used for UIC compared of the participants with TD and euthyroid participants [17].

4. Results

The number of planned, actualy collected, and analyzed samples is shown in Table 2.